BUSHBUCK ECOLOGY AND MANAGEMENT AT SHONGWENI DAM AND GAME RESERVE

By

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PREFACE

This study was carried out in the School of Botany and Zoology, University of Natal, Pietermaritzburg, from April 2002 to December 2003 under the supervision of Prof. Colleen T. Downs and co-supervision of Prof. Mike R. Perrin.

This study represents the original work by the author and has not been submitted in any form to another university. Where the work of others has been used they are duly acknowledged in the text.

This dissertation is written in the form of research papers where Chapters 2, 3, 4 and 5 are written according to the required manuscript format for the respective journal intended for submission.

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ABSTRACT

Msinsi Holdings (Pty) Ltd are considering the introduction of nyala to Shongweni Dam and Game Reserve in KZN. This reserve has a naturally resident population of bushbuck and is located beyond the natural distribution of nyala. Concerns for competition between these two species causing declines in bushbuck numbers elsewhere prompted the present study. The main aim of the present study was to determine some aspects of the ecology of bushbuck within the reserve to assist with decision-making regarding the introduction of nyala and species specific-management of bushbuck at the study site.

Bushbuck home range and habitat utilisation was investigated with the aid of radio telemetry and Geographical Information Systems. Estimates of total home range size for males using minimum convex polygons (MCPs) and fixed kernels (FKs) were 33.9 ha and 32.1 ha respectively. Estimates of total home range size for females using MCPs and FKs were 12.0 ha and 13.5 ha respectively. A significant difference between total home range size for gender (male and female) was found but there was no significant difference for age (adult and subadult). Bushbuck typically utilised one core area within their home ranges in which 50 % of their time was spent in approximately 17 % and 11.7 % of their total home range for males and females respectively. A substantial overlap in total home range and core areas between animals was found.

Bushbuck showed preference for short thickets and avoidance of low closed grasslands. High reedbeds were utilised in proportion to their availability and tall woodlands were not utilised by the study animals, but were observed to be utilised by other non radio-collared bushbuck. Habitat preference was a consequence of favourable cover being provided by the structure of the vegetation and the occurrence of favourable foraging species. Bushbuck utilisation of topographical aspect was largely determined by the vegetation type that occurred on the respective slopes.

Estimations of bushbuck density and abundance were made using sighting efforts, drive counts, and mark-resightings. Sighting efforts using distance sampling during spring were found to be the most effective in terms of accuracy and man-hour costs , however, these were still not considered to be precise estimations of the total bushbuck population at SDGR, but would be useful for monitoring population trends as a result of the high repeatability and simplicity of the method.

Sex, age ratios and nocturnal activity were determined using field classification. The field classification method of age and sex ratio determination used during the present study was found to be very subjective and was therefore suggested to have produced ratios which may be largely biased towards the female component of the population. This in turn also effected the determination of social organization and was evident when compared to previous studies. Bushbuck activity determined from radio telemetry and sighting efforts produced results that corresponded with all previous studies, showing bushbuck to be largely nocturnal, moving much larger distances at night than during the day, and spending most of their time walking and feeding at night.

The status and management of synoptic bushbuck and nyala in KwaZulu-Natal was also investigated by means of a questionnaire survey. From the opinions of landowners and reserve managers, the status of bushbuck sharing a sympatric relationship with nyala in KwaZulu-Natal (KZN) appeared to be stable to declining, whereas nyala status was increasing. This trend was suggested to be a result of competition for resources between the two species. Northern KZN recorded a higher frequency of this trend (57.7%, n = 26) compared to the Midlands (35.7%, n = 14), as did Ezemvelo KZN Wildlife Reserves (85.7%, n = 7) compared to privately owned properties (42.4%, n = 33). Very little species-specific management for nyala and bushbuck occurred in reserves that participated in the present survey.

TABLE OF CONTENTS

		Page
PREFACE		i
ACKNOWLEDGEMENTS		ii
ABSTRACT		iv
CHAPTER 1.	**General Introduction**	
	Project Background and Motivation	1
	The Study Animal: Bushbuck	2
	The Main Study Area: SDGR	5
	Previous Studies on Bushbuck	9
	Aim and Objectives of the Present Study	10
	References	11
CHAPTER 2.	**A telemetry based study of bushbuck *Tragelaphus scriptus* home range in Valley Bushveld**	
	Abstract	16
	Introduction	17
	Materials and Methods	18
	Results	21
	Discussion	22
	References	26
	Tables and Figures	30
CHAPTER 3.	**Summer utilisation of Valley Bushveld by bushbuck *Tragelaphus scriptus* : a telemetry based study**	
	Abstract	37
	Introduction	38
	Materials and Methods	39
	Results	42
	Discussion	45
	References	47
	Tables and Figures	50
CHAPTER 4.	**Population estimation and behaviour of bushbuck (*Tragelaphus scriptus*)**	
	Abstract	56
	Introduction	57
	Materials and Methods	58
	Results	64
	Discussion	66
	Literature Cited	73
	Tables and Figures	78

CHAPTER 5.	**A survey of the status and management of sympatric bushbuck and nyala in KwaZulu-Natal, South Africa**	
	Abstract	87
	Introduction	88
	Materials and Methods	89
	Results and Discussion	92
	References	99
	Tables and Figures	101
CHAPTER 6.	**Synthesis and Management Recommendations**	
	Limitations of the Present Study	110
	Nyala Introductions and Possible Competition with Bushbuck	112
	Management Recommendations for Bushbuck at SDGR	114
	Future Research	121
	References	125
APPENDIX A	**Bushbuck mensural data**	129
APPENDIX B	**Bushbuck capture and radio telemetry**	130
APPENDIX C	**Circulated questionnaire used in survey**	141
APPENDIX D	**Overall frequency of response to questionnaire**	143

CHAPTER 1
General Introduction

Project Background and Motivation

Competition between ungulate species for food and space has been widely inferred where similar habitat requirements are evident (van Rooyen 1992; Breebart *et al.* 2002; Gordon 2003). Although many ungulates overlap in habitat requirements some are able to co-exist successfully owing to resource partitioning (e.g., differences in utilisation and preference of habitat and diet) among other aspects (e.g., predation) (Voeten and Prins 1999). Some ungulates do compete directly for resources in a synoptic situation (occupying the same geographical area and home ranges overlap), which can cause a decrease in numbers of one competitor or the separating of species where they occupy the same geographical area but their home ranges do not overlap (Putman *et al* 1993). This is thought to be the case where nyala (*Tragelaphus angasi*) and bushbuck (*T. scriptus*) co-exist in the same area as they display similar utilisation and preference for both food and habitat (Seymour 2002).

Bushbuck and nyala are both listed as common antelope species in KwaZulu-Natal (KZN) (Anderson *et al.* 1996). However, nyala are more popular with tourists and hunters, making them the higher status species economically (Rowe-Rowe 1994). It is suggested that nyala provide opportunity for a range of benefits including ecotourism and recreation, community involvement, sustainable harvesting, and vegetation management (Tredger and Jacobs 1998). The managers of many reserves are therefore attracted to the option of introducing nyala to their property, many of which lie beyond the natural distribution of nyala and are at present, historically inhabited by bushbuck.

It is the opinion of the KZN conservation body, Ezemvelo KwaZulu-Natal Wildlife (EKZNW), as well as many private reserves that nyala and bushbuck compete for the same key resources (Rowe-Rowe 1994). This is based primarily on observations made in northern KZN during the 1950s and 1960s where a rapid increase in nyala numbers coincided with a rapid decrease in bushbuck numbers (Mentis 1970; Brooks and Macdonald 1983). More recent observations show similar trends where nyala have been introduced beyond their natural range in other provinces in South Africa including the Eastern Cape, Mpumalanga, Gauteng and the Limpopo Province (various pers comm., Chapter 5).

Proposals for the introduction of nyala to areas where bushbuck already exist have, therefore, been met with concern for fear of losing bushbuck from the ecosystem. There is however, no or little documented evidence to verify this competitive interaction. Large numbers of nyala continue to be introduced beyond their historical range, further expanding their present range and possibly compounding a growing management and ecological concern.

Msinsi Holdings (Pty) Ltd are considering the introduction of nyala to Shongweni Dam and Game Reserve (SDGR) in KZN for the possibly beneficial reasons mentioned previously. This reserve appears to have the suitable resource requirements for nyala (Tredger and Jacobs 1998), has a naturally resident population of bushbuck, and also lies beyond the natural distribution of nyala. Suggestions of competition between nyala and bushbuck causing localised declines in bushbuck prompted Msinsi Holdings (Pty) Ltd to take the initiative in conjunction with the University of Natal and EKZNW to conduct this preliminary study.

The Study Animal: Bushbuck

Description

Bushbuck belong to the genus *Tragelaphus* which includes the spiral horned antelopes such as nyala (*T. angasi*), kudu (*T. strepsiceros*) and sitatunga (*T. spekei*). Three subspecies of bushbuck have been recorded in the southern African subregion of which the Cape bushbuck (*T. scriptus sylvaticus*), first described by Sparmann in 1780, exists in KZN (Skinner and Smithers 1990). Adult males stand 0.8 m at the shoulder with an average mass of 40 kg while adult females stand 0.7 m at the shoulder with an average mass of 30 kg (Walker 1996). Colouration may vary from a rusty red/brown to a darker grey/brown with characteristic white spots and stripes on their flanks and belly (Skinner and Smithers 1990). Only males possess the strongly keeled horns.

Distribution

Being amongst the most widely distributed antelope species on the African continent (Allsopp 1978), bushbuck are found in suitable habitat comprising densely structured vegetation south of the Sahara through west, central, east and south-east Africa (Skinner and Smithers 1990). In southern Africa they are associated with the coastal and sub-coastal areas of dense Valley Bushveld, as well as moist montane and coastal forests (Anderson *et al.* 1996). They are widespread within northern Botswana, Zimbabwe, Mozambique, Swaziland and the East Coast of South Africa extending from the Limpopo Province and Mpumalanga to as far south as George in the Cape Province. Apart from their distribution being restricted to suitable vegetation, they can be further localised by their dependence on, or preference for, areas where surface water is available (Jacobson 1974; Walker 1975; Rautenbach 1982) although they may also occur in thickets away from water during the summer (Simpson 1974a; Allen-Rowlandson 1986; Skinner and Smithers 1990). They have also exploited cultivated land where there is suitable cover (Bigalke 1958; Smithers 1966; Rautenbach 1982), even in suburban areas (Kingdon 1982; Smithers 1983). Their favourable response to bush encroachment (Smithers and Tello 1976) and some forms of habitat modification (i.e. exotic plantations and canelands), also contribute to their widespread distribution (Mentis 1973; Odendaal and Bigalke 1979b; Allen-Rowlandson 1986).

Status

Owing to its nocturnal and secretive habits, bushbuck numbers are difficult to establish and those that have been recorded are vague estimates with little accuracy (Rautenbach *et al.* 1981; MacLeod 1992). The IUCN/SSC (World Conservation Union/ Species Survival Commission) conducted an antelope survey throughout Africa and generally recorded bushbuck as being common throughout its expected distribution and having a stable conservation status (East 1989, 1996). As a result of this *T. scriptus* is not mentioned in the Red Data Book for terrestrial mammals (Walker 1996). In southern Africa bushbuck numbers appear to be satisfactory (Anderson *et al.* 1996), however, EKZNW propose that certain populations have been slowly decreasing in KZN as a consequence mainly of habitat destruction, and to a lesser extent, proposed competition with nyala (Rowe-Rowe 1994). Numerous properties have also recorded distinct declines in bushbuck numbers outside of KZN where nyala have been introduced beyond their natural distribution (various pers comm., Chapter 4). The status of bushbuck in KZN is still, however, considered to be secure to the extent that males are classified as "ordinary game" and may be shot by anybody in possession of a hunting license during the hunting season and with the landowners' permission, while females are classified as "protected game" and may only be shot on a permit issued to the landowner (Rowe-Rowe 1994).

Habits

Bushbuck are described as being secretive animals that are rarely seen, being primarily nocturnal and most active in the early mornings and early evenings (MacLeod 1992; Haschick 1994; Walker 1996). Reports of bushbuck being diurnally active during overcast conditions or when undisturbed are also common (Waser 1975a; Okiria 1980; Coetzee 1985), but generally this antelope will remain in the concealment of dense scrub (Jacobson 1974; MacLeod 1992) or sunbathe in safe areas such as tall grass and reeds by day (Shaw 1947; pers obs.). This species also readily takes to water and are good swimmers (Child 1968; Rautenbach 1982). Although regarded as solitary animals, associations may be formed numbering from 2 to 8 animals (Simbotwe and Sichone 1989). Males are rarely seen together with associations usually comprising of males pairing with females during breeding, or more commonly, adult females and their offspring and adolescents congregating in favourable foraging areas (Rowe-Rowe 1994). Although perceived to be a shy animal, the male bushbuck can become extremely aggressive during the mating season or when hunted with fatalities to rival males, dogs, leopards and even humans being recorded (Walker 1996). Territoriality amongst males was believed to be prominent (Jackson 1955), however, it is now known that spatial territoriality is not exhibited and that in fact there may be a large degree of overlap in home range between adults (Odendaal and Bigalke 1979; Allen-Rowlandson 1986). A dominance hierarchy appears to operate with the strongest adults of age breeding and having access to the most suitable areas (Haschick 1994; Rowe-Rowe 1994). If a particular habitat provides food and water on a year round basis, the seasonal movements of this animal may often be restricted to within that habitat (MacLeod 1992).

Feeding

Being highly selective feeders, bushbuck are mainly browsers but occasionally take grass. Feeding occurs predominantly at night where they forage along forest margins and riparian fringes (Rowe-Rowe 1994). They feed mainly on leaves but will also eat mushrooms, twigs with buds, seed pods, roots, flowers and wild fruits of a wide variety of plants (Jacobson 1974; Odendaal 1977; Allen-Rowlandson 1986; Skinner and Smithers 1990; MacLeod 1992; Haschick 1994; Walker 1996). Their ratio of browse to graze appears to be approximately 90:10 (Simpson 1974b; Rowe-Rowe 1994).

Reproduction

Bushbuck are prolific breeders and breeding occurs throughout the year where females may come into oestrus at any time (Coetzee 1985). During these periods dominant males may form a transitory "mating association" with these females which are then defended against intruding males (Allsopp 1978). There is a gestation period of approximately 200 days after which a single calf may be born at any time during the year (Coetzee 1985), but lambing peaks appear to occur during April, August and November (Von Ketelhodt 1976; Odendaal and Bigalke 1979a). A strong mother-young relationship is apparent, however, this is only stable until the next birth (Jarman 1974).

The Study Area: SDGR

Location and Extent

Shongweni Dam and Game Reserve is situated in the Mlazi Catchment between Durban and Pietermaritzburg in KZN. It extends approximately 4 km upstream from Ntshongweni Dam along the Mlazi River and can be located at approximately 29° 51'S and 30° 43' E (Figure 1.1). It is roughly hourglass shaped covering an expanse

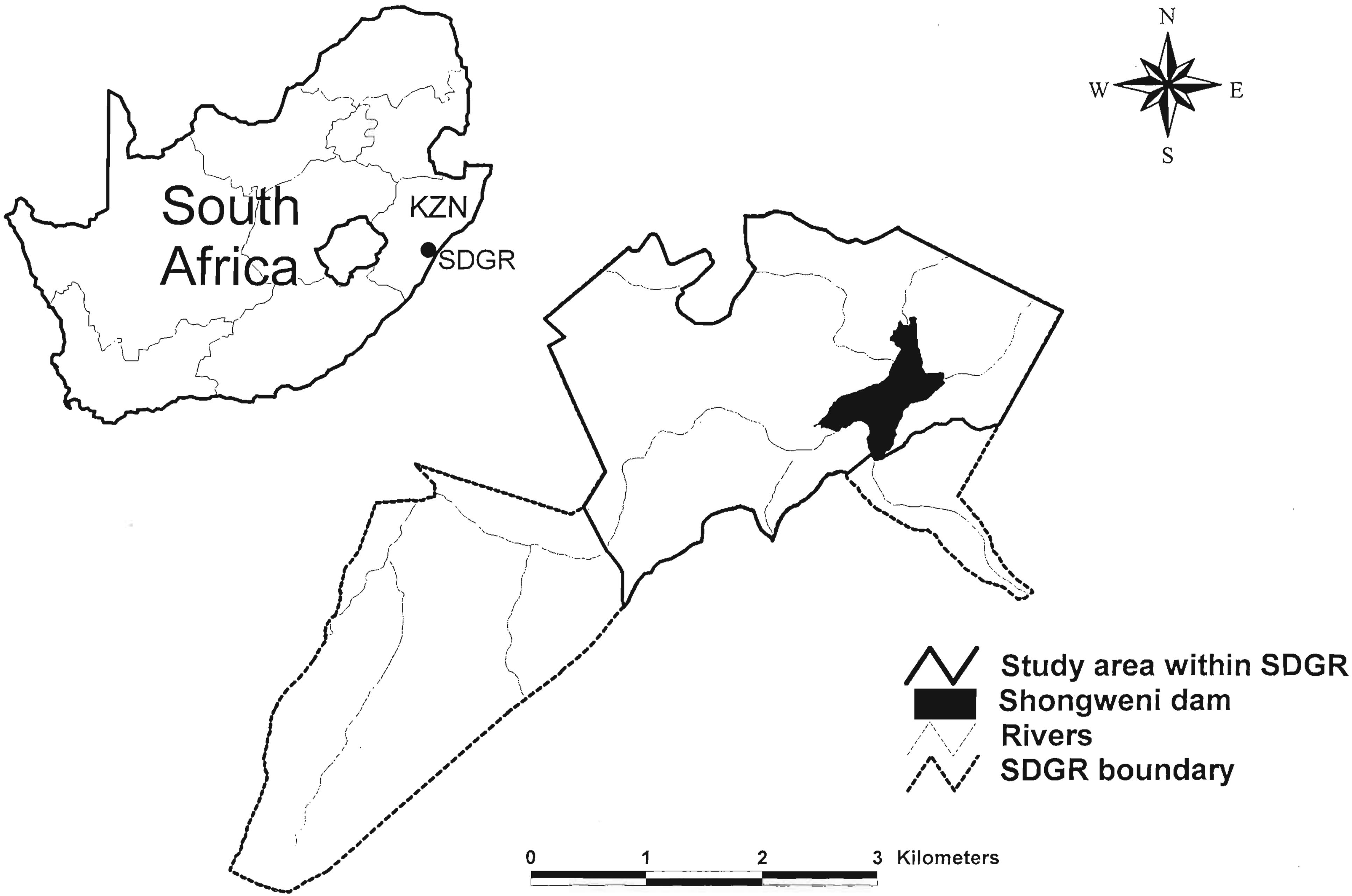

Figure 1.1 Location of Shongweni Dam and Game Reserve (SDGR) and the study area

of approximately 1700 ha (Tredger and Jacobs 1998) and is divided into a wilderness area in the southwest and zones of high utilisation for tourism around the dam in the northeast (Patrick 1998).

History

Ntshongweni is the name of a prominent hill situated in the Mlazi River Valley (Morris 1967) derived from the Zulu word 'ntshongwe, a column of smoke', referring to the mist that occurs in the valley in early mornings (Patrick 1998). The area around the Ntshongweni Hill was originally declared a protected area in approximately 1920 (Wildlife Society 1968). However, the need to increase the potable water supply to Durban resulted in the construction of a dam at the base of Ntshongweni Hill (originally named the Vernon Hooper Dam), which began in 1923 and was completed in 1927 (Larken 1996).

Ntshongweni Dam was no longer required as a water source for Durban in 1992 and a decision of either removing the wall or restoring the wall to provide a recreational area had to be made. Through negotiations between the Wilderness Leadership School and the landowners, Umgeni Water, the latter was decided upon. Msinsi Holdings (Pty) Ltd was formed in 1992 to take over the management of the area which was then named Shongweni Resources Reserve and recently changed to SDGR.

Prior to Msinsi Holdings (Pty) Ltd taking over management of the land in 1992, the area was subjected to overgrazing by cattle causing bush encroachment and the invasion of alien vegetation. No fencing demarcated the boundary of the reserve and people, domestic cattle, goats and dogs from the surrounding communities roamed freely within the reserve (Tredger and Jacobs 1998). An agreement was entered into by the surrounding communities and Msinsi Holdings (Pty) Ltd to remove all domestic animals and fence the reserve. This was done with the understanding that the surrounding communities would receive benefits by being incorporated in sustainable development, social responsibility and environmental education/management (Coulon pers comm.[1]). Fencing commenced in 1994 and was completed in 1997 with an additional fence dividing the reserve into a wilderness area

[1] Coulon, P. Land and Wildlife Manager, Msinsi Holdings (Pty) Ltd. Private Bag X1020 Hillcrest 3650

and a visitor area of approximately 850 ha each. Small populations of game were introduced to the visitor section during the mid 1990s while existing populations of naturally occurring fauna and flora species (see Fauna and Flora below) were maintained in the wilderness area. It was then decided in 1998 to remove the fence separating the wilderness area to allow the game to move more freely (Tredger and Jacobs 1998).

Nichols and Fairall (1992) describe the area contained by SDGR to be the "largest single piece of protected natural bush and virtually unspoilt scenery in the metropolitan area of Durban". It has also been incorporated into plans for the Durban Metropolitan Open Space System, D'MOSS (Patrick 1998).

Climate and Topography

The climatic conditions experienced at SDGR are semi-arid and hot which contrasts markedly with the expected regional warm, moist climate. This is a result of the area occurring in a rain shadow, due primarily to interactions between topography and wind (Patrick 1998). Two prevailing winds predominate, from the northeast and southwest (Morris 1967). Mean annual temperatures range between a maximum of 28°C in February and a minimum of 6.5°C in June/July while mean annual precipitation ranges from a maximum of 99 mm in February to a minimum of 16 mm in July (Patrick 1998). Being in a rain shadow, SDGR also experiences a much lower mean annual rainfall of 703 mm than that experienced in surrounding areas (>1000mm) with 80% of mean annual precipitation falling between October and April (Patrick 1998).

The reserve is situated in a valley therefore topography is described as being rugged with a lowest altitude of 260 m below the dam wall and a highest altitude of 690 m at the top of the cliffs bounding the reserve. Flat open floodplains in the north-east of the reserve rise steeply to the sandstone cliffs that form the edges of the various plateaus in the area while two spurs in the south-west provide somewhat gentler relief in the wilderness area (Patrick 1998).

Fauna and Flora

Shongweni Dam and Game Reserve is highly rated as a bird sanctuary and contains over 200 species, including the endangered black stork *Ciconia nigra* (Patrick 1998). Several species of insects, arachnids, fish, amphibians, reptiles and small mammals occur naturally while large game including white rhinoceros *Ceratotherium simum*, buffalo *Syncerus caffer*, kudu *Tragelaphus strepsicerus*, impala *Aepycerus melampus*, giraffe *Giraffa camelopardalis*, reedbuck *Redunca arundinum* and zebra *Equus burchelli* were stocked in the mid 1990s. Small game including bushbuck, grey duiker *Sylvicapra grimia* and blue duiker *Cephalophus monticola* as well as numerous small nocturnal predators such as black backed jackal *Canis mesomelas*, caracal *Felis caracal*, genet *Genetta* spp. and mongoose *Mungos* spp. were also already naturally established (Patrick 1998; Tredger and Jacobs 1998). A complete list of faunal species recorded at SDGR is available from Msinsi Holdings (Pty) Ltd on request[2].

The reserve falls within the Savanna Biome (Rutherford and Westfall 1994) and contains Acock's (1988) Valley Bushveld (Veld Type 23) and Coastal Forest and Thornveld (Veld Type 1). Low and Rebelo (1996) describe SDGR as containing Coast-Hinterland Bushveld with a small portion of Valley Thicket. A complete list of floral species recorded at SDGR is available in Patrick (1998).

Previous Studies on Bushbuck

Bushbuck are one of the best studied African antelopes with a number of academic studies being completed (Allsopp 1970; Thomson 1972; Morris 1973; Simpson 1974c; Odendaal 1977; Allen-Rowlandson 1986; MacLeod 1992; Haschick 1994) and subsequent scientific papers of bushbuck ecology being published in leading journals (Allsopp 1971,1978; Simpson 1973, 1974a, 1974b, Morris and Hanks 1974; Odendaal and Bigalke 1979a, 1979b; Odendaal 1983; Allen-Rowlandson 1985; MacLeod *et al.* 1996; Haschick and Kerley 1996, 1997). Earlier studies on bushbuck published in popular journals focused only on general aspects of the biology and ecology of *T. scriptus* (Shaw 1947; Kolbe 1948; Duckworth 1948; Jackson 1955; Blower 1962; Burton 1963; Bainbridge 1973) while scientific studies only followed the tsetse fly control campaigns in Zambia and Zimbabwe when considerable

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[2] Msinsi Holdings (Pty) Ltd Head Office, Box 2444, Hillcrest, 3650.

numbers of bushbuck were shot (Wilson and Child 1964). Other published scientific papers include behaviour, habitat preferences, dietary habits and social and spatial organisation (Elder and Elder 1970; Allsopp 1971, 1978; Jacobsen 1974; Waser 1975a, 1975b; Okiria 1980; Schmidt 1983; Smits 1985; Simbotwe and Sichone 1989; Seymour 2002). However, only two previous studies have been done regarding radio tracking of bushbuck and they both occurred primarily in exotic plantations of pine and eucalyptus (Odendaal 1977; Allen-Rowlandson 1986). The present study was therefore unique in that it involved radio tracking of bushbuck solely in their natural Valley Bushveld habitat.

Aim and Objectives of the Present Study

The aim of this study was to determine some aspects of bushbuck ecology at SDGR to learn more about this population before and if the introduction of nyala does occur. If nyala are introduced in the future this study could be used as a grounding to a greater study investigating the interaction and possible competition between these two species. This study also serves to provide information that can be used to compile a species specific management plan for bushbuck at SDGR to firstly conserve, and secondly sustainably utilise the population. The following main objectives were set for this study:

1. Determine the home ranges of bushbuck in terms of extent, utilisation and overlap.
2. Determine habitat utilisation by bushbuck in terms of selection, preference and dependence.
3. Determine the status of the present bushbuck population at SDGR in terms of their density, numbers and population ratios.
4. Determine some aspects of bushbuck behaviour.

An additional objective was to investigate the present status and management strategies for synoptic bushbuck and nyala in KZN by way of a questionnaire survey. It was hoped that this information would assist with decision making as to whether or not nyala should be introduced to areas beyond their natural distribution, and also to assist with management of these two species living .

References

Acocks J. (1988) Veld types of South Africa. *Memoirs of the Botanical Survey of South Africa*. Botanical Research Institute.

Allen-Rowlandson, T.S. (1985) An ecological study of the bushbuck in relation to forest management. *Pelea* 4: 7-16.

Allen-Rowlandson, T.S. (1986) *An autecological study of bushbuck and common duiker in relation to forest management*. Unpublished PhD Thesis, Pietermaritzburg.

Allsopp, R. (1970) *The population dynamics and social biology of the bushbuck (Tragelaphus scriptus,* Pallas). MSc. Thesis, University of Nairobi.

Allsopp, R. (1971) Seasonal breeding in bushbuck *(Tragelaphus scriptus,* Pallas, 1766). *East African Wildlife Journa.* 9: 146-149.

Allsopp, R. (1978) Social biology of bushbuck, *(Tragelaphus scriptus,* Pallas, 1766) in the Nairobi National Park, Kenya. *East African Wildlife Journa.* 16: 153-166.

Anderson, J.L., Knight M., Lloyd, P., Reilly, B., Rowe-Rowe, D., van der Walt, P.T., Viljoen, P. and Vrahimis, S. (1996) *Chapter 3: South Africa.* In East, R. *Antelope Survey Update number 3*. IUCN/SSC Antelope Specialist Group Report. Pp 8-33.

Bainbridge, W.R. (1973) Natal Mammals. No.2 The bushbuck. *Natal Wildlife*. 14(1): 12-15.

Bigalke, R.C. (1958) On the present status of ungulate mammals in South West Africa. *Mammalia* 22: 478-497.

Blower, J.H. (1962) Wildlife of Uganda, 5: The bushbuck. *Wildlife and Sport* 3(2): 26-27.

Breebart, L., Bhikraj, R. and O'Connor, T.G.O. (2002) Dietary overlap between boergoats and indigenous browsers in a South African savanna. *African Journal of Range and Forage Science* 19(1): 17-25.

Brooks, P.M. and Macdonald, I.A.W. (1983) *The Hluhluwe-Umfolozi Reserve: an ecological case history.* In Owen-Smith N. *Management of large mammals in African conservation areas.* Haum Educational Publishers, Pretoria. Pp 51-77.

Burton, M. (1963) *Courageous, unmannerly, bushbuck*. Illustrated London News 242:896.

Child, G. (1968) An ecological survey of north-eastern Botswana. FAO Report No. TA 2563. 155pp.

Coetzee, P.W. (1985) Some aspects of the social behaviour, reproduction and fertility in the Cape bushbuck – *Tragelaphus scriptus sylvaticus*. *Pelea* 4: 18-23.

Duckworth, R.R. (1948) Two species of bushbuck. *African Wildlife* 2(3): 26-28.

East, R. (compiler) (1989) Antelopes: Global Survey & Regional Action Plan, Part 2: Southern & South-central Africa. IUCN, Gland.

East, R. (compiler) (1996) Antelope Survey Update number 3: December 1996. IUCN, Gland.

Elder, W.H. & Elder, N.L. (1970) Social groupings and primate associations of the bushbuck (*Tragelaphus scriptus*). *Mammalia* 34: 356-362.

Gordon, I.J. (2003) Browsing and grazing ruminants: are they different beasts? *Forest Ecology and Management* 181: 13-21.

Haschick S.L. (1994) *Foraging and digestion by bushbuck (Tragelaphus scriptus) and boergoats (Capra hircus) in captivity*. MSc. Thesis. University of Port Elizabeth.

Haschick, S.L. and Kerley, G.I.H. (1996) Experimentally determined foraging heights of bushbuck (*Tragelaphus scriptus*) and boergoats (*Capra hircus*). *African Journal of Ecology* 26(2): 64-65.

Haschick, S.L. and Kerley, G.I.H. (1997) Browse intake rates by bushbuck (*Tragelaphus scriptus*) and boergoats (*Capra hircus*). *African Journal of Ecology* 35: 146-155.

Jackson, W.T. (1955) That fighting fury, the bushbuck. *African Wildlife* 9(4): 335-338.

Jacobsen, N.H.G. (1974) Distribution, home range and behaviour patterns of bushbuck in the Lutope and Sengwe Valleys, Rhodesia. *Journal of southern African Wildlife Management Association* 4(2): 75-93

Jarman, P.J. (1974) The social organisation of antelope in relation to their ecology. *Behaviour* 48(3-4): 215-267

Kingdon, J. (1982) East African Mammals: An Atlas of Evolution in Africa. Volume 3, Part C (Bovids). London: Academic Press.

Kolbe, F.F. (1948) The bushbuck – a scientific note. *African Wildlife*. 1(4): 9.

Larken, P. (1996) *History of water supply*. Umgeni Water, Pietermaritzburg.

Low, A.B. and Rebelo, T.G. (1996) Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

MacLeod, S.B. (1992) *Habitat use and diet of bushbuck in the Alexandria Coastal Reserve.* MSc. Thesis. University of Port Elizabeth.

MacLeod, S.B., Kerley, G.I.H. and Gaylard, A. (1996) Habitat and diet of bushbuck (*Tragelaphus scriptus*) in the Woody Cape Nature Reserve: observations from faecal analysis. *South African Journal of Wildlife Research* 26(1): 19-25.

Mentis, M.T. (1970) Estimates of natural biomasses of large herbivores in the Umfolozi Game Reserve area. *Mammalia* 34: 363-393.

Morris, J. (1967) *Descriptive and quantitative plant ecology of Ntshongweni, Natal.* Masters Thesis. University of Natal, Pietermaritzburg.

Morris, N.E. and Hanks, J. (1974) Reproduction in the bushbuck (*Tragelaphus scriptus ornatus*). *Arnoldia* 7(1): 1-8.

Nichols, G. and Fairall, M. (1992) *Day walks in and around Durban and Pietermaritzburg*, Struik, Cape Town.

Odendaal, P.B. (1977) *Some aspects of the ecology of bushbuck (Tragelaphus Scriptus, Pallas 1776) in the southern Cape.* MSc Thesis. University of Stellenbosch.

Odendaal, P.B. (1983) Feeding habits and nutrition of bushbuck in the Knysna forests during winter. *South African Journal of Wildlife Research* 13(2): 27-31.

Odendaal, P.B., and Bilgalke, R.C. (1979a) Home range and groupings of bushbuck in the southern Cape. *South African Journal of Wildlife Research* 9: 96-101.

Odendaal, P.B., and Bilgalke, R.C. (1979b) Habitat Selection by bushbuck in a disturbed Environment. *South African Forestry Journal* 108:39-41.

Okiria, R. (1980) Habitat exploitation by the bushbuck in Rwenzori National Park. *African Journal of Ecology* 18: 11-17.

Patrick, B.G. (1998) *Open space planning: Integrating Shongweni Resources Reserve with the Umlaas river park and parts of the lower Mlazi catchmment.* MSc thesis, University of Natal, Durban.

Putman, R.J., Culpin, S. and Thirgood, S.J. (1993) Dietary differences between male and female fallow deer in sympatry and in allopatry. *Journal of Zoology, London* 229: 267-275.

Rautenbach, I.L. (1982) *Mammals of the Transvaal.* Pretoria: Ecoplan.

Rautenbach, I.L., Nel, J.A.J., and Root, G.A. (1981) Mammals of the Itala Nature Reserve, Natal. *The Lammergeyer* 31: 21-37.

Rowe-Rowe, D.T. (1994) *The ungulates of Natal.* Natal Parks Board, Pietermaritzburg.

Rutherford, M.C. and Westfall, R.H. (1994) Biomes of southern Africa – an objective categorisation. *Memoirs of the Botanical Survey of South Africa* 63:1-94.

Schmidt, J.L. (1983) A comparison of census techniques of common duiker and bushbuck in timber plantations. *South African. Forestry Jouranl* 126: 15-19.

Seymour, G. (2002) Ecological separation of greater kudu, nyala and bushbuck at Londolozi. *CC Africa Ecological Journal* 4: 137-146

Shaw, E.H.J. (1947) The bushbuck: alert, dignified, courageous. *African Wildlife* 1(3): 16-19.

Simbotwe, M.P., and Sichone, P.W. (1989) Aspects of behaviour of bushbuck in the Kafue National Park, Zambia. *South African Journal of Wildlife Res*earch 19:38-41.

Simpson, C.D. (1973) Tooth replacement, growth and ageing criteria for the Zambezi bushbuck (*Tragelaphus scriptus ornatus* Pocock). *Arnoldia* 6(6): 1-31.

Simpson, C.D. (1974a) Habitat preference and seasonal movement in the Chobe bushbuck (*Tragelaphus scriptus ornatus* Pocock, 1900). *Arnoldia* 6(31): 1-7.

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

Simpson, C.D. (1974c) *Ecology of the Zambezi valley bushbuck (Tragelaphus scriptus ornatus Pocock).* PhD. Thesis, Texas A & M University.

Skead, C.J. (1987) *Historical mammal incidence in the Cape Province, Volume 2: The eastern half of the Cape Province, including the Ciskei, Transkei and Griqualand.* The Chief Directorate Nature and Environmental Conservation of the Cape of Good Hope. Cape Town, R.S.A.

Skinner, J.D. and Smithers, R.H.N. (1990) *The Mammals of the Southern African Subregion* (2nd edition). University of Pretoria.

Smithers, R.H.N. (1966) *The mammals of Rhodesia, Zambia and Malawi.* London: Collins.

Smithers, R.H.N. (1983) *The mammals of the Southern African Subregion.* Pretoria: University of Pretoria.

Smithers, R.H.N. and Tello, J.L.P.L. (1976). *Check List and Atlas of the mammals of Mocambique*. Museum Memoir No.8. Salisbury: Trustees of the National Museums and Monuments of Rhodesia.

Smits, C.M.M. (1985) Diet composition and habitat use of the West African bushbuck (*Tragelaphus scriptus scriptus* (Pallas 1776)) during the first half of the dry season. *South African Journal of Zoology* 1986,21: 89-94.

Thomson, G.R. (1972) The distribution and habitat preference of bushbuck (*Tragelaphus scriptus ornatus*) within the Victoria Falls National Park. Certificate in Field Ecology,University of Rhodesia, Salisbury.

Tredger, N.M. and Jacobs, D.L. (1998) Proposed nyala (*Tragelaphus angasi*) introduction at Shongweni Resources Reserve. Unpublished document.

Van Rooyen, A.F. (1992) Diets of impala and nyala in two game reserves in Natal, South Africa. *South African Journal of Wildilife Resarch* 22(4): 98-101.

Voeten, M.M. and Prins, H.H.T. (1999) Resource partitioning between sympatric wild and domestic herbivores in the Tarangire region of Tanzania. *Oecologia* 120: 287-294

Von Ketelhodt, H.F. (1976) Observations of the lambing interval of the Cape bushbuck, *Tragelaphus scriptus sylvaticus. Zoologica Africana* 11: 221-225.

Walker, C. (1996) *Signs of the Wild.* Struik Publishers, Cape Town.

Walker, E.P. (1975) *Mammals of the World*, Vol. 2. 3rd edition. Baltimore: John Hopkins.

Waser, P. (1975a) Diurnal and nocturnal strategies of the bushbuck (*Tragelaphus scriptus* (Pallas)). *East African Wildlife Journal*- 13: 49-63.

Waser, P. (1975b) Spatial associations and social interactions in a "solitary" ungulate: the bushbuck (*Tragelaphus scriptus* (Pallas)). *Zeitschrift fur Tierpsychologie*: 37(4): 24-36.

Wildlife Society (1968) A report on the Shongweni Dam area. Project report by the Natal fieldwork section of the Wildlife Protection and Conservation Society. P.O Box 2985, Durban.

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

CHAPTER 2

A telemetry based study of bushbuck (*Tragelaphus scriptus*) home range in Valley Bushveld

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Abstract

With the aid of radio telemetry, bushbuck home range was investigated to determine total home range size, home range utilisation and home range overlap for the summer season. Estimates of total home range size for males using minimum convex polygons (MCPs) and fixed kernels (FKs) were 33.9 ha and 32.1 ha respectively. Estimates of total home range size for females using MCPs and FKs were 12.0 ha and 13.5 ha respectively. A significant difference between total home range sizes for gender (male and female) was found but there was no significant difference for age (adult and sub adult). Female bushbuck home range size was compared to that expected from the published allometric relationship for the scaling of home range area on body mass, where the study animals appeared to have home ranges of half to that predicted.
Bushbuck typically utilised one core area within their home ranges in which 50 % of their time was spent in approximately 17 % and 11.7 % of their total home range for males and females respectively. A substantial overlap in total home range and core areas between animals was found.

Key words: Bushbuck, telemetry, total home range, body mass, utilisation, overlap, minimum convex polygons, fixed kernels

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INTRODUCTION

Bushbuck *Tragelaphus scriptus* are one of the better researched African antelopes with a number of studies having included behaviour, habitat preference, dietary habits and social organisation (Simpson, 1973; Jacobsen, 1974; Odendaal, 1977; Allen-Rowlandson, 1986; Simbotwe & Sichone, 1989; MacLeod, 1992; Haschick, 1994; Seymour, 2002). Three sub-species have been recorded in southern Africa, of which the Cape bushbuck *T. s. sylvaticus* occurs in KwaZulu-Natal, South Africa (Rowe-Rowe, 1994). All three sub-species are similar in habit and are therefore collectively referred to as bushbuck, distinguished only in the colour and pattern variations that occur locally in parts of its widespread distribution (Skinner & Smithers, 1990).

Bushbuck are medium-sized antelope that are secretive, largely solitary and nocturnal showing preference for dense vegetation and feeding almost exclusively from browsable material (Rowe-Rowe, 1994). However, few studies have documented their patterns of spatial utilisation with early studies being based on opportunistic sightings (Jacobsen, 1974; Waser, 1975; Allsopp, 1978) and may therefore have been somewhat speculative. Animals that are secretive, solitary, nocturnal and inhabit dense vegetation present obvious difficulties for determining spatial utilisation patterns by opportunistic sightings (Anderson, 1978; Owen-Smith, 1984; Allen-Rowlandson, 1986) and comprehensive studies of bushbuck spatial utilisation did not occur until the age of radio telemetry. Two telemetry based studies of bushbuck have been conducted, however, both were based mainly in commercial timber plantations (Odendaal & Bigalke, 1979; Allen-Rowlandson, 1986). The methods of analysing spatial utilisation have also advanced considerably since these studies and the present computer based modelling estimation methods provide statistical analyses and have the potential to be far more comprehensive than the commonly used, non-statistical minimum convex polygon method (Mohr 1947). The latter was utilised by the previous authors but has many faults (Jenrich & Turner, 1969; Anderson, 1982; Bowland, 1990; Thouless, 1996; Heath and Coulson, 1997; Njiforti & Kortekaas, 1998; Taylor and Skinner, 2003). Du Toit (1990) has also shown that a relationship exists between home range size and body mass for adult female African browsing ruminants. This study was therefore undertaken to determine bushbuck home range size, utilisation and overlap in their natural valley bushveld habitat. It was expected that female bushbuck would have home ranges similar to that predicted for body size, and that all study animals would utilise some parts of their home range more than others, as well as display a high degree of home range overlap between gender and age.

MATERIALS AND METHODS

Study area

Shongweni Dam and Game Reserve (SDGR) is situated between Durban and Pietermaritzburg in KwaZulu Natal, South Africa (29° 51'S and 30° 43' E). The reserve is managed by Msinsi Holdings (Pty) Ltd, a private conservation management company working with the landowners Umgeni Water. This study was done in an area of approximately 800ha of the reserve, excluding the wilderness area and the area below the dam wall. A number of game species have been introduced to the reserve except bushbuck, duiker and various small nocturnal predators that were already naturally established and occurred in fair abundances (Tredger & Jacobs, 1998). The reserve experiences a mean annual precipitation of 703mm, most falling during the summer months, while mean annual maximum and minimum temperatures range from 28°C in February to 6,5°C in June/July respectively (Patrick, 1998). The reserve falls within the Savanna Biome (Rutherford & Westfall, 1994) and contains Acocks' (1988) Valley Bushveld (Veld Type 23) and Coastal Forest and Thornveld (Veld Type 1). Topography is varied from steep cliffs and hills to flat open flood plains.

Capture and telemetry

The capture and collaring of eight bushbuck took place between September - December 2002. Capture methods used were net capture and chemical immobilisation by darting. Captured animals had mensural data recorded (Appendix A) and were fitted with collars containing custom built 2-stage transmitters with an estimated one-year battery life. Collared animals included two adult males (AM1 and AM2), one subadult male (SAM1), two adult females (AF1 and AF2) and three subadult females (SAF1, SAF2 and SAF3). Alinco DJ – X10 wide band receivers with three-element Yagi antennas were used to locate the study animals that were identified according to the unique frequency that their collars emitted. An attempt was made to track the study animals on a 24 hour basis to ensure an accurate representation of their movements. Triangulation (Andreka, 1996) was the only method of tracking that rendered this collection of data possible in terms of time efficiency required to achieve a high frequency of localities. However, the dense nature of the vegetation and the steep topography hampered the accuracy of this method to the extent that the data initially collected using this method was not considered to be usable. The homing in technique (White & Garrott, 1990) therefore had to be adopted, but the time investment required to locate each animal separately only allowed for two locations to be collected for each animal per day. Other authors suggest that bushbuck are mainly nocturnal and mostly active at dusk and dawn (Allen-Rowlandson, 1986; MacLeod, 1992; Haschick, 1994; Walker, 1996), therefore, locations were independently and randomly collected for each animal, one before dawn and another after dusk, for two weeks of every month for the duration of the transmitter life. Further details of capture and telemetry are presented in Appendix B.

Home range analysis

Bushbuck locations were plotted on a digitised aerial photo of the reserve using a Geographical Information System (ArcView® version 3.3, ESRI 1996). Home range was then estimated using the fixed kernel (FK) method (Worton, 1989) and the minimum convex polygon (MCP) method (Mohr, 1947) from the Animal Movement Analysis ArcView® extension (Hooge & Eichenlaub, 1997).

The FK uses a global smoothing factor and produces a non-parametric estimation of a distribution range based on a random sample of point observations (Worton, 1989). The FK estimates are evaluated the same computationally as the harmonic mean method, however the density estimates can take negative values for the latter and estimation is only possible on a finite region of the plane (Reid & Slotow, 2002). This method is based on probability density estimations (Creswell & Smith, 1992) and is useful for estimating the use distribution density (the distribution of an animals position in the plane), as there are no constraints placed on the form of the use distribution (Worton, 1989). Due to occasional excursions made by the animal that are not representative of its true total home range, the FK uses 95 % of locations to estimate total home range thereby eliminating outliers (Reid & Slotow, 2002). The fact that the FK is based on distribution density also enables it to determine home range utilisation (Taylor & Skinner, 2003). This was done using 50 % probability polygons that identified possible bedsites, refuges, and regular food or water sources that provided core areas of frequent utilisation (Bowland, 1990; Mizutani & Jewel, 1998; Broomhall *et al.*, 2003).

Home range estimation using MCPs was done by connecting the outermost points recorded for each animal to create a polygon with the least number of sides possible (Mohr, 1947). The area inside the polygon was then considered to be the home range utilised by the animal. This is the simplest method of home range size estimation and is historically the most widely used method (Southwood, 1966; Allen-Rowlandson, 1986; Bowland, 1990; Avenant & Nel, 1998; Taylor and Skinner, 2003). However, problems associated with this method are numerous in that 100 % of points recorded are usually used and therefore do not provide any indication of home range utilisation and may also include outliers created by occasional excursions made by the animal which do not represent the animals true home range (Thouless, 1996; Njiforti & Kortekaas, 1998). This method may also include large unused areas in the estimate of range size by assuming that the home range shape is convex (Bowland, 1990). It is also influenced by sample size such that the home range estimate increases with increasing sample size (Jenrich & Turner, 1969; Anderson, 1982). Present computer programmes such as the one used in this study provide more accurate and meaningful estimations of home range size and utilisation, therefore, MCPs are not normally the first choice method of most studies done recently. However, it is frequently included as it provides useful comparisons to other studies that have used this method in the past (Bowland, 1990; Heath and Coulson, 1997; Taylor and Skinner, 2003).

A repeated measures analysis of variance (RMANOVA) was performed using a statistics computer package (STATISTICA, Statsoft Inc.) to determine significant differences for all effects with methods as dependent variables and bushbuck age and gender as independent variables. A post hoc Scheffe test was then performed to indicate significance for the main effect of methods.

Bushbuck do not display territoriality (Odendaal, 1977; Allen-Rowlandson 1986) and where radio-collared bushbuck had been caught in close proximity to each other, it was expected that overlaps in home range would occur. Home ranges (with core areas and common reference points) were therefore superimposed to show overlap or segregation (Bowland, 1990).

RESULTS

Home range estimates for the study animals at SDGR as well as the duration of tracking and number of locations collected for each animal are given in Table 2.1. All transmitters failed prematurely resulting in duration of tracking being limited to mainly the summer season, hence, no temporal comparisons could be made. Other telemetry studies have suggested that greater than 30 points are required per animal to estimate home range accurately (Odendaal, 1977; Allen-Rowlandson, 1986, Bowland 1990, Andreka 1996, Taylor & Skinner 2003). This criterion was fulfilled for all 8 radio-collared bushbuck in this study.

Total home range

Mean total home range of radio tracked-bushbuck using 100 % MCPs for males (n = 3) was 33.9 ha (maximum 43.3 ha, minimum 25.2 ha) and females (n = 5) was 12.0 ha (maximum 18.8 ha, minimum 6.3 ha). Mean total home range using 95 % FK for males (n = 3) was 32.1 ha (maximum 50.1 ha, minimum 13.6 ha) and females (n = 5) was 13.5 ha (maximum 23.9 ha, minimum 6.5 ha). The location of bushbuck home ranges relative to each other within the reserve are shown by the 100 % MCPs in Figure 2.1. The results from the RMANOVA for gender and age are given in Table 2.2 and Table 2.3 respectively. There was a significant difference between estimates for gender but no significant difference between the two methods and there was no interaction. No significant differences were found between estimates for age or between the two methods and there was no interaction. The post hoc Scheffe test revealed no significant differences between estimation methods as a main effect for neither gender ($p = 0.942$), nor age ($p = 0.909$).

Home range utilisation

Home range utilisation of radio-tracked bushbuck determined from 50 % FK probability polygons for male and female bushbuck are shown in Figure 2.2 and Figure 2.3 respectively. All bushbuck only utilised 1 core area (50 % probability) throughout their home range except for AM1 which had 4 core areas. Mean percentage of the total home range that was utilised as core areas by females (n = 5) was 17 % (maximum 26 %, minimum 6 %) and by males (n = 3) was 11.7 % (maximum 15 %, minimum 7 %).

Home range overlap

Substantial overlap in total home range and core areas of radio-tracked bushbuck was observed between SAM 1, AF 1 and SAF 3 (Figure 2.4). Overlap in home range was fairly represented by these animals only as the other animals were considered to have displayed little or no overlap as a result of being captured too far apart from each other. However, numerous uncollared bushbuck were also frequently observed within all the study animals' home ranges (Coates pers obs.) which further suggests a substantial overlap in home range between bushbuck at SDGR.

DISCUSSION

Total home range

Other studies of mammal home range using the MCP and FK methods have found the MCP estimates to be consistently smaller than the FK estimates (Taylor & Skinner, 2003). No significant difference was found between the estimates of total home range sizes for bushbuck using the MCP and FK methods during the present study. Estimates of bushbuck total home range sizes using the MCP method are therefore considered to be accurate and comparisons to other studies using the same method can be made.

Other studies of bushbuck total home range size using radio telemetry found much larger sizes when compared to the present study. Odendaal & Bigalke (1979) found the average total home range for bushbuck to be approximately 102 ha while Allen-Rowlandson (1986) found a similar size of approximately 90 ha. Both these studies used MCPs to determine total home range size and when compared to the MCP value for total home ranges for this study, approximately 23 ha, the differences are marked. Earlier studies not based on radio telemetry by Jacobsen (1974), Waser (1975) and Allsopp (1978) suggested average bushbuck total home range size to be 1.5 ha, 20 ha and 5 ha respectively. Wasers' (1985) value of 20 ha is the most similar to this study with the others presenting the other extreme of much smaller total home range sizes.

When female bushbuck home range was compared to the predicted value based on body mass (du Toit 1990), it was found that a mean home range of 12ha at SDGR was almost half of the predicted value for a body mass of 30 kg (average mass of an adult female bushbuck based on available figures from Walker, 1996). The variation in home range of bushbuck from previous studies, the present study, and the predicted value suggest that home range is affected by several factors, possibly aspects such as population density, habitat, method used and sample size.

Odendaal & Bigalke (1979) suggest a negative correlation between the size of bushbuck home ranges and the population density. The bushbuck population density recorded at SDGR during another study (Chapter 4) and Allen-Rowlandsons (1986) study at Weza state forest were included in the correlation proposed by Odendaal & Bigalke (1979) (Figure 2.5). The densities of bushbuck in the previous telemetry studies were much lower than those recorded by Jacobsen (1974), Waser (1975), Allsopp (1978) and the present study. Bushbuck densities and the areas that they occur in can be directly related to the availability of food and cover, and subsequently the prevailing habitat type (Allsopp, 1978). Where the availability of food and cover is higher, the less area they need to search for it. While bushbuck are not territorial (Allen-Rowlandson, 1986), males avoid each other but do tolerate the presence of others allowing for substantial overlap in home range and subsequently the potential for high densities (Jacobsen, 1974). The fact that the two studies that recorded the largest home range sizes (Odendaal & Bigalke, 1979; Allen-Rowlandson, 1986) were conducted in commercial plantations whereas the other three studies (Jacobsen, 1974; Waser, 1975; Allsopp, 1978), including the present study, were conducted in the Savanna Biome region, substantiates this.

Total home range size may vary between genders and age for bushbuck. Male home ranges have been consistently larger than females in other studies (Allsopp, 1978; Odendaal & Bigalke, 1979; Allen-Rowlandson, 1986) and the same was noted during the present study. Differences in home range size between adults and subadults were also noted in previous studies, however, with much less consistency. Allsopp (1978) did not find any difference for age of females but did for males where subadult males had a far larger home range than adults. Odendaal & Bigalke (1979) and Allen-Rowlandson (1986) found the opposite with subadult females having a larger home range than adult females while there were no differences for ages of males. The present study found no significant difference in home range size for age of males or females, however, the home range of the only sub adult male was larger than both of the adult males. This corresponds with Allsopps' (1978) findings who explains this to be a result of females maturing early and the possibility of both adults and subadults being pregnant is high. This would make females in both age categories vulnerable and cause them to remain in a smaller area. Males, however, are responsible for initiating reproduction and seeking out females in oestrous which requires that they cover a larger area. Subadult males wishing to mate need to cover an even larger area as they will most frequently find themselves in competition with the older and stronger animals.

Home range utilisation and overlap

Overlap in home range amongst bushbuck such as that displayed by SAM 1, AF1 and SAF3 in the present study has been documented in all other bushbuck home range studies (Jacobsen, 1974; Waser, 1975; Allsopp, 1978; Odendaal & Bigalke, 1979; Allen-Rowlandson, 1986). What has not been documented previously in any detail is the overlap in home range utilisation. It is apparent from the present study that most bushbuck have one core area where they spend at least 50 % of their time. This area represents approximately 15% of the total home range and is considered to be a bed site or refuge to which the animal returns frequently after being out in search of food or a mate (Bowland, 1990). The overlap in core areas displayed by SAM 1, AF1 and SAF3 in the present study suggest that these animals were spending a large part of their time in close proximity to each other. However, due to tracking constraints, the data collected from the present study does not represent a complete documentation of bushbuck movements as animals could only be tracked twice daily. No random or stratified sampling approach was therefore possible, and the fact that bushbuck are not entirely crepuscular in nature has resulted in a degree of bias.

Radio-collared male bushbuck in the present study were captured too far apart from each other to display any overlap in home range, but it is expected from other studies where male home ranges overlapped extensively (Jacobsen, 1974; Allsopp, 1978; Odendaal & Bigalke, 1979; Allen-Rowlandson, 1986), that the same occurs at SDGR. Non radio-collared males were also frequently observed during routine drives through the reserve within the home ranges and core areas of the males tracked in the present study, which further suggests overlap in total home range area and utilisation by males (Coates pers obs.).

The present study shows that bushbuck core areas were typically not far from permanent water sources and corresponds with suggestions from other authors that bushbuck depend or show preference for areas where water is readily available (Jacobsen, 1974; Walker, 1975; Rautenbach, 1982; Smithers, 1983). Seasonal changes in bushbuck home range and core areas were not determined in the present study as data collection was limited to one season. Odendaal & Bigalke (1979) suggest that bushbuck home range size decreases with increasing rainfall and Allen-Rowlandson (1986) found that while there may be some seasonal change in home range size for bushbuck in timber plantations, the animal remains more or less in the same area. Bushbuck in natural areas are suggested to exhibit little seasonal change in home range, also remaining more or less in the same area even through the worst of droughts (Stevenson-Hamilton, 1947; Jacobsen, 1974; MacLeod, 1992). Routine census drives through the reserve during winter at SDGR, immediately after the completion of the present radio tracking study, revealed an increase in collared and uncollared bushbuck sightings compared to similar census drives conducted during spring and summer (Chapter 4). Increased sightings may have been due to better visibility, however, it is our opinion that bushbuck were concentrating in the riparian areas along permanent rivers and the dam that provided favourable forage and cover (Coates pers obs.). This may have been a shift in core areas only and not necessarily a shift of total home ranges. Similar observation have been made from other bushbuck populations elsewhere (Child, 1968; Jacobsen, 1974; Simbotwe & Sichone, 1989).

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REFERENCES

Acocks, J. (1988). *Veld types of South Africa. Memoirs of the Botanical Survey of South Africa.* Botanical Research Institute.

Allen-Rowlandson, T.S. (1986). *An autecological study of bushbuck and common duiker in relation to forest management.* Unpublished PhD Thesis, University of Natal, Pietermaritzburg.

Allsopp, R. (1978). Social biology of bushbuck, *(Tragelaphus scriptus,* Pallas, 1766) in the Nairobi National Park, Kenya. *East African Wildlife Journal* 16: 153-166.

Anderson, J.L. (1978). *Aspects of the ecology of the nyala (Tragelaphus angasi* Gray, 1849) *in Zululand.* PhD Thesis, London University.

Anderson, I.G. (1982). Mass and body measurements of impala (*Aepyceros melampus*), from a game ranch. *South African Journal of Wildlife Research* 12(2): 76-78.

Andreka, G.E. (1996). *Spatial utilisation, habitat selection and population status of the wild dog (Lycaon pictus) population in Huluhluwe Umfolozi park.* MSc Thesis, University of Natal, Pietermaritzburg.

Avenant, N.L. & Nel, J.A.J. (1998). Home range use, activity and density of the caracal in relation to prey density. *African Journal of Ecology* 36: 347-359.

Bowland, J.M. (1990). *Diet, Home range and movement patterns of serval on farmland in Natal.* MSc. Thesis. University of Natal, Pietermaritzburg.

Broomhall, L.S., Mills, M.G.L & du Toit, J.T. (2003). Home range and habitat use by cheetahs (*Acinonyx jubatus*) in the Kruger National Park. *Journal of Zoology, London* 261: 119-128.

Child, G. (1968). An ecological survey of north-eastern Botswana. FAO Report No. TA 2563. 155pp.

Creswell, E. J. & Smith, G. C. (1992). The effects of temporally autocorrelated data on home range analysis. In: *Wildlife telemetry: remote monitoring and tracking of animals.* Priede, I. & Swift, S. (Eds). Chichester: Ellis Harward.

Du Toit (1990). Home range – body mass relations: field study on African browsing ruminants. *Oecologia* 85: 301-303.

ESRI (1996). *Arcview® GIS: the geographic information system for everyone™*.Environmental Systems Research Institute, Inc., New York.

Haschick, S.L. (1994). *Foraging and digestion by bushbuck (Tragelaphus scriptus) and boergoats (Capra hircus) in captivity.* MSc. Thesis. University of Port Elizabeth.

Heath, M.A. & Coulson, I.M. (1997). Home range size and distribution in a wild population of Cape pangolins, *Manis temminkii*, in north-west Zimbabwe. *African Journal of Ecology* 35: 94-109.

Hooge, P.N. & Eichenlaub, B (1997). Animal Movement Extension to ArcView. Ver. 1.1. Alaska Science Center – Biological Science Office, U.S. Geological Survey, Anchorage, AK, USA.

Jacobsen, N.H.G. (1974). Distribution, home range and behaviour patterns of bushbuck in the Lutope and Sengwe Valleys, Rhodesia. *Journal of southern African Wildlife Management Association* 4(2): 75-93.

Jennrich, R.I. & Turner, F.B. (1969). Measurement of non-circular home range. *Journal of Theoretical Biology* 22: 227-237.

MacLeod, S.B. (1992). *Habitat use and diet of bushbuck in the Alexandria Coastal Reserve.* MSc. Thesis. University of Port Elizabeth.

Mizutani, F. & Jewell, P.A. (1998). Home range and movements of leopards (*Panthera pardus*) on a livestock ranch in Kenya. *Journal of Zoology London* 244: 269-286.

Mohr, C.O. (1947). Table of equivalent populations of North American small mammals. In Avenant, N.L. and Nel, J.A.J. Home-range use, activity, and density of caracal in relation to prey density. *African Journal of Ecology* 36: 347-359.

Njiforti, H.L. & Kortekaas, K.H. (1998). Home range size and dispersion in the helmeted guineafowl (*Numida meleagris galeata* Pallas) of the Waza National Park, Cameroon. *African Journal of Ecology* 36: 295-302.

Odendaal, P.B. (1977). *Some aspects of the ecology of bushbuck (Tragelaphus scriptus, Pallas 1776) in the southern Cape.* MSc Thesis, University of Stellenbosch.

Odendaal, P.B., & Bilgalke, R.C. (1979a). Home range and groupings of bushbuck in the southern Cape. *South African Journal of Wildlife Research* 9: 96-101.

Owen-Smith, N. (1984). Spatial and temporal components of the mating systems of kudu bulls and red deer stags. *Animal Behaviour* 32: 321-332.

Patrick, B.G. (1998). *Open space planning: Integrating Shongweni Resources Reserve with the Umlaas river park and parts of the lower Mlazi catchmment.* MSc thesis, University of Natal, Durban

Rautenbach, I.L. (1982). *Mammals of the Transvaal.* Pretoria: Ecoplan.

Reid, C. & Slotow, R. (2002). Spatial and temporal use by Black rhinos (*Diceros bicornis* L.) in Hluhluwe-Unfolozi Park. Unpublished report. University of Natal, Durban.

Rowe-Rowe, D.T. (1994). *The ungulates of Natal.* Natal Park Board,Pietermaritzburg.

Rutherford, M.C. & Westfall, R.H. (1994). Biomes of southern Africa – an objective categorisation. *Memoirs of the Botanical Survey of South Africa* 63:1-94.

Seymour, G. (2002). Ecological separation of greater kudu, nyala and bushbuck at Londolozi. *CC Africa Ecological Journal* 4: 137-146

Simbotwe, M.P. & Sichone, P.W. (1989). Aspects of the behaviour of bushbuck in the Kafue National Park, Zambia. *South African Journal of Wildlife Research* 19:38-41.

Simpson, C.D. (1973). Tooth replacement, growth and ageing criteria for the Zambezi bushbuck (*Tragelaphus scriptus ornatus* Pocock). *Arnoldia* 6(6): 1-31.

Skinner, J.D. & Smithers, R.H.N. (1990). *The mammals of the Southern African Subregion* (2^{nd} edition). University of Pretoria.

Smithers, R.H.N. (1983). *The mammals of the Southern African Subregion.* Pretoria: University of Pretoria.

Southwood, T.R.E. (1966). *Ecological Methods: With particular reference to the study of insect populations.* Chapman & Hall, London.

Stevenson-Hamilton, J. (1947). *Wildlife in Southern Africa.* Cassell, London.

Taylor, W.A. & Skinner, J.D. (2003). Activity patterns, home ranges and burrow use of aardvarks (*Orycteropus afer)* in the Karoo. *Journal of Zoology London* 261: 291-297.

Thouless, C.R. (1996). Home ranges and social organisation of female elephants in northern Kenya. *African Journal of Ecology* 34: 284-297.

Tredger, N.M. & Jacobs D.L. (1998). Proposed nyala (*Tragelaphus anagsi)* introduction at Shongweni Resources Reserve. Unpublished document.

Verheyen, R. (1955). Contribution a l'ethologie du waterbuck (*Kobus defassa ugandae* Neumann) et de l'antilope harnachee (*Tragelaphus scriptus* Pallas). *Mammalia* 19: 309-319.

Walker, E.P. (1975). *Mammals of the World*, Vol. 2. 3rd edition. Baltimore: John Hopkins.

Walther, F. (1964). Verhaltensstudien an der gattung (*Tragelaphus* de Blainville 1816) in gefangenschaft, unter besonderer beruchsichtigung des sozialverhaltens. *Zeitschrift fur Tierpsychologie* 21(4): 393-467.

Waser, P. (1975b). Spatial associations and social interactions in a "solitary" ungulate: the bushbuck (*Tragelaphus scriptus* (Pallas)). *Zeitschrift fur Tierpsychologie* 37(4): 24-36.

White, G.C. & Garrott, R.A. (1990). *Analysis of wildlife radio-tracking data.* Academic Press, California.

Worton, B.J. (1989). Kernal methods for estimating the utilization distribution in home range studies. *Ecology* 70: 164-168.

Table 2.1 Home range estimations of 8 radio-tracked bushbuck at Shongweni Dam and Game Reserve using the 100% Minimum Convex Polygons (MCP's) and 95% and 50% Fixed Kernels (FK) methods.

Animal No.	Gender	Age Class	Animal code	Date Captured	Last Located	No. of Locations	100% MCP's (ha)	95% FK (ha)	50% FK (ha)
1	Female	Sub adult	SAF 1	04.09.02	17.12.02	32	8.9	6.5	1.7
2	Male	Sub adult	SAM 1	04.09.02	12.02.03	65	43.3	50.1	7.6
3	Female	Adult	AF 1	04.09.02	05.03.03	84	12.5	16.7	2.2
4	Female	Sub adult	SAF 2	04.09.02	27.03.03	88	13.5	12.2	0.7
5	Female	Adult	AF 2	05.09.02	18.03.03	94	6.3	8.1	1.9
6	Female	Sub adult	SAF 3	23.10.02	02.06.03	51	18.8	23.9	3.8
7	Male	Adult	AM 1	04.12.02	17.06.03	76	33.3	32.7	4.2
8	Male	Adult	AM 2	04.12.02	23.06.03	77	25.2	13.6	1.0

Table 2.2 Results of RMANOVA comparing the total home range estimations for radio-tracked bushbuck genders using two estimation methods. Home range estimation methods used were 100% Minimum Convex Polygons and 95% Fixed Kernels.

Source of Variation	d.f. Effect	MS Effect	d.f. Error	MS Error	*F*	*P*
Gender	1	1544.323	6	168.782	9.149	0.023*
Method	1	0.096	6	17.902	0.005	0.944
Gender x method	1	10.086	6	17.563	0.563	0.481

* indicates significant difference ($p < 0.05$)

Table 2.3 RMANOVA results comparing total home range estimation for radio-tracked bushbuck ages using two estimation methods. Home range estimation methods used were 100% Minimum Convex Polygons and 95% Fixed Kernels.

Source of Variation	d.f. Effect	MS Effect	d.f. Error	MS Error	*F*	*P*
Age	1	51.840	6	417.528	0.124	0.737
Method	1	0.250	6	17.423	0.014	0.909
Age x method	1	12.960	6	17.423	0.744	0.421

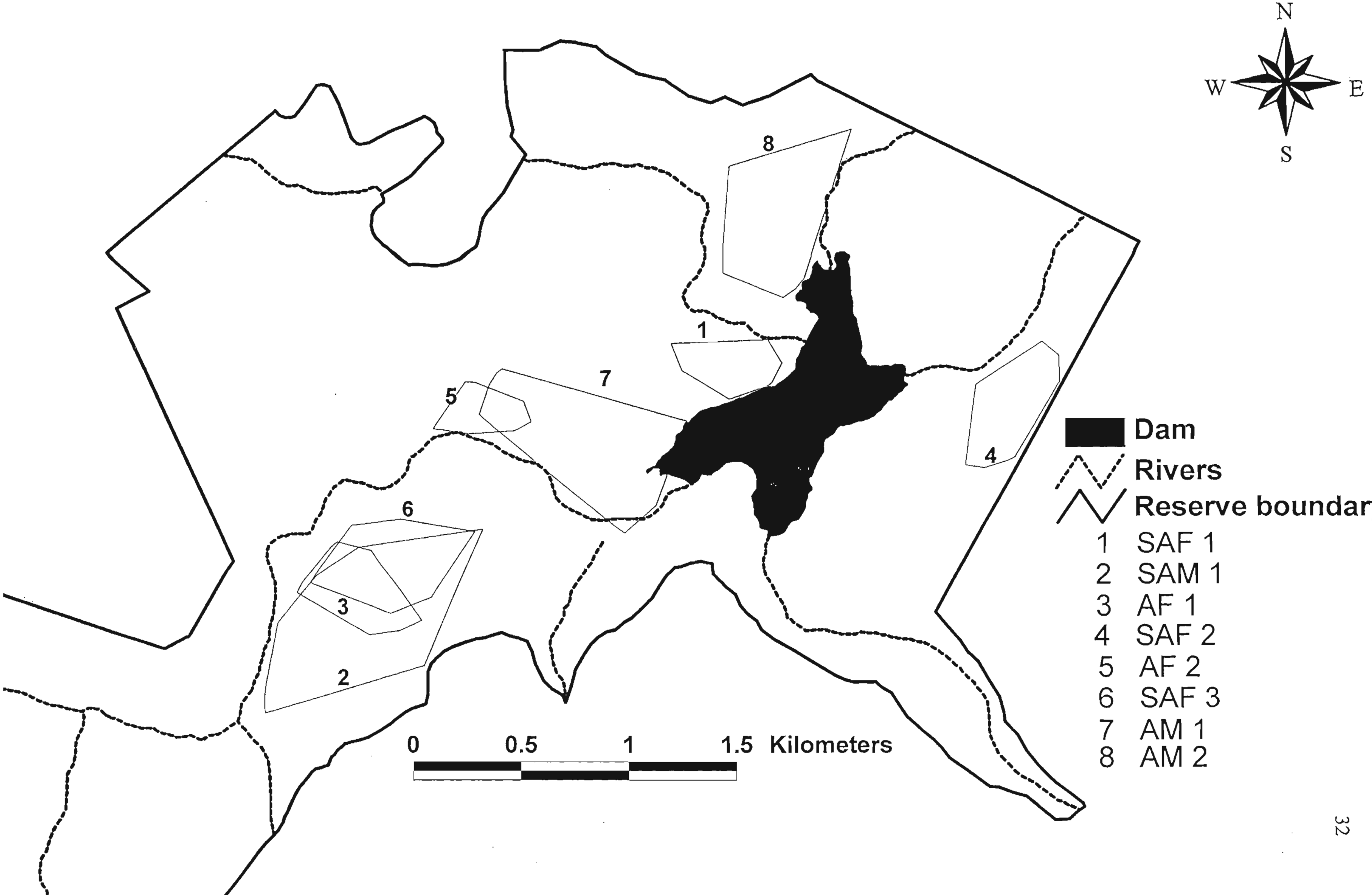

Figure 2.1 Estimation of bushbuck total home range size using 100% Minimum Convex Polygons

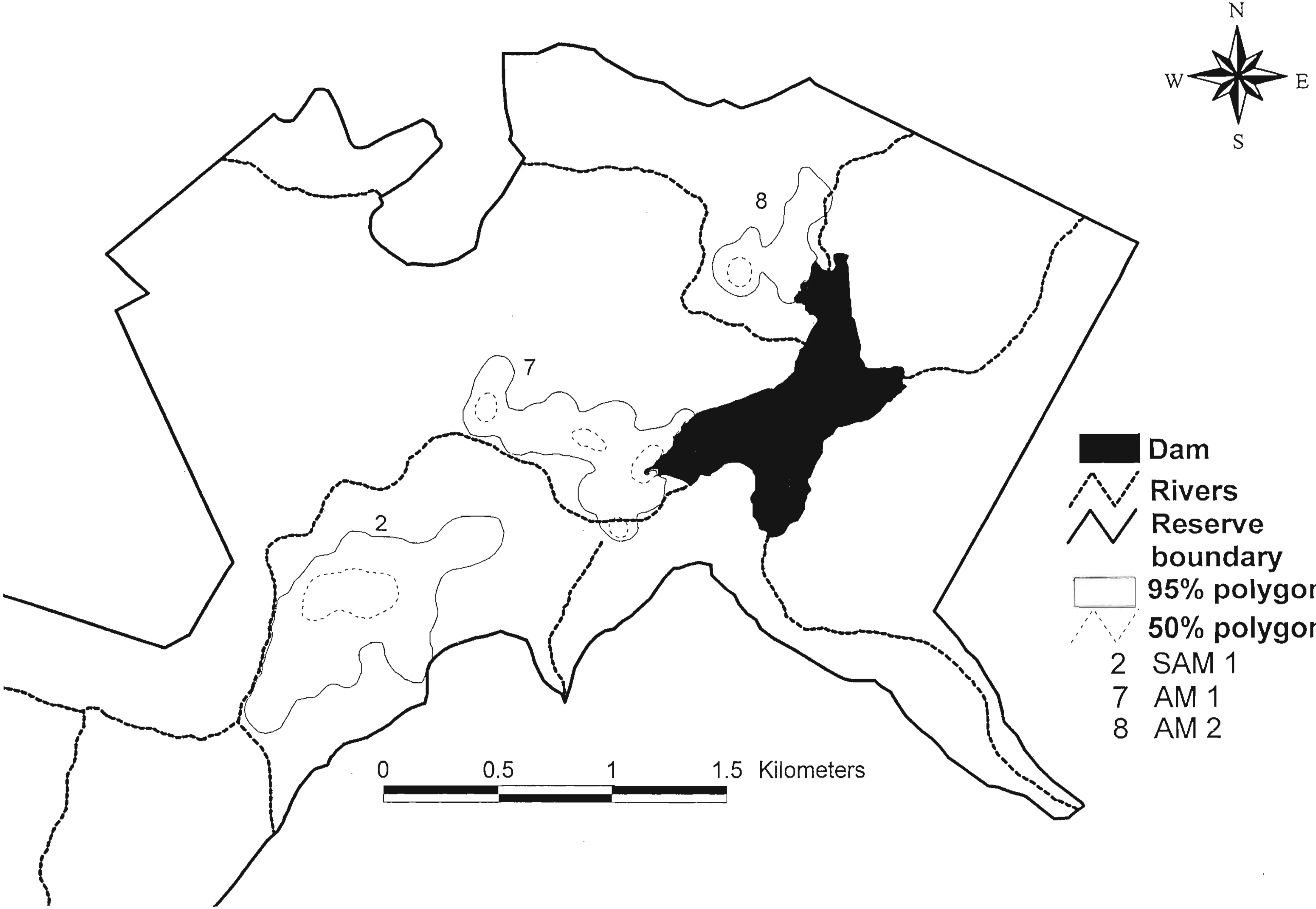

Figure 2.2 Estimation of male bushbuck home range size and utilisation using 95% and 50% Fixed Kernel probability polygons

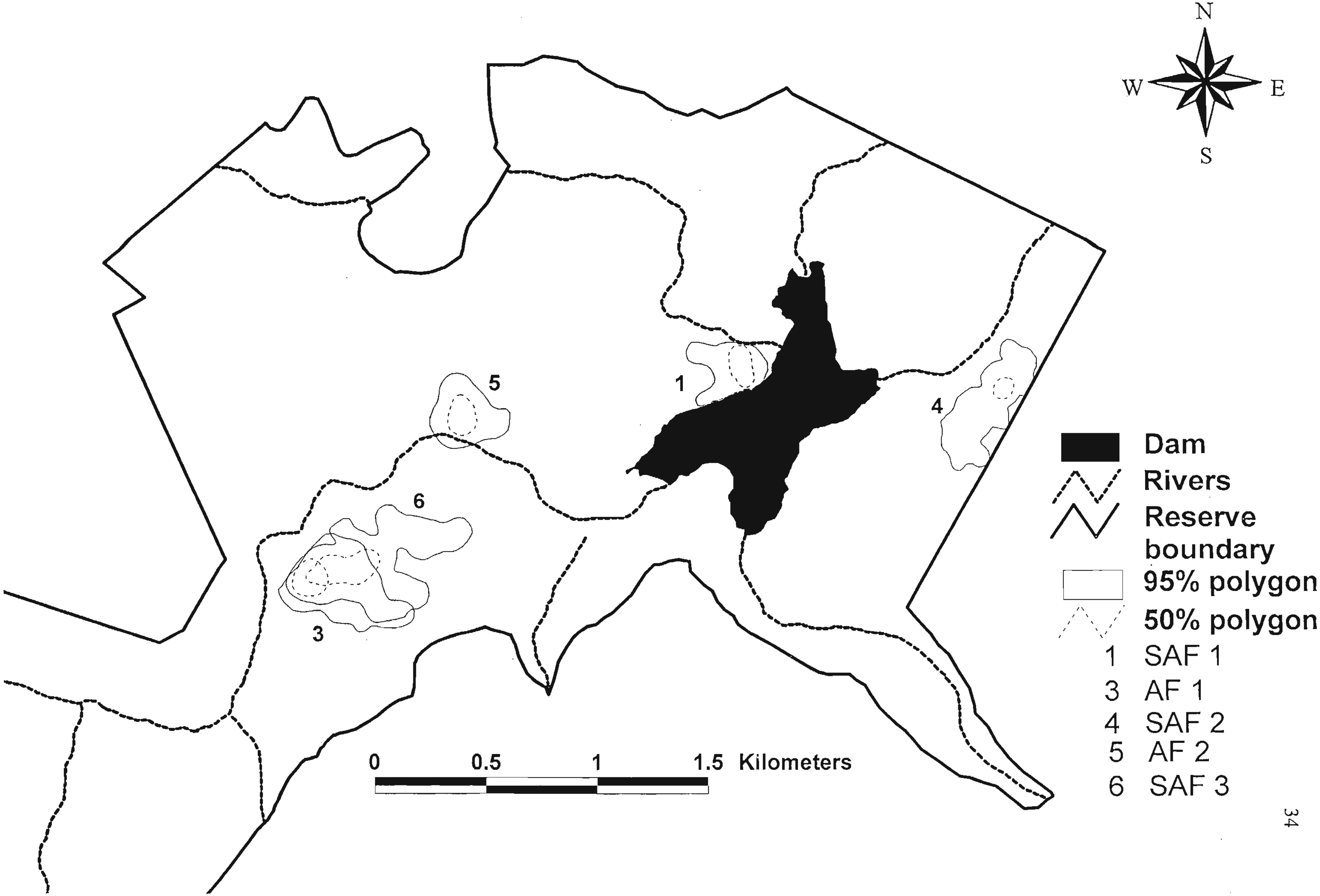

Figure 2.3 Estimation of female bushbuck home range size and utilisation using 95% and 50% Fixed Kernel probability polygons

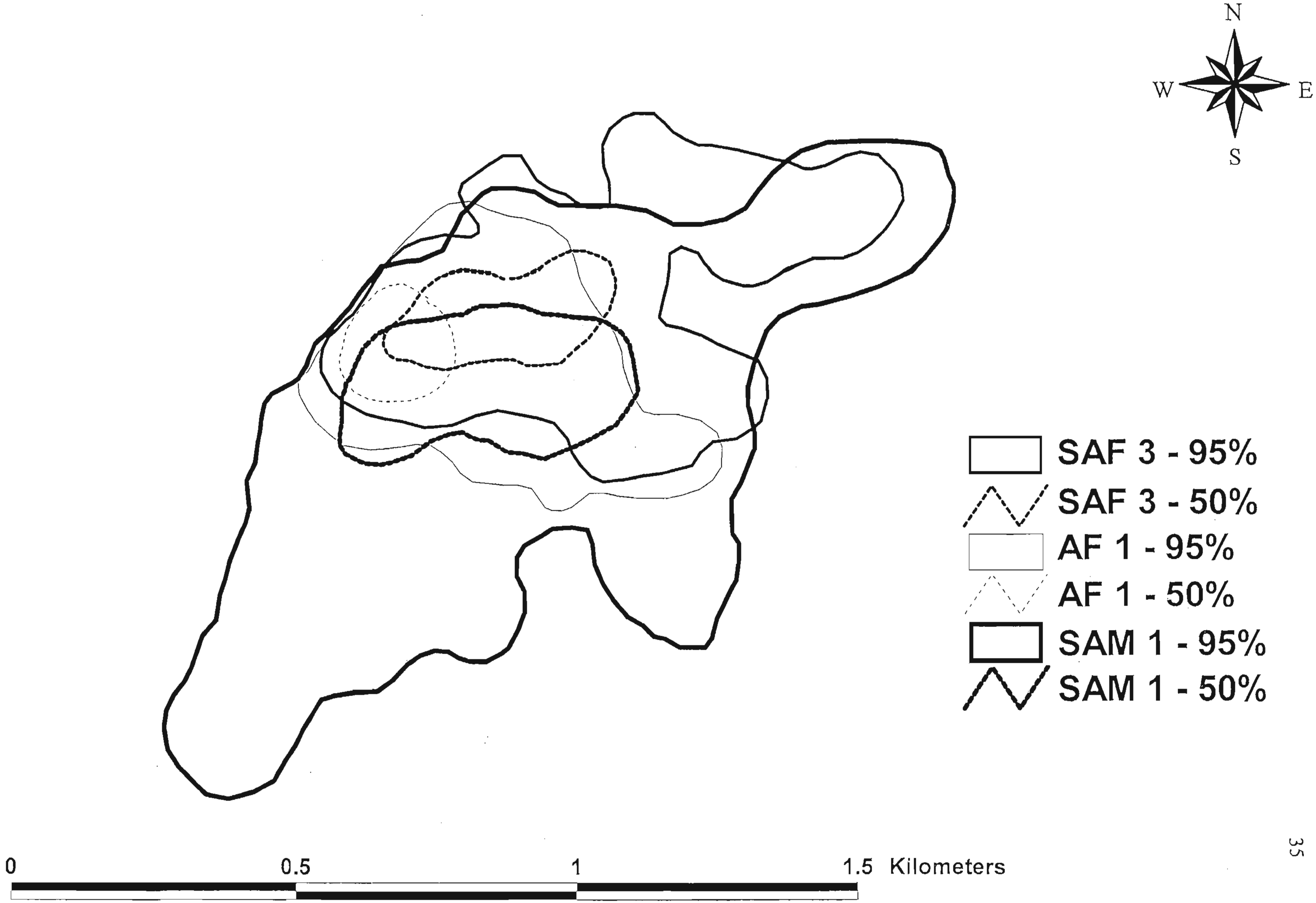

Figure 2.4 Overlap of total and core home range areas for 3 bushbuck (SAF 3, AF1 and SAM 1).

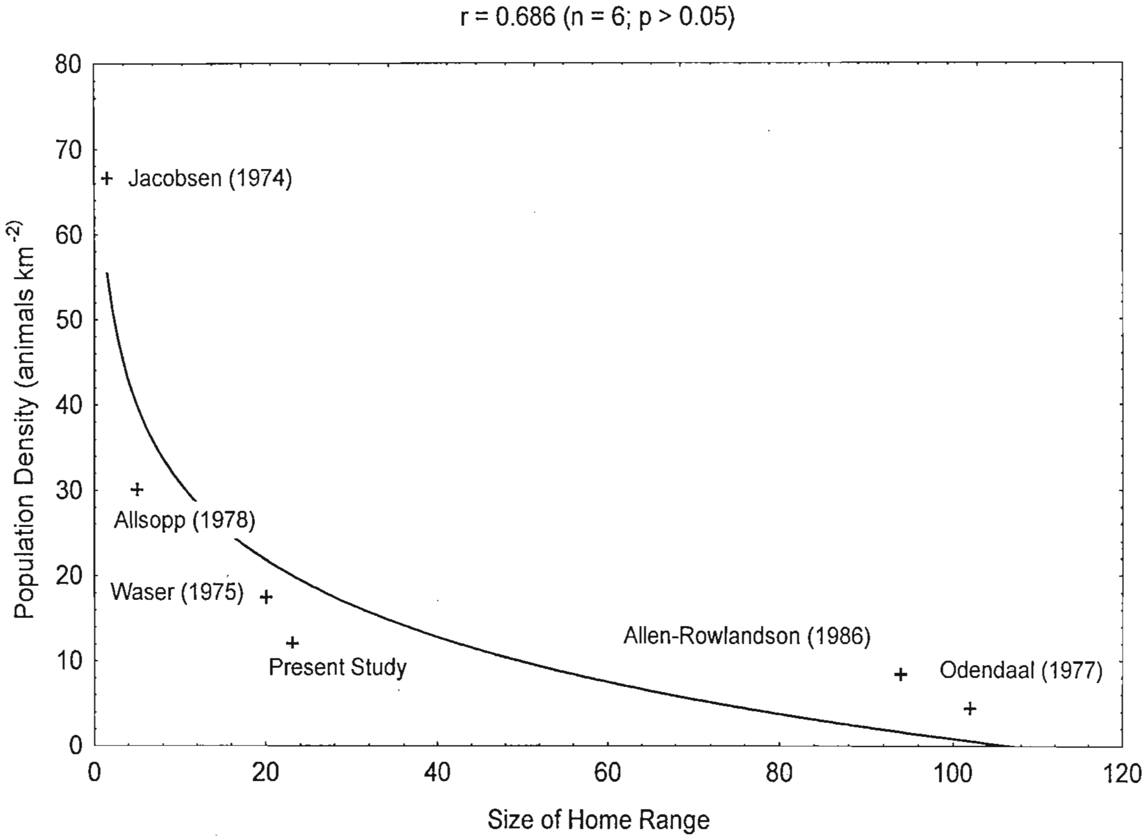

Figure 2.5: Multiple regression showing a negative correlation between the size of bushbuck home range and population densities (After Odendaal & Bigalke, 1979).

The 4 studies represented on the left of the regression were conducted in natural bushbuck habitats within the Savanna Biome whereas the 2 studies on the right of the regression were conducted in commercial timber plantations.

CHAPTER 3

Summer utilisation of valley bushveld by bushbuck (*Tragelaphus scriptus*): a telemetry based study

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Abstract

Eight bushbuck were fitted with radio-collars and tracked in their natural valley bushveld habitat for the summer season. Tall Closed Woodlands were not utilised by the study animals but were observed to be utilised by other individuals of the population. The utilisation of high reedbeds in proportion to their availability by bushbuck was unexpected and may have been biased by the high utilisation of this habitat type by one individual. The preference or avoidance of tall closed woodlands and high reedbeds by bushbuck was, therefore, unclear from the present study and needs to be investigated further. Low closed grasslands were avoided, however, they were still considered to be important for bushbuck as they enabled the fringe areas where bushbuck fed nocturnally and they provided some important forb and grass species that may have been utilised by bushbuck. Bushbuck preferred the short thicket habitat types as they provided the necessary canopy and lateral cover that bushbuck required as shelter. These habitat types also comprised of the favourable foraging species that bushbuck have been documented to utilise in other studies. These habitat types were therefore considered to be the most important to the survival of bushbuck at the study site.

Key words: Bushbuck, radio tracking, habitat utilisation

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INTRODUCTION

Bushbuck (*Tragelaphus scriptus*) are one of the most widely distributed antelope species on the African continent (Skinner & Smithers, 1990), and may therefore be expected to utilise a wide variety of habitat types. Although many subspecies occur throughout Africa, numerous studies involving most subspecies have confirmed that they are all similar in habit, especially feeding and habitat preferences (Jacobsen, 1974; Simpson, 1974; Waser, 1975; Evans, 1979; Okiria, 1980; Odendaal, 1983; Smits, 1985; Allen-Rowlandson, 1986; MacLeod, 1992; Seymour, 2002). Bushbuck frequently utilise the fringes of densely vegetated areas and occasionally open areas during their nocturnal activities, however, their strong reliance on thick vegetation for shelter is what largely influences their habitat preference and dependence (Rowe-Rowe, 1994). Vegetation species composition and structure is an important factor in determining food selection and preference of most herbivores (Owen-Smith, 1982; Gordon, 2003), particular highly selective browsers such as bushbuck (Haschick & Kerley, 1997). These factors are also important in determining habitat selection, preference and dependence as the selected habitats need to provide the animal with adequate food, and in the case of bushbuck, adequate shelter on which it depends greatly (Odendaal & Bigalke, 1979; MacLeod *et al.*, 1996).

Bushbuck are resident on many farms and game reserves and are considered to be a valuable species to have on the property (Rowe-Rowe, 1994). Farmers and reserve managers are encouraged to conserve this species because it provides potential ecological and economic benefits. Habitat destruction and modification are the leading causes of bushbuck declines and management plans for this species have been outlined, almost exclusively based on habitat management (Allen-Rowlandson, 1986; Marchant, 1991; Rowe-Rowe, 1994). The nature reserve where the present study was conducted had an abundance of bushbuck and the management of the reserve was in need of a management plan to firstly conserve, and secondly sustainably utilise the bushbuck population. Habitat availability and utilisation by bushbuck was therefore investigated in the present study to assist with the compilation of a species-specific management plan for bushbuck at the study site.

MATERIALS AND METHODS

Study area

The study area comprised approximately 800 ha of the Shongweni Dam and Game Reserve (SDGR) situated 29 km inland from Durban (29°51'S, 30°43'E) in KwaZulu Natal, South Africa. Mean annual maximum and minimum temperature ranges from 28°C in February to 6.5°C in June/July respectively and 80 % of the mean annual precipitation of 703mm falls during the summer months (Patrick, 1998). The reserve falls within the Savanna Biome (Rutherford & Westfall 1994) and contains Acocks' (1988) Valley Bushveld (Veld Type 23) and Coastal Forest and Thornveld (Veld Type 1). Recent vegetation studies by Patrick (1998) provided a comprehensive vegetation analysis and identified 8 plant communities within the study area. These were:

Community 1: *Phragmites mauritianus-Cynodon dactylon* high closed reedbed – dominated by high reed cover with a uniform height of approximately 1.5 m with some forbs and grasses but very few woody species.

Community 2: *Cyperus immensus-Cynodon dactylon* low closed grassland – consisting mostly of grasses and forbs with very few shrubs or trees.

Community 3: *Asystasia gangetica-Dactyloctenium australe* low closed grassland – sparsely vegetated with mainly clumps of grasses and forbs and very few trees or shrubs.

Community 4: *Albizia adianthifolia-Isoglossa sp.* tall closed woodland – dominated by tall trees and shrub understorey with woody species providing substantial cover. Forbs also dominant.

Community 5: *Protorhus longifolia-Panicum maximum* short thicket – dominated by a tree layer with mainly grass understorey. Forbs and shrubs also abundant.

Community 6: *Ehretia rigida-Spirostachys africana* short thicket – similar to community 5 but forbs more abundant than grasses.

Community 7: *Aloe ferox-Aristida junciformis* low closed grassland/low bushland mosaic – mosaic of grassland and bushland dominated by grasses and forbs with a few shrubs and trees.

Community 8: *Chamaecrista mimosoides-Aristida junciformis* low closed grassland – dominated by grasses and forbs with no trees or shrubs.

Habitat availability

Polygon habitat maps of vegetation composition, vegetation structure and topographical aspect for the study area were constructed using a Geographical Information System (GIS) (Arcview® version 3.3, ESRI 1996). Vegetation structure and vegetation composition were determined from an existing vegetation map obtained from a comprehensive vegetation study conducted in the study area by Patrick (1998). Topographical aspect was determined by field observations where the observer visited all accessible areas within the study area and recorded the perpendicular compass bearing for all slopes (Everett, 1991). Topographical aspect of inaccessible areas was determined by remote sensing using digitised 1:5 000 aerial photos. Within each habitat map, habitat types were defined and availability of each habitat type was determined using GIS by estimating the proportion (area in hectares) that each contributed to the total study area.

Habitat utilisation

Habitat utilisation was determined using positional data collected from radio tracking of a representative (random) sample of the bushbuck population. A representative sample is required to be greater than 10 % of the total population (White & Garrott, 1990) and prior population estimates of bushbuck abundance in the study area (Chapter 4) suggested that eight study animals would satisfy this requirement. Eight bushbuck, including two adult males, one sub-adult male, two adult females, and three sub-adult females, were captured using nets and chemical capture by darting between

September and December 2002. Captured animals were fitted with radio collars and tracked for approximately six months each using the 'homing in' method (White & Garrott, 1990). Dense vegetation and steep topography prevented 24 hour trackingLocations were recorded twice daily, at dusk and dawn, to prevent autocorrelation (Taylor & Skinner, 2003).

Premature transmitter failures resulted in a shortened duration of tracking time which prevented a large enough data set from being obtained to determine habitat utilisation for each individual or to investigate seasonal variation. Therefore, locations recorded for all study animals were pooled (n = 567) and habitat utilisation was only determined for the summer season. Locations were overlaid onto each habitat map and classified as to the habitat type in which they occurred which enabled a proportion of time that bushbuck spent in a particular habitat type during this period to be estimated (White & Garrott, 1990).

Habitat preference

A Chi-squared test (χ^2) was performed to test for the goodness of fit of utilised habitat by bushbuck to available habitat types (Neu *et al.*, 1974). This test determines whether there is a significant difference between 'expected' use of habitat types (based on their availability) and observed frequency of usage (Everett, 1991). Two null hypotheses are tested by the χ^2 test, as described by Alldredge & Ratti (1986). H_{01}, in which usage occurs in proportion to availability, considering all habitats types simultaneously, and if H_{01} is rejected by the χ^2 test, then there is an option of testing a second hypothesis using the Bonferroni Z-statistic, H_{02}, that usage occurs in proportion to availability, considering each habitat type separately.

The Bonferroni Z-statistic is a confidence interval technique that determines which habitat types are preferred, and hence, also what habitat types are avoided (Neu *et al.*, 1974, Byers *et al.*, 1984). The simultaneous Bonferroni confidence intervals are calculated using:

$$P_{io} - Z_{\alpha/2k} \, [P_{io} \, (1-P_{io}) \, / \, n]^{1/2} \quad < p < \quad P_{io} + Z_{\alpha/2k} \, [P_{io} \, (1-P_{io}) \, / \, n]^{1/2}$$

Where P_{io} is the observed proportion of usage; $Z_{\alpha/2k}$ is the upper standard normal table value corresponding to a probability tail area of $\alpha/2k$; k is the number of habitat types tested; n is the total number of observations.

If the expected proportion of usage (p_{ie}) does not fall within the interval, it is concluded that the expected and observed utilisation are significantly different. If the expected proportion of usage is greater than the limits of the confidence interval then the habitat type is concluded to be used less than expected by chance and therefore 'avoided'. Conversely, if the expected proportion of usage is smaller than the limits calculated, then it is concluded that it was utilised more than expected by chance and therefore 'preferred' (White & Garrott, 1990; Taolo, 1995).

This statistical test assumes that animals have access to, and the opportunity of being observed, in all the various available habitat types. The applicability of the procedures depends on animals moving independently of each other. The temporal spacing of the observations must also be such that they are not autocorrelated (Byers *et al.*, 1984).

The Z statistic is a normal approximation for a variable that follows a binomial distribution. Therefore, if expected frequency (p_{ie}) is close to 1 or 0, n should be larger to maintain a good approximation. A conservative rule of thumb is if $n \times p_{ie}$ and $n(1 - p_{ie}) > 5$ then sample size is sufficiently large (Everett, 1991). This criterion was fulfilled in this study.

RESULTS

Habitat availability

The availability of each habitat type in the study area at SDGR expressed as a percentage and as the number of hectares contributed to the total study area is given in Table 3.1.

Eight vegetation composition types were identified in the study area (Figure 3.1). Availability varied but comprised mostly of *Protorhus longifolia-Panicum maximum* thickets (35 %) and *Ehretia rigida-Spirostachys africana* thickets (36 %) with the other composition types contributing less than 11 % each.

Four vegetation structure types were identified in the study area (Figure 3.2) where availability was dominated by short thickets (72 %) and low closed grasslands (21 %) with the other two structure types making up the remaining 7 %.

Nine topographical aspect types were identified in the study area (Figure 3.3). East facing slopes (21 %) contributed the most to topographical aspect followed by south facing (15 %) and north facing (14 %) slopes. The other topographical aspect types contributed between 11 % and 5 % each.

Vegetation composition

Only four of the eight available vegetation composition types were utilised by the study animals (Figure 3.1). The χ^2 critical value for vegetation composition utilised by radio-tracked bushbuck was 129.29. The probability of observing such a large χ^2 critical value with 7 degrees of freedom is $p < 0.0005$. Therefore, H_{01}, in which usage occurs in proportion to availability, considering all habitat types simultaneously, was rejected for vegetation composition.

Simultaneous Bonferroni confidence intervals were therefore applied, the results of which are presented in Table 3.2. Of the four vegetation composition types utilised by the study animals, *Phragmites mauritianus-Cynodon dactylon* reedbeds and *Asytasia gangetica-Dactyloctenium australe* grasslands were observed to be utilised in proportion to their availability. H_{02}, that usage occurs in proportion to availability, was therefore accepted for these two vegetation composition types. Observed proportions of utilisation for *Protorhus longifolia-Panicum maximum* thickets and *Ehretia rigida-Spirostachys africana* thickets were significantly different ($P < 0.05$) than expected proportions of utilisation, in which case these two vegetation composition types were both preferred by bushbuck. H_{02}, that usage occurs in proportion to availability, was therefore rejected for these two vegetation composition types and for all other vegetation composition types not utilised.

Vegetation structure

Three of the four available vegetation structure types were utilised by the radio-tracked bushbuck (Figure 3.2). The χ^2 critical value for vegetation structure utilised by the study animals was 107.71. The probability of observing such a large χ^2 critical value with 3 degrees of freedom is $p < 0.0005$. Therefore, H_{01}, in which usage occurs in proportion to availability, considering all habitat types simultaneously, was rejected for vegetation structure.

Simultaneous Bonferroni confidence intervals were therefore applied, the results of which are presented in Table 3.3. Of the three vegetation structure types utilised by the study animals, only high closed reedbeds were observed to be utilised in proportion to their availability. H_{02}, that usage occurs in proportion to availability, was therefore accepted for this vegetation structure type. Observed proportions of utilisation for low closed grasslands and short thickets were significantly different ($P < 0.05$) than expected proportions of utilisation. Low closed grasslands were avoided while short thickets were preferred by bushbuck. H_{02}, that usage occurs in proportion to availability, was therefore rejected for these two vegetation structure types and for the other vegetation structure type (tall closed woodlands) not utilised.

Topographical aspect

All nine available topographical aspect types were utilised by the study animals (Figure 3.3). The χ^2 critical value for topographical aspect utilised by radio-tracked bushbuck was 388.73. The probability of observing such a large χ^2 critical value with 8 degrees of freedom is $p < 0.0005$. Therefore, H_{01}, in which usage occurs in proportion to availability, considering all habitat types simultaneously, was rejected for topographical aspect.

Simultaneous Bonferroni confidence intervals were therefore applied, the results of which are presented in Table 3.4. Of the topographical aspect types utilised by the study animals, only slopes facing south were observed to be utilised in proportion to their availability. H_{02}, that usage occurs in proportion to availability, was therefore accepted for this topographical aspect type. Observed proportions of utilisation for all other topographical aspect types were significantly different ($P < 0.05$) than expected proportions of utilisation. Slopes facing north, north-west and south-east were preferred by bushbuck, whereas, slopes facing east, west, north-east, south-west and flat floodplains were avoided by bushbuck. H_{02}, that usage occurs in proportion to availability, was therefore rejected for these topographical aspect types.

DISCUSSION

Bushbuck habitat preference is determined by their dependence on densely structured vegetation during the day for shelter (Jacobsen, 1974; Odendaal & Bigalke, 1979; Allen-Rowlandson, 1986) and the availability of highly nutritious forage species (Smits, 1985; MacLeod *et al.*, 1996). Where habitat types comprised of species that provided both favourable forage and structured cover in other studies, it has been preferred by bushbuck (Jacobsen, 1974; Allen-Rowlandson, 1986; Simbotwe & Sichone, 1989; MacLeod *et al.*, 1996).

At SDGR, *Protorhus longifolia / Panicum maximum* thickets and *Ehretia rigida / spirostachys africana* thickets provided favourable canopy and lateral cover. These thickets also have favourable browse species such as *Capparis tomentosa, Ziziphus mucronata, Grewia occidentalis, Combretum sp.*, *Rhoicissus sp.* and *Euclea sp.* (Patrick, 1998; Coates pers obs.). It was therefore expected that bushbuck would show preference for these habitat types with regards to vegetation composition and vegetation structure. This preference was observed suggesting a degree of dependence on these habitat types and also their importance for bushbuck management at SDGR.

The vegetation types that were characterised by low vegetation, namely grasslands, were avoided in terms of the amount of time that bushbuck spent in these vegetation composition and structure types. This was expected as the same has been observed in other studies of bushbuck habitat utilisation (Jacobsen, 1974; Allen-Rowlandson, 1986; Simbotwe & Sichone, 1989; MacLeod *et al.*, 1996). However, this is suggested to be no indication of the importance of these grasslands to bushbuck at SDGR. Bushbuck typically feed on dicotyledonous material within the fringe areas characteristic between thick vegetation and open grasslands, and sometimes venture into these open grasslands to feed on forb species which can make up a large proportion of the diet (Jacobsen, 1974; Smits, 1985; MacLeod *et al.*, 1996; Patrick 1998; Coates pers obs.). Occasional ingestion of nutritious grass species by bushbuck has been recorded (Odendaal, 1983; Rowe-Rowe 1994) of which *Cynodon dactylon, Panicum maximum* and *Dactyloctenium australe* are present at SDGR (Patrick 1998) and may be of importance to bushbuck.

The *Albizia adianthifolia / Isoglossa sp.* tall closed woodland vegetation type was not utilised by the radio-collared bushbuck in this study. However, this is more than likely due to most of the collared animals not being captured in close proximity to this vegetation type and its low availability (1 %). This vegetation composition and structure type appears to provide adequate cover and food for bushbuck (Patrick, 1998) and other individuals not collared were occasionally observed in this vegetation type during routine drives through the reserve for population estimation (Coates pers obs, Chapter 4). Bushbuck therefore do utilise this vegetation type at SDGR but it is not known whether or not they prefer or avoid it.

Perhaps unexpected, was the bushbuck utilisation of the vegetation type *Phragmites mauritianus / Cynodon dactylon* high reedbeds. In particularly an adult male spent a substantial amount of time in this vegetation type. The high reedbeds contribute a fairly small amount to available habitat (6 %) and the high utilisation by the one male of this section may not be representative of the entire population. Other bushbuck, including two with radio collars, were occasionally observed in this structure type during routine drives through the reserve (Chapter 4), however, the conclusion that bushbuck utilise this structure type according to its availability may not be accurate. Only Jacobsen (1974) recorded bushbuck utilising areas of tall grasses and reeds (1.2 m – 2.5 m). Bushbuck preference and dependence on them is therefore unknown. The high reedbed vegetation type at SDGR does, however, appear to provide adequate cover to conceal a bushbuck (Coates pers obs.) and species such as *Cynodon dactylon* utilised as forage by bushbuck in other studies are also common in this habitat type (Patrick, 1998).

Bushbuck utilisation of topographical aspect has not been documented before, although, it has been suggested that they are indifferent to slope or aspect (Skinner & Smithers, 1990; Rowe-Rowe, 1994). Some animals prefer slopes that are warmer (Everett, 1991) or that have a particular type of vegetation (Taolo, 1995). All the slopes found to be preferred by bushbuck in this study were mostly vegetated with the short thicket vegetation composition and structure types whereas the slopes that were avoided (including flat floodplains) were mostly vegetated with low closed grasslands or high reedbeds (Coates pers obs.). The type of vegetation that was found on each slope is therefore considered to have largely determined utilisation of topographical aspect by bushbuck in the present study.

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REFERENCES

Acocks, J. (1988). *Veld types of South Africa. Memoirs of the Botanical Survey of South Africa.* Botanical Research Institute.

Alldredge, J.R. & Ratti (1986). Comparison of some statistical techniques for analysis of resource selection. *Journal of Wildlife Management* 50 (1): 157-165.

Allen-Rowlandson, T.S. (1986). *An autecological study of bushbuck and common duiker in relation to forest management.* PhD. Thesis, University of Natal, Pietermaritzburg.

Andreka, G.E. (1996). *Spatial utilisation, habitat selection and population status of the wild dog (Lycaon pictus) population in Huluhluwe Umfolozi park.* MSc Thesis, University of Natal, Pietermaritzburg.

Byers, C.R., Steinhorst, R.K. & Krausman, P.R. (1984). Clarification of a technique for analysis of utilization-availability data. *Journal of Wildlife Management.* 48(3): 1050-1503.

ESRI (1996). *Arcview® GIS: the geographic information system for everyone™.* Environmental Systems Research Institute, Inc, New York.

Evans, P.G.H. (1979). Habitat preferences of ungulates in closed savanna of central Africa. *Mammal Review.* 9(1): 19-32.

Everett, P.S. (1991). *The ecology and status of oribi in Natal.* MSc. Thesis. University of Natal, Pietermartzburg.

Gordon, I.J. (2003). Browsing and grazing ruminants: are they different beasts? *Forest Ecology and Management.* 181: 13-21.

Haschick, S.L. & Kerley, G.I.H. (1997). Browse intake rates by bushbuck

(*Tragelaphus scriptus*) and boergoats (*Capra hircus*). *African Journal of Ecology* 35: 146-155.

Jacobsen, N.H.G. (1974). Distribution, home range and behaviour patterns of bushbuck in the Lutope and Sengwe Valleys, Rhodesia. *Journal of southern African Wildlife Management Association* 4(2): 75-93

MacLeod, S.B. (1992). *Habitat use and diet of bushbuck in the Alexandria Coastal Reserve.* MSc. Thesis. University of Port Elizabeth.

MacLeod, S.B., Kerley, G.I.H. & Gaylard, A. (1996). Habitat and diet of bushbuck (*Tragelaphus scriptus*) in the Woody Cape Nature Reserve: observations from faecal analysis. *South African Journal of Wildlife Research* 26(1): 19-25.

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

Odendaal, P.B. (1983). Feeding habits and nutrition of bushbuck in the Knysna forests during winter. *South African Journal of Wildlife Research* 13(2): 27-31.

Odendaal, P.B., & Bilgalke, R.C. (1979). Habitat Selection by bushbuck in a disturbed Environment. *South African Forestry Journal* 108:39-41.

Okiria, R. (1980). Habitat exploitation by the bushbuck in Rwenzori National Park. *African Journal of Ecology.* 18: 11-17.

Owen-Smith, N. (1982). Factors influencing the consumption of plant products by large herbivores. *In: Ecological Studies,* Vol.42: *Ecology of Tropical Savannas,* ed. Huntley, B.J. & Walker, B.H. Pp. 359-404. Berlin: Springer Verlag.

Patrick B.G. (1998). *Open space planning: Integrating Shongweni Resources Reserve with the Umlaas river park and parts of the lower Mlazi catchmment.* MSc Thesis. University of Natal, Durban.

Rowe-Rowe,D.T. (1994). *The ungulates of Natal.* Natal ParksBoard, Pietermaritzburg.

Rutherford, M.C. & Westfall, R.H. (1994).Biomass of southern Africa – an objective categorisation. *Memoirs of the Botanical Survey of South Africa.* 63:1-94.

Simbotwe, M.P., & Sichone, P.W. (1989). Aspects of behaviour of bushbuck in the Kafue National Park, Zambia. *South African Journal of Wildlife Research*19 (1):38-41.

Seymour, G. (2002). Ecological separation of greater kudu, nyala and bushbuck at

Londolozi. *CC Africa Ecological Journal*. 4: 137-146.

Simpson, C.D. (1974). Habitat preference and seasonal movement in the Chobe bushbuck (*Tragelaphus scriptus ornatus* Pocock, 1900). *Arnoldia* 6(31): 1-7.

Skinner, J.D. & Smithers, R.H.N. (1990). *The Mammals of the Southern African Subregion* (2nd edition). University of Pretoria.

Smits, C.M.M. (1985). Diet composition and habitat use of the West African bushbuck (*Tragelaphus scriptus scriptus* (Pallas 1776)) during the first half of the dry season. *South African Journal of Zoology* 1986,21: 89-94.

Taolo, C.L. (1995). *Habitat use and feeding ecology of the roan antelope at Weenen Nature Reserve.* MSc. Thesis. University of Natal.

Taylor, W.A. & Skinner, J.D. (2003). Activity patterns, home ranges and burrow use of aardvarks (*Orycteropus afer)* in the Karoo. *Journal of Zoology, London* 261: 291-297.

Waser, P. (1975). Diurnal and nocturnal strategies of the bushbuck (*Tragelaphus scriptus* (Pallas)). *East African Wildlife Journal.* 13: 49-63.

White, G.C. & Garrott, R.A. (1990). *Analysis of wildlife radio-tracking data.* Academic Press, California.

Table 3.1 Habitat availability in terms of vegetation composition, vegetation structure and topographical aspect within the study area (800 ha) at SDGR.

	Contribution	
Habitat type	%	Ha
Vegetation composition		
Phragmites mauritianus /Cynodon dactylon reedbed	6	48
Cyperus immensus /Cynodon dactylon grassland	1	8
Asytasia gangetica /Dactyloctenium australe grassland	5	40
Albizia adianthifolia /Isoglossa sp woodland	1	8
Protorhus longifolia /Panicum maximum thicket	35	284
Ehretia rigida /Spirostachys africana thicket	36	292
Aloe ferox /Arsitida junciformis grassland	10	72
Chamaescrista mimosoides /Aristida junciformis grassland	6	48
Vegetation structure		
High closed reedbed	6	48
Low closed grassland	21	168
Tall closed woodland	1	8
Short thicket	72	576
Topographical aspect		
North	14	112
East	21	168
South	15	120
West	5	40
Northeast	6	48
Northwest	10	80
Southeast	9	72
Southwest	9	72
Flat floodplains	11	88

Table 3.2 Simultaneous confidence intervals to determine bushbuck utilisation and preference of vegetation composition types at SDGR: p_{io} = observed proportion of usage; p_{ie} = expected proportion of usage. Where p_{io} does not lie within the Bonferroni confidence interval, the expected and actual uses are significantly different.

Vegetation composition	p_{io}	p_{ie}	Bonferroni C I	Conclusion
Phragmites mauritianus / Cynodon dactylon reedbed	0.04	0.06	0.019 < p < 0.065	#
Cyperus immensus / Cynodon dactylon grassland	0	0.01	-	†
Asytasia gangetica / Dactyloctenium australe grassland	0.05	0.05	0.023 < p < 0.073	#
Albizia adianthifolia / Isoglossa sp woodland	0	0.01	-	†
Protorhus longifolia / Panicum maximum thicket	0.44	0.35	0.383 < p < 0.497*	prefer
Ehretia rigida / Spirostachys africana thicket	0.47	0.36	0.412 < p < 0.528*	prefer
Aloe ferox / Arsitida junciformis grassland	0	0.1	-	†
Chamaescrista mimosoides / Aristida junciformis grassland	0	0.06	-	†

Z = 2.7347; n = 567
* indicates a significant difference at $p < 0.05$
# utilised in proportion to availability
† not utilised by study animals

Table 3.3 Simultaneous confidence intervals to determine bushbuck utilisation and preference of vegetation structure types at SDGR: p_{io} = observed proportion of usage; p_{ie} = expected proportion of usage. Where p_{io} does not lie within the Bonferroni confidence interval, the expected and actual uses are significantly different.

Vegetation structure	p_{io}	p_{ie}	Bonferroni C I	Conclusion
High closed reedbed	0.04	0.06	0.019 < p < 0.061	#
Low closed grassland	0.05	0.21	0.027 < p < 0.073*	avoid
Tall closed woodland	0	0.01	-	†
Short thicket	0.91	0.72	0.880 < p < 0.940*	prefer

Z = 2.4981; n = 567
* indicates a significant difference at $p < 0.05$
# utilised in proportion to availability
† not utilised by study animals

Table 3.4 Simultaneous confidence intervals to determine bushbuck utilisation and preference of topographical aspect types at SDGR: p_{io} = observed proportion of usage; p_{ie} = expected proportion of usage. Where p_{io} does not lie within the Bonferroni confidence interval, the expected and actual uses are significantly different.

Aspect	p_{io}	p_{ie}	Bonferroni C I	Conclusion
N	0.26	0.14	$0.209 < p < 0.311$*	prefer
E	0.04	0.21	$0.017 < p < 0.063$*	avoid
S	0.15	0.15	$0.108 < p < 0.192$	#
W	0.01	0.05	$0.000 < p < 0.022$*	avoid
NE	0.02	0.06	$0.004 < p < 0.036$*	avoid
NW	0.24	0.10	$0.190 < p < 0.290$*	prefer
SE	0.18	0.09	$0.135 < p < 0.225$*	prefer
SW	0.04	0.09	$0.017 < p < 0.063$*	avoid
Flat	0.06	0.11	$0.032 < p < 0.088$*	avoid

$Z = 2.7742$; $n = 567$

* indicates a significant difference at $p < 0.05$

utilised in proportion to availability

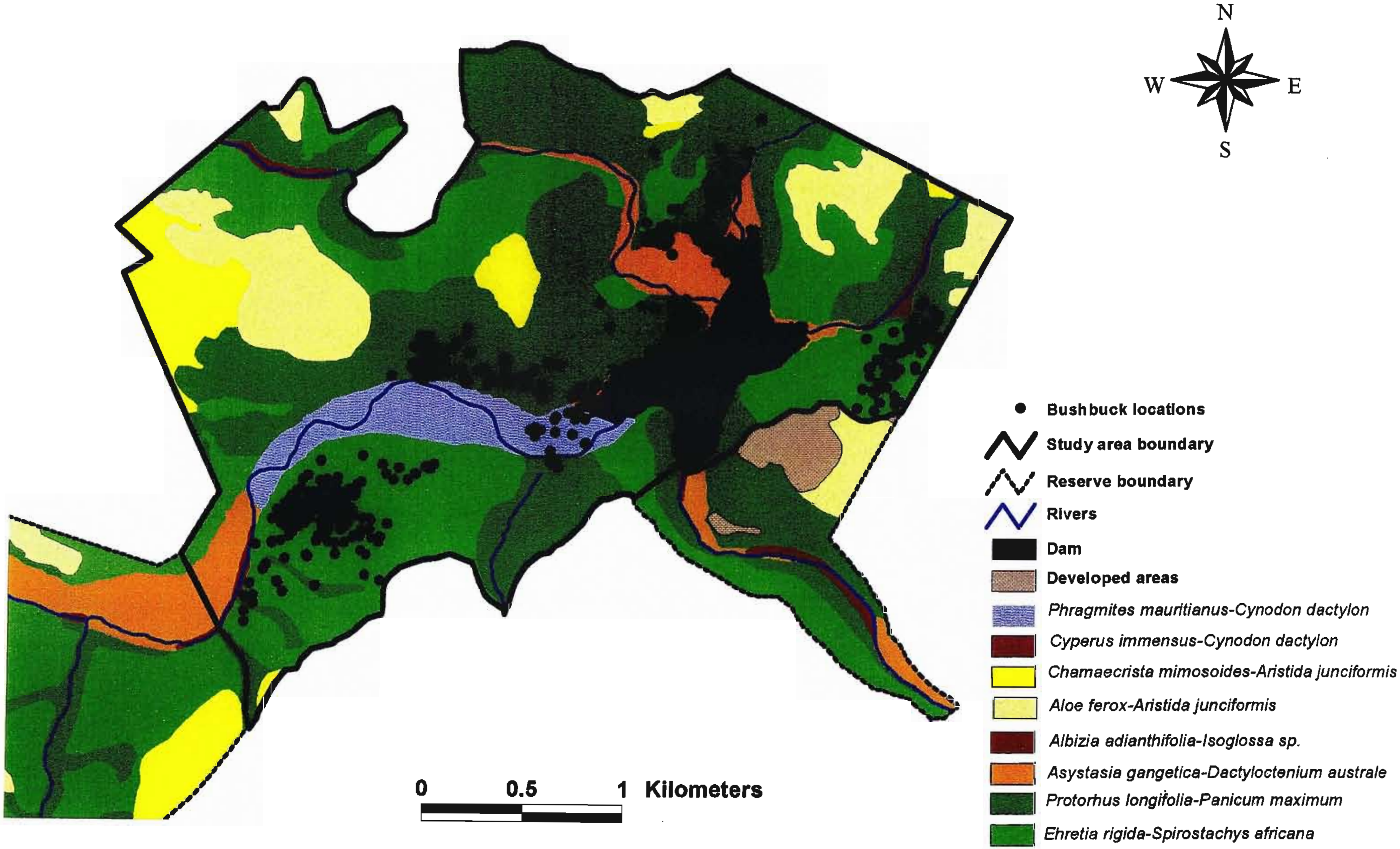

Figure 3.1 Vegetation composition types utilised by radio-collared bushbuck at Shongweni Dam and Game Reserve

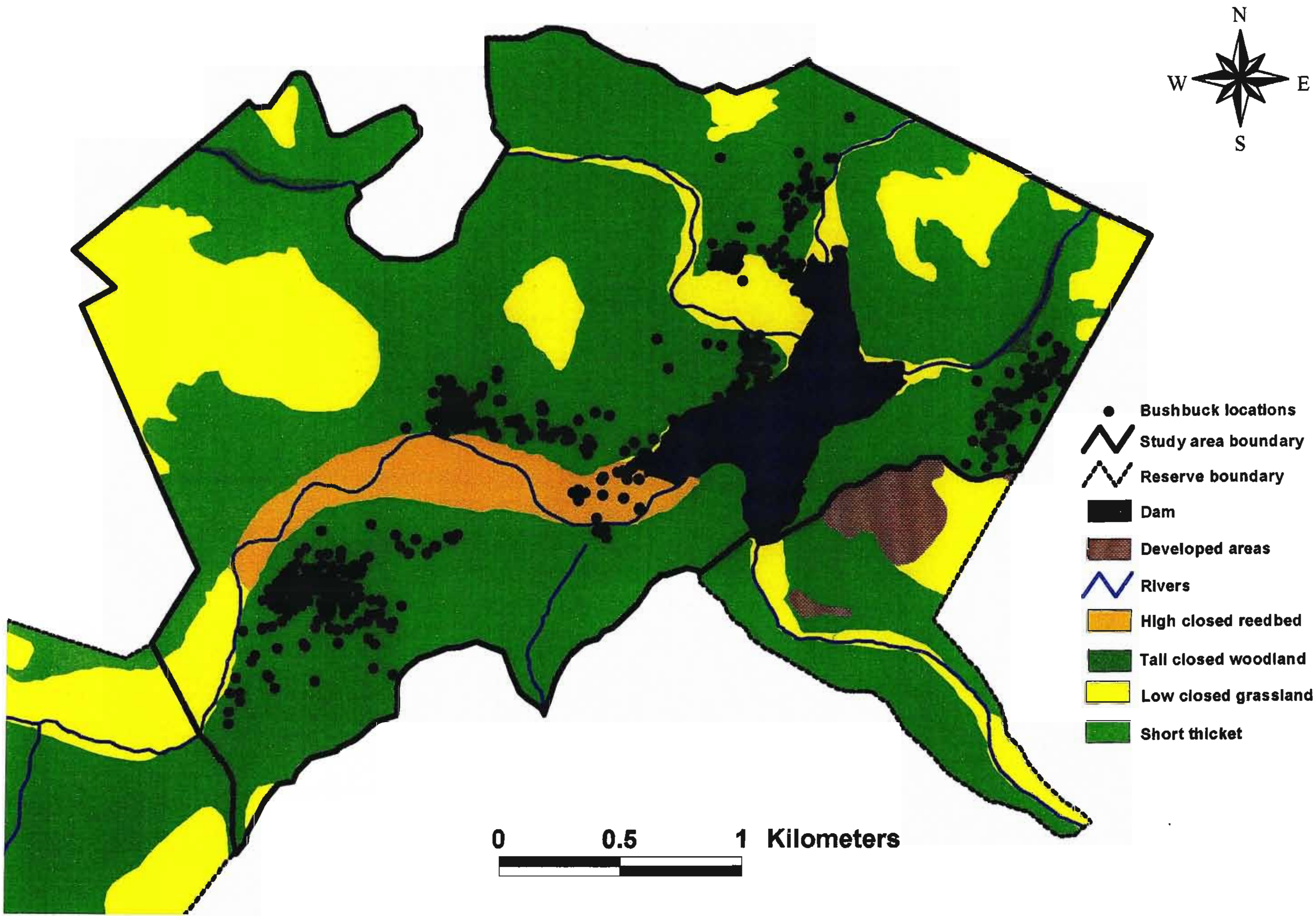

Figure 3.2 Vegetation structure types utilised by radio-collared bushbuck at Shongweni Dam and Game Reserve

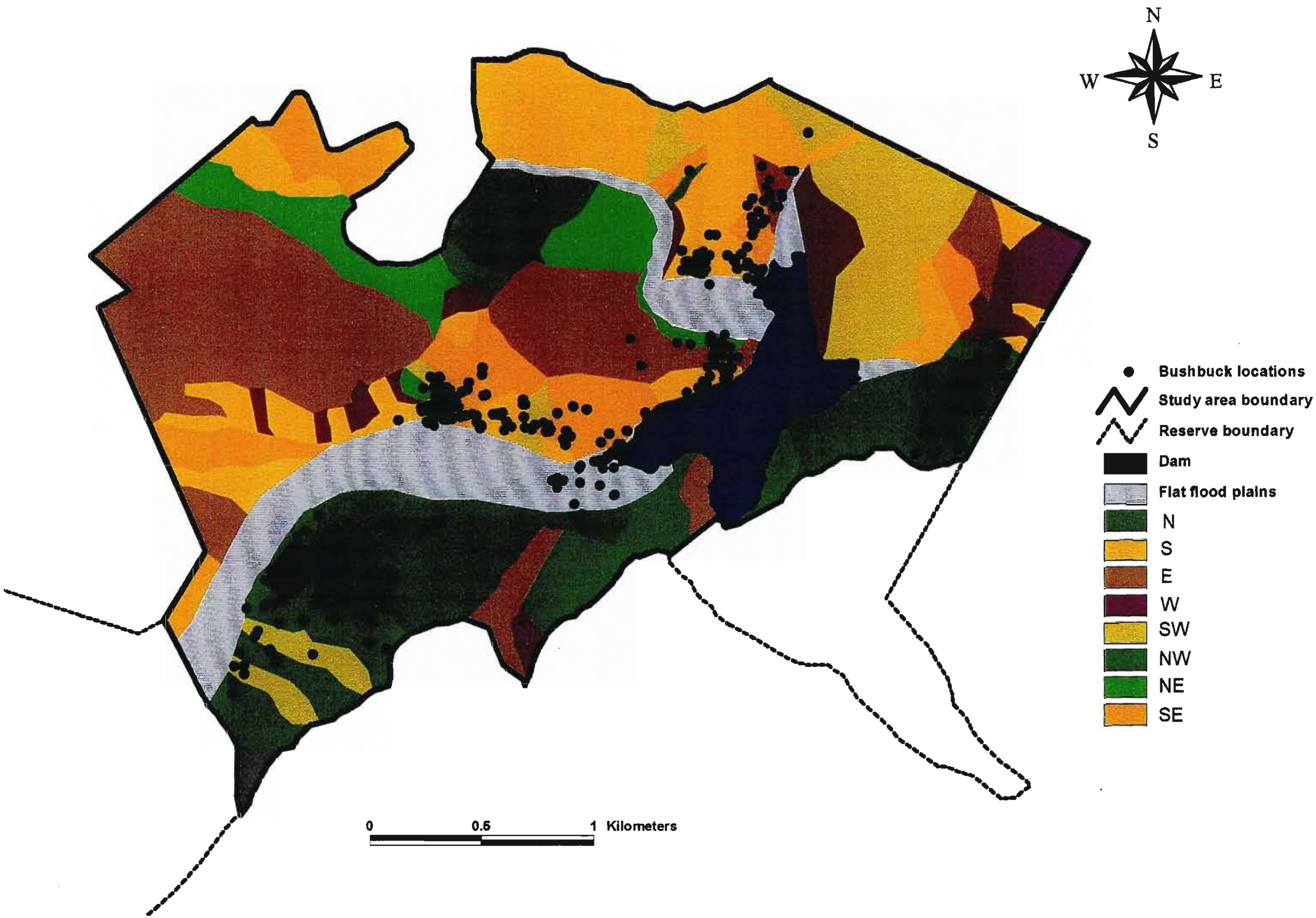

Figure 3.3 Topographical aspect types utilised by radio-collared bushbuck at Shongweni Dam and Game Reserve

CHAPTER 4

POPULATION ESTIMATION AND BEHAVIOUR OF BUSHBUCK (*TRAGELAPHUS SCRIPTUS*)

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No particular method of estimating bushbuck *Tragelaphus scriptus* density and abundance has been found to be accurate in past studies or in the present study. This was because bushbuck are usually nocturnal, solitary, secretive and inhabit thick bush which makes this species difficult to enumerate accurately. The present study assessed simulated drive counts, distance sampling from sighting efforts, and mark-resighting for management purposes. Sighting efforts using distance sampling during spring were found to be the most effective in terms of accuracy and pecuniary costs for estimating bushbuck density and abundance at Shongweni Dam and Game Reserve (SDGR). However, these were still not considered to be precise estimations of the total bushbuck population at SDGR, but would be useful for monitoring population trends as a result of the high repeatability and simplicity of the method.

Population structure was also identified as a corollary for effective management of the population. The field classification method of age and sex ratio determination used during the present study was found to be very subjective and was therefore suggested to have produced ratios that may be largely biased towards the female component of the population. This in turn also effected the determination of social organization and was evident when compared to previous studies. Bushbuck activity determined from radio telemetry and sighting efforts produced results that corresponded with all previous studies, showing bushbuck to be largely nocturnal, moving much larger distances at night than during the day, and spending most of their time walking and feeding at night.

Key words: *Tragelaphus scriptus*, population estimation, behaviour.

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The game industry in South Africa has grown extensively in the past decade with millions of hectares of privately owned land previously under beef production being converted back to game (Flack, 2002). This conversion has been driven almost exclusively by the local and overseas demand for hunting of trophy game and biltong production (Eloff, 2002). Hunting of trophy game attracts foreign clients who contribute in bulk to the annual income generated from this sport providing an economic opportunity for many private landowners. Economic opportunities are increased if the landowner has highly prized trophy species, which has resulted in numerous exotic species being introduced to exploit this economic opportunity (Flack, 2002). One such highly prized trophy is the nyala *Tragelaphus angasi* (Rowe-Rowe, 1994). This antelope is indigenous to some parts of the eastern regions of the country (Skinner & Smithers, 1990), but has been introduced, and continues to be introduced, to many other areas throughout South Africa and beyond its historical distribution. It is therefore considered to be an exotic in these areas (Rowe-Rowe, 1994; Flack, 2002) and has been suggested to compete with naturally occurring species to their detriment. One of these species is the bushbuck *T. scriptus*.

Msinsi Holdings (Pty) Ltd, a private conservation management company, are considering the introduction of nyala to one of its subsidiary nature reserves, Shongweni Dam and Game Reserve (SDGR), which lies beyond the natural distribution of nyala in the KwaZulu-Natal province. This reserve has a natural population of bushbuck and suggestions of localised declines in numbers of this species after nyala introductions elsewhere in the country (Chapter 5) have caused concerns with regard to possibly losing bushbuck from competition with nyala. To aid in decision-making regarding the introduction of nyala, and the compilation of a species-specific management plan for bushbuck, the status of the resident bushbuck population at SDGR and some aspects of their behaviour were investigated.

Aspects of an animal population that define its status, and provide useful knowledge for managers, include estimates of their abundance, density, and descriptions of population structure according to age and sex ratio (Allen-Rowlandson 1986; Marchant 1991). A census is usually done in order to evaluate such aspects of an animal population (Collinson 1985) and can also be useful to determine some aspects of behaviour such as social interaction and activity patterns (van Rooyen 1979).

Various methods have been described for determining density and abundance, age and sex ratio, social organisation and activity patterns of African antelopes (Lamprey 1964; Vincent 1979; van Rooyen; 1979; Collinson 1985; Lawson, 1986; Bowland 1990). A number of these methods have been attempted in many previous studies of bushbuck to determine their population status and behaviour, (Simpson 1973; Jacobsen 1974; Odendaal 1977; Allsopp 1978; Schmidt 1983; Allen-Rowlandson 1986; Simbotwe and Sichone 1989). However, all the previous studies concluded that only few of these methods were applicable to bushbuck as they are usually nocturnal, solitary, secretive, and inhabit thick vegetation. The few methods regarded as satisfactory to gain a fair knowledge of bushbuck population status and behaviour were adopted for the present study and are discussed according to their effectiveness at the study site.

MATERIALS AND METHODS

Study area. – The present study took place at Shongweni Dam and Game Reserve located at 29° 51'S and 30° 43'E in KwaZulu-Natal, South Africa. The intensive study area comprised 800ha of this reserve in the Mlazi river catchment densely vegetated by Coast-Hinterland Bushveld and Valley Bushveld (Low and Rebelo 1996). This area falls within the Savanna bioclimatic region of South Africa (Rutherford and Westfall 1994) and receives a mean annual precipitation of 703 mm with mean annual maximum and minimum temperature ranges of 28°C in summer to 6.5°C in winter respectively (Patrick 1998).

Simulated Drive counts. - Conventional drive counts (Collinson 1985) were not possible to employ during the present study due to the large number of staff required. However, the net capture of bushbuck that took place in spring 2002 for telemetry purposes simulated conventional drive counts and therefore also provided data that could be used for population estimation. Counts were conducted similarly to Schmidt (1983) and Allen-Rowlandson (1986) where a team of approximately 20 beaters was used to drive animals towards a configuration of nets manned by additional observers at 15 m intervals. Labourers were made aware of the criteria inherent for valid estimation using drive counts (Collinson 1985) and all fleeing animals observed (caught and escaped) were recorded by a scribe according to sex and age (adult or juvenile).

Within the study area of 800 ha, only 531 ha was considered to be available/suitable for bushbuck inhabitance at SDGR (Figure 4.1). The conventional drive count method is a total count rather than a sampling method, since by its assumptions it counts the whole population by sampling the entire expanse of available habitat (Bowland 1990). Steep topography and very dense vegetation severely limited accessibility for sampling in the study area at SDGR and the simulated drive counts used in this study only included 75 ha of the total 531 ha of available/suitable bushbuck habitat. Therefore, these counts are considered to be a sample of the total population and the positioning of the counts are shown in Figure 4.1.

Fifteen drives were conducted over 3 days in Spring 2002 with each drive covering an area of approximately 5 ha. All counts were conducted in habitat considered to be available or suitable for bushbuck. Population density was therefore estimated using the equation in Bowland (1990) modified to give density in hectares per animal:

$$\text{Ecological density (ED)} = \frac{\text{total area (ha) covered by drive counts}}{\text{total number of bushbuck sighted}}$$

Habitat utilisation studies (Chapter 3) quantified available/suitable habitat for bushbuck (A) in the study area. This enabled an ecological abundance estimate to be calculated as:

$$\text{Ecological abundance (EA)} = \frac{A}{ED}$$

Sighting efforts. - Accumulative transect counts may be done by either walking transects through the bush or driving along a road in a vehicle representing a census route (Collinson 1985). Bushbuck are primarily nocturnal (Odendaal 1977; Allen-Rowlandson 1986), therefore, counts needed to be done at night. This presented obvious complications for walking transects and so spotlight counts conducted from a vehicle were employed. These spotlight counts represented sighting efforts along a modified strip transect and followed the criteria inherent for valid estimations stated by Collinson (1985). Counts were conducted during spring 2002, summer 2002/3 and winter 2003 with repetitions within each season, and followed Allen-Rowlandson (1986) and Bowland (1990) for specific estimation using King's census equation and the variable width transect equation respectively. These two calculations were chosen as they are the most successful in terms of expenditure and accuracy. They are also similar to the extent that sampling for both calculations can be done simultaneously, thereby reducing sampling effort (Collinson 1985).

A route of 8.3 km was driven along the contour road through the reserve from the main gate to the bush lodge (Figure 4.1). The wilderness area was not included as vehicle accessibility was limited. The counts were made from a 1-ton pick-up truck by an observer and the driver, both equipped with 1 000 000 c.p. Cadac spotlights, who searched for bushbuck on their respective sides of the vehicle. A speed of approximately 5 km/hr was maintained until a bushbuck was spotted. The vehicle was then stopped and the straight-line distance from the vehicle to where the bushbuck was first spotted (King's census) and the perpendicular distance of the bushbuck to the census route (variable width transect) were estimated using a rangefinder and recorded. The presence of a radio-collar on any sighted bushbuck was also noted for the purpose of abundance calculation using a mark-resighting index.

Predetermined perpendicular visibility along the census route was also estimated as a comparison for perpendicular animal sighting distance using the variable width transect method. This was done independently of the sighting efforts described previously and on evenings when sighting efforts were not being undertaken. Similarly to Lawson (1986), a white marker of dimensions 100 cm x 100 cm was placed at 100 m intervals along the entire census route. These markers were receded perpendicularly into the bush on both sides of the route and when it was no longer visible to the observer in the vehicle on the route, this distance was measured to the nearest meter. The average visibility for each side of the road, and subsequently strip width, was then obtained by calculating the mean distances. This was done for each sampling season.

Distance sampling calculations. - The variable width transect equation (Collinson 1985) calculates density and was modified to give density in hectares per animal and for cumulative sighting efforts:

$$D_1 = \frac{k(2L.w)}{n.10\ 000}$$

Where D_1 = density estimate
k = number of sighting efforts
L = length of census route (m)
w = (a) mean perpendicular animal sighting distance for k sighting efforts (m)
or
(b) mean predetermined perpendicular visibility for k sighting efforts (m)
n = number of animals sighted for k number of sighting efforts

As with ecological density, an abundance estimate (N_1) could also be calculated from the variable width transect equation:

$$N_1 = \frac{A}{D_1}$$

King's census equation (King 1975) calculates abundance for a certain area of available/suitable habitat, and was modified to give abundance for cumulative sighting efforts:

$$N_2 = \frac{n.A.10\ 000}{k(2L.D)}$$

Where N_2 = abundance estimate
n = number of animals sighted for k number of sighting efforts
A = area of available/suitable habitat (ha)
k = number of sighting efforts
L = length of census route (m)
D = mean straight-line animal sighting distance for k sighting efforts (m)

Similarly, a second density estimate (D_2) of ha per animal can also be calculated from King's census equation:

$$D_2 = \frac{A}{N_2}$$

Mark-resighting. - Some individuals in the population had been fitted with radio-collars for home range (Chapter 2) and habitat utilisation studies (Chapter 3). These individuals thereby constituted marked individuals in the population providing the opportunity to calculate abundance estimates using mark-resighting indices. Collection of data for this estimation was also possible from the sighting efforts mentioned.

Commonly used mark-resighting indices have been the Jolly-Seber method, Bailey's index, Schnabel's index and the common Lincoln-Peterson estimate (Allen-Rowlandson 1986; White and Garrott 1990; Kenward 2001). The common Lincoln-Peterson estimate derived by Chapman (1951) has been, and is still currently the preferred estimate (Kenward 2001) where:

$$N_i = \frac{(n_I + 1)(n_{ii} + 1)}{(m_{ii} + 1)} - 1$$

Where N_i = abundance estimate
n_I = number of collared animals in population
n_{ii} = number of animals sighted
m_{ii} = number of collared animals sighted

The common Lincoln-Peterson estimate is, however, based only on one survey at a time. Precision of the estimation can be improved by increasing the number of surveys k and by using a combined Lincoln-Peterson estimate. Rice and Harder (1977) successfully used a combined Lincoln-Peterson estimate for calculating abundance of a known, geographically closed (fenced) white tailed deer population based on an unweighted, arithmetic mean from numerous surveys ($k = 5$). This estimator was therefore adopted here where:

$$N_3 = \sum_{i=2}^{k+1} N_i \,/\, k$$

Where N_3 = abundance estimate
N_i = common Lincoln-Peterson estimate
k = number of sighting efforts

As with King's census equation, a third density estimate (D_3) of ha per animal could also be calculated from the result of the combined Lincoln-Peterson estimate:

$$D_3 = \frac{A}{N_3}$$

Bushbuck population structure. – Age determination by field age classification was the only possible method for the present study. Allen-Rowlandson (1986) used this method and visually distinguished between adults, subadults juveniles and infants for female bushbuck by comparing shoulder heights of animals when seen together, and for males by classifying horn length in comparison to ear length. The low sighting frequency of two or more females together during the present study rendered this classification technique largely inadequate, therefore, subadults were included as adults. The sighting frequency of positively identified male bushbuck during this study was also low and the fact that females had not been distinguished between adult and subadult suggested that the same criteria should be applied for males. Similar complications arose when trying to distinguish between juveniles and infants. Therefore, these two age categories were also merged and were recorded as juveniles still accompanied by their mother and with a shoulder height of less than two thirds of that of its mother. Juveniles were not sexed as juvenile males at this age do not have horns yet and are the same colour as females which made it impossible to distinguish between sexes by sighting alone for this age category.

Bushbuck behaviour. - Bushbuck nocturnal activity was recorded during sighting efforts for population estimation where the activity of the animal when first sighted (walking, lying down, feeding) was recorded (Venter 1979). An obvious concern with this method is disturbance of the animals' natural or initial behaviour due to the observers approach (in a vehicle using spotlights during this study). All sightings of fleeing animals were therefore discarded. Those that had obviously been disturbed (standing still with eyes directed straight into the light) but still stood their ground, were observed for a further two minutes by holding the spotlight in such a way that the beam did not shine directly at the animal, but still provided enough light to observe its behaviour. The activity reverted to first by the observed animal was then regarded as the animals initial activity. If the animal fled or failed to revert back to any of the previously mentioned activity categories, it too was eliminated from the data set.

Man-hour *cost for census methods.* - Man-hours required to perform each census method in the field and to input data and calculate estimates were recorded. Labour input was discriminated between semi-skilled (e.g. field rangers and assistants) and skilled (e.g. researchers and wildlife managers) personnel (Bowland 1990).

RESULTS

Simulated drive counts. – Twelve bushbuck were recorded from 15 drives covering an expanse of approximately 75 ha of the 531 ha considered to be available or suitable for bushbuck habitation within the study area.

Sighting efforts. - The number of bushbuck sighted for each sampling season are given in Table 4.1, including the respective sighting distances and re-sightings necessary to calculate each of the estimates. The average number of bushbuck sighted on each sighting effort during spring was 3.9. Summer revealed a similar number of bushbuck sightings at 3.0 per sighting effort, however, winter sightings were much higher at 12.9. Mean animal sighting distances were comparatively shorter in spring and summer than in winter. More re-sightings of marked animals were also recorded in winter than in spring and summer.

Variable bushbuck abundance and density. - Density and abundance estimates of bushbuck calculated for each method for all three sampling periods are given in Table 4.1. Using the statistical computer package STATISTICA (Statsoft Inc. 1998), a repeated measures analysis of variance (RMANOVA) was performed on the four methods used for calculating abundance and density from sighting efforts for all three sampling periods (spring, summer, winter) to investigate any significant differences within these sampling periods. A significant difference was found for abundance (RMANOVA, $F_{(6,66)} = 17.32$, $p < 0.05$) and density estimates (RMANOVA, $F_{(6,66)} = 22.97$, $p < 0.05$). A Post-hoc Scheffe test was then performed to identify which sampling period and which methods differed significantly from each other. Winter abundance and density estimates were shown to be significantly different ($p < 0.05$) to spring and summer estimates. Abundance and density estimates using method N1a (variable width transect method using the mean perpendicular animal sighting distance) were not significantly different ($p > 0.05$) to those calculated using method N1b (variable width transect method using mean predetermined perpendicular visibility). Estimates using N1a and N1b were, however, shown to be significantly different ($p < 0.5$) to estimates calculated using methods N2 (King's census method) and N3 (combined Lincoln-Peterson estimate). Estimates from methods N2 and N3 were also significantly different ($p < 0.05$) to each other. Figure 4.2 and Figure 4.3 also illustrate this variation. The cumulative estimates of abundance in Figure 4.2a reflect minimum sampling effort for each method during each sampling period.

Bushbuck population structure. - Age determination of bushbuck observed from all census methods and all sampling periods are summarised in Table 4.2. Three population ratios were determined from age determination namely sex ratio of adult males to adult females; ratio of adult females to juveniles; and ratio of adults (males and females together) to juveniles. The calculated sex ratio of adult males to adult females was 1 : 3.4. The calculated ratio of juvenile bushbuck to adult bushbuck was 1 : 4.4, and that of juveniles to adult females was 1 : 3.4.

Bushbuck behaviour. - Bushbuck at SDGR were observed to be primarily solitary (Figure 4.4a) with 97% of adult males and 57% of adult females being on their own when sighted (Figure 4.4b). One sighting of an adult male and an adult female together was recorded while occasional sightings of two adult females together or mother and juvenile together were recorded. Rare sightings (4.2%) of more than two animals in a group did occur, usually consisting of two adult females and a juvenile, while one sighting of seven animals in a group consisting of adult females and juveniles was also recorded.

Percentage of sightings, and therefore time spent by bushbuck at night was fairly evenly allocated to walking and feeding with rare sightings of animals lying down (Figure 4.5). Adult females appeared to be spending less time moving than adult males during nocturnal sightings.

Man-hour costs for census methods. - Minimum costs, in terms of man-hours, for each census method are summarised in Table 4.3. Sighting efforts required a fair amount of man-hour investment, but were relatively conservative compared to the substantial investment required to conduct drive counts arising from the large number of semi-skilled labourers involved. Sighting efforts did, however, require greater man-hour costs in terms of skilled labour.

Man-hour costs for simulated drive counts included 15 drives taking 1 hour each to conduct, using 30 semi-skilled labourers (450 hours) and 2 skilled labourers (1 wildlife manager to supervise counts, 15 hours, and 1 researcher to record and analyse data, 17 hours). Costs for sighting efforts included 25 transects taking 2 hours each to conduct, using 1 semi-skilled labourer (50 hours) and 1 skilled labourer (50 hours). Additional man-hour costs for sighting efforts were also encountered. These included the collection of predetermined perpendicular visibility for each season using 1 semi-skilled labourer (12 hours) and 1 skilled labourer (12 hours), and the determination of available/suitable bushbuck habitat by 1 skilled labourer using GIS (2 hours), as well as the input of data and calculation of estimates (10 hours). Additional man-hour costs were also evident for mark-resighting, as animals had to be caught and marked. These costs were, however, not included here, as bushbuck had already been marked previously for other study purposes.

DISCUSSION

Bushbuck density and abundance - Past census techniques used for bushbuck included direct methods such as spotlight counts, drive counts, walking line transects, mark-resighting, and indirect methods such as surveys of animal signs (tracks and pellet group counts) (Simpson 1973; Jacobsen 1974; Odendaal 1977; Allsopp 1978; Schmidt 1983; Allen-Rowlandson 1986). Evaluations of these techniques for determining density and abundance of bushbuck revealed that each technique had its advantages and disadvantages and that when considering accuracy, costs, manpower and equipment needed; drive counts and accumulative transect counts were the most effective techniques to use (Odendaal 1977; Schmidt 1983; Allen-Rowlandson 1986). Mark-resighting was also used during the present study as radio-collared animals conveniently enabled this method, which has proved useful in determining fairly accurate estimations of bushbuck in other studies, but is not realistically considered as a monitoring strategy (Odendaal 1977; Allen-Rowlandson 1986). These techniques were therefore assessed for the present study, and also largely satisfied considerations such as the relative number of individuals, their size, activity and behaviour, and environmental factors such as accessibility, habitat diversity and the density and structure of the vegetation.

Variation in bushbuck density and abundance estimates were encountered between seasons and methods for the present study. Similar variation was encountered in previous studies by Schmidt (1983); Odendaal (1977), and Allen-Rowlandson (1986) using the same methods. Variation seemed to be consistent for seasons, i.e., methods that gave highest and lowest estimates in spring also gave highest and lowest estimates respectively in summer and winter, suggesting that bushbuck density and abundance was fluctuating within the strip area utilised for sighting efforts (distance sampling and mark-resighting). Distance sampling using King's census equation and the variable width transect equation presented less variation in density and abundance estimates than mark-resighting over the three sampling seasons. Mark-resighting appeared to severely underestimate the density and abundance of bushbuck when compared to the other calculations and may have been as a result of too few animals being marked and sighted/resighted during spring and summer particularly (White and Garrott 1990).

Most notable variation occurred during winter where estimates of bushbuck density and abundance were considerably higher than spring and summer. Jathana *et al.* (2003) encountered a similar situation where estimates of large herbivore densities in the tropical forests of India varied greatly between spring and winter as a result of animal seasonal movements. The variation in bushbuck density and abundance estimates of the present study may have been as a result of bushbuck being attracted from other areas of the reserve to the food and cover of riverine vegetation along permanent rivers and the dam causing concentrations in these areas. Jacobsen (1974), Allsopp (1978) and Simbotwe and Sichone (1989) recorded similar concentrations of bushbuck in riverine vegetation during winter. The only census route available for sighting efforts included primarily these riverine areas resulting in a higher number of bushbuck being sighted in winter than spring and summer when bushbuck may have been more dispersed throughout the reserve. The estimations of bushbuck density and abundance obtained from distance sampling for winter was therefore considered to be grossly overestimated.

The estimates obtained for bushbuck density and abundance from mark-resighting for winter correspond with those obtained from distance sampling in spring and summer, which may suggest that the higher number of animals sighted and resighted during this period presented a more accurate estimation of bushbuck density and abundance for the entire study area using mark-resighting.

Conventional drive counts are considered to be the most accurate and precise method of population estimation for antelope such as bushbuck (Schmidt 1983; Marchant 1991). However, other studies have noted high financial and man-hour costs when using this method that often makes it inefficient and too expensive (Schmidt 1983; Collinson 1985). Allen-Rowlandson (1986) tried to minimize pecuniary costs by attempting to utilise net capture as simulated drive counts for bushbuck in timber plantations. He found that this did not work effectively due to labour improficiency leading to unreliable estimates and subsequently abandoned this method. Contrary to this, the simulated drive counts used in spring during the present study provided estimates that corresponded to those calculated from distance sampling during the same period. The small areas covered by the drives and consequently the low number of animals observed from each drive during the present study may have decreased labour discrepancies. However, the relatively small area collectively sampled using this method, and the subjective placement of drives, may have resulted in biased estimates of bushbuck density and abundance for the entire study area.

Minimum sampling effort required to estimate bushbuck density and abundance at SDGR was shown to be greater than 8 repetitions when using sighting efforts and greater than 10 repetitions when using drive counts. This corresponds with studies of similar forest dwelling antelopes (Bowland 1990). Man-hour costs suggest that sighting efforts are more cost effective than drive counts in terms of labour required and still provide fair estimates of population density and abundance. Apart from extensive labour requirements, the nature of the vegetation, size of the reserve and steep topography are also factors negatively influencing the use of drive counts at SDGR. Mark-resighting is suggested to have greatly underestimated bushbuck population density and abundance during the present study and the high costs involved in capturing and marking animals renders this method inadequate. Therefore, drive counts and mark resighting are not considered to be appropriate for monitoring the bushbuck population at SDGR.

Sighting efforts using King's census equation and the variable width transect equation are frequently used as monitoring programmes for wildlife populations (Collinson 1985). Visibility has been a concern for some authors when using sighting efforts (Schmidt 1983; Collinson 1985). However, estimations obtained from the variable width transect equations using (a) mean perpendicular animal sighting distance and (b) mean predetermined perpendicular visibility did not differ significantly, which suggests that visibility did not significantly effect estimations obtained from sighting efforts using the variable width transect equation during the present study. Estimates of bushbuck abundance using King's census method in other studies has been suggested to underestimate abundance (Schmidt 1983). Using King's census might therefore provide a conservative estimate to ensure overutilisation of the population does not occur, however, this might also prevent optimum utilisation of the population. Estimates obtained from the variable width transect equations were consistently and significantly higher than those obtained from King's census and may therefore be a more accurate estimation.

Bushbuck population estimations have generally been advised to be conducted during winter when using sighting efforts, as visibility at this time of the year is best (Schmidt 1983; Allen-Rowlandson 1986; Marchant 1990). However, due to the probable situation that exists at SDGR, where bushbuck concentrate in riverine vegetation through which the only available census route exists causing substantial bias, it is suggested that bushbuck population estimation at SDGR be conducted during spring as in Lannoy *et al.* (2003) when bushbuck are more likely to be uniformly dispersed throughout the reserve.

The density estimates obtained from the present study are not directly comparable to estimates calculated from other studies as the variation in density is considerable, anything from 1 animal per 1.5 ha to 1 animal per 33 ha + (Marchant 1991; Allen-Rowlandson 1986). It is not clear if this variation in bushbuck density is a reflection of the productivity (quality) of the habitat, which can be expressed in terms of rainfall during the growing season (Odendaal and Bigalke 1979), or is owing to the difficulties associated with counting the animals (Marchant 1991).

Bushbuck population structure - An important aspect of population management is the determination of population structure according to sex and age ratios (Spinage 1973; Marchant 1991). The most accurate accounts of age determination are made by techniques such as tooth eruption and replacement sequence, tooth attrition, cementum annuli, eye lens mass, and growth parameters (Taber 1969; Morris 1973; Spinage 1973; Simpson 1973; Allen-Rowlandson 1986).

These techniques all require a large number of animals to either be killed (culling and hunting), or captured and physically handled. No bushbuck were intended to be killed during the present study at SDGR and the few animals that were caught for telemetry purposes did not yield a large enough sample size to render any of the above mentioned techniques practical. The only other possible method of age determination was by field age classification during sighting efforts for population estimation, as used in the present study and numerous others (Allsopp 1978; Okiria 1980; Allen-Rowlandson 1986; MacLeod 1992; Venter 1979). These other studies commonly classified animals as adult, sub-adult, juvenile and infant. However, as with Allen-Rowlandson (1986), the inconspicuous nature and strong preferences shown by bushbuck for densely vegetated habitats complicated this method, especially when attempting to distinguish between adults and sub adults, and juveniles and infants. For these reasons, and because of their largely nocturnal, solitary and secretive habits, bushbuck age determination for this study was often based on brief sightings and therefore rather subjective on occasion.

Sex ratio of unborn infants recorded from random pregnant females culled during the tsetse fly control campaign in Zimbabwe showed that equal numbers of male and female infants are conceived (Wilson and Child 1964). In natural, unhunted populations, the sex ratio of bushbuck is therefore suggested to be 1 male to 1 female (Marchant 1991; Rowe-Rowe 1994) and has been recorded as approximately so in a number of studies (Elder and Elder 1970; Thomson 1972; Odendaal 1977; Allsopp 1978), also shown in Table 4.4. However, other studies have also shown sex ratio to either favour males (Wilson and Child 1964; Jacobsen 1974) or favour females (Mentis 1970; Morris 1973; Simpson 1973; Allen-Rowlandson 1986). The sex ratio calculated for the present study favours females heavily at a ratio of 1 male to 3.4 females. This is the most heavily weighted sex ratio recorded in available literature followed by Dasmann and Mossman (1962) who recorded a sex ratio of 1 male to 2.4 females.

The low frequency of male bushbuck recorded during the present study may have been as a result of misidentification of young 'red' males to be females. As explained by Allen-Rowlandson (1986), young males under the age of 14 months are the same colour and size as females and are not distinguishable from females, as they have not grown horns yet. This may have severely affected the sex ratio calculated from the present study but was unrectifiable without a more accurate method of distinguishing between young males and adult or sub adult females such as random culling.

Allen-Rowlandson (1986) was able to collect comparable data on sex ratio from random culling during his study, which suggested that the sex ratio of bushbuck at Weza state forest was in fact approximately 1 male to 1 female, as apposed to the sex ratio of 1 male to 1.2 females obtained from field classification. Positively identified males during the present study was still very low and even if a third of the total number of females recorded had been misidentified, the sex ratio still would not have been 1 male to 1 female. This suggests that there was still a sex ratio favouring females at SDGR.

The age ratio of 1 juvenile to 3.4 adult females calculated during the present study was affected by the same sampling limitations mentioned for sex ratio and was therefore suggested to be biased towards adult females for the same reasons. However, the high frequency of juveniles observed during the present study resulted in a high juvenile to female and juvenile to adult ratio, which was higher than other studies (Odendaal 1977; Allsopp 1978; Allen-Rowlandson 1986), and not expected if the number of females had been overestimated.

Bushbuck behaviour - Other studies of bushbuck behaviour have included descriptions from prolonged observations of certain individuals, either in captivity (Haschick 1994), or from disclosed hides (Jacobsen 1974). As conducted in the present study, the behaviour of bushbuck has also been widely documented during sighting efforts for population estimation or traversed transects where social interaction and activities were documented and classified according to congregations and description of activity when first sighted. Three of these studies only included diurnal activity of bushbuck (Jacobsen 1974; Allsopp 1978; Simbotwe and Sichone 1989) while the others (Odendaal 1979; Okiria 1980; Allen-Rowlandson 1986) included nocturnal and diurnal activity. The present study only included nocturnal activity as a result of very few diurnal sightings of bushbuck at SDGR.

Typically, bushbuck are solitary and non-sociable (Marchant 1991). Most adults observed in other studies (Bourliere and Verschuren 1960; Walther 1964; Wilson and Child 1964; Elder and Elder 1970; Jacobsen 1974; Allsopp 1978; Odendaal and Bigalke 1979; Allen-Rowlandson 1986; Simbotwe and Sichone 1989), occurred singly with occasional sightings of two or more in a group. The same was observed during the present study, also shown in Table 4.5. Groups of two consisted mainly of adult females with their young, which is not considered to be indicative of social behaviour (Allen-Rowlandson 1986). Groups of two adults together mainly consisted of two females rather than two males or a male and female suggesting little social interaction between genders other than during mating, and that females associated more freely with other individuals than males did. Where a male-female group was observed, the male was an adult, which corresponds with the previous authors who found that 100% of subadult males were solitary. Groups of larger than two were not common during the present study, or any of the previous studies, with the largest group consisting of 7 individuals. This is considered to be rare when compared to the previous studies and is probably best explained by Rowe-Rowe (1994) as a number of individuals briefly gathering in a favourable feeding area. This large grouping is further suggested not to last for more than a couple of hours, after which the group breaks up rather than forming some sort of social cohesion.

Most other studies (Bourliere and Verschuren 1960; Wilson and Child 1964; Elder and Elder 1970; Odendaal and Bigalke 1979; Allen-Rowlandson 1986; Simbotwe and Sichone 1989) found that the solitary male, solitary female and male-female associations accounted for the majority of the sightings during their studies and Odendaal and Bigalke (1979) suggest that these associations play an important role in the social organisation of bushbuck. They recorded a low frequency of female-female and female-juvenile associations, which was not the case in the present study and others (Walther 1964; Allsopp 1978) where these associations take the place of the male-female association in terms of importance. The low frequency of male-female and absence of male-male associations during the present study may have been as a result of the suggested low number of adult males at the study site as determined for bushbuck population structure.

Odendaal and Bigalke (1979) also found that male-male associations did not occur throughout the year whereas male-female and female-female associations did. It is suggested that male bushbuck are not territorial (Rowe-Rowe 1994), and the widely documented overlaps in home range and tolerance of other males supports this (Waser 1974; Jacobsen 1974; Allsopp 1978; Odendaal and Bigalke 1979; Allen-Rowlandson 1986). A male rank-hierarchy is suggested to govern male dominance (Jarman 1974; Jacobsen 1974) and when males have been documented to meet, a pronounced tolerance has been noted, but only when not associated with a female (Odendaal and

Bigalke 1979). Bushbuck are prolific breeders and breed throughout the year (Rowe-Rowe 1994), therefore, the absence of male-male associations at SDGR during the present study may have been as a result of the low number of adult males being constantly occupied by the high availability of females.

Nocturnal activity of bushbuck during the present study was almost entirely dedicated to walking and feeding and corresponds with other studies of bushbuck nocturnal activity (Odendaal 1979; Okiria 1980; Allen-Rowlandson 1986). Jacobsen (1974) found that bushbuck reacted negatively to spotlights at night and suggested that accounts of bushbuck nocturnal activity during his study were therefore not possible. The contrary was found during the present study with most bushbuck being seemingly unperturbed by the presence of spotlights at night or the approaching vehicle. This may have been as a result of the bushbuck population being accustomed to the high frequency of night drives with spotlights that took place within the reserve on almost a daily basis.

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LITERATURE CITED

ALLEN-ROWLANDSON, T.S. 1986. An autecological study of bushbuck and common duiker in relation to forest management. Ph.D.Thesis, University of Natal Pietermaritzburg.

ALLSOPP, R. 1978. Social biology of bushbuck, (*Tragelaphus scriptus*, Pallas, 1766) in the Nairobi National Park, Kenya. East African Wildlife Journal. 16: 153-166.

ANDREKA, G.E. 1996. Spatial utilisation, habitat selection and population status of the wild dog (*Lycaon pictus*) population in Huluhluwe Umfolozi park. MSc Thesis, University of Natal, Pietermaritzburg.

BOURLIERE, F. AND VERSCHUREN, J. 1960. Introduction a`l'e`cologie des ongules du Parc National Albert. Explor. Parc natn.

BOWLAND, A.E. 1990. The Ecology and Conservation of Blue duiker and Red Duiker in Natal. Ph.D. Thesis. University of Natal, Pietermaritzburg.

CHAPMAN, D.G. 1951. Some properties of the hypergeometric distribution with applications to zoological sample censuses. In WHITE, G.C. AND GARROTT, R.A. (1990) Analysis of wildlife radio-tracking data. Academic Press, California.

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

DASMANN, R.F. AND MOSSMAN, A.S. 1962. Abundance and population structure of wild ungulates in some areas of Southern Rhodesia. Journal of Wildlife Management. 26(3): 262-268.

ELDER, W.H. AND ELDER, N.L. 1970. Social groupings and primate associations of the bushbuck (*Tragelaphus scriptus*). Mammalia. 34: 356-362.

ELOFF, T. 2002. The economic realities of the game industries in South Africa. In: FLACK, P.H. Exotic Game-Catching up with Texas. *Man*MAGNUM October 2002.

ESRI. 1996. Arcview® GIS: the geographic information system for everyone™. Environmental Systems Research Institute, Inc, New York.

FLACK, P.H. 2002. Exotic Game-Catching up with Texas. *Man*MAGNUM October 2002.

HASCHICK, S.L. 1994. Foraging and digestion by bushbuck (*Tragelaphus scriptus*) and boergoats (*Capra hircus*) in captivity. MSc. Thesis. University of Port Elizabeth.

JACOBSEN, N.H.G. 1974 Distribution, home range and behaviour patterns of bushbuck in the Lutope and Sengwe Valleys, Rhodesia. Journal of southern African Wildlife Management Association. 4(2): 75-93.

JATHANA, D., KARANATH, K.U. AND JOHNSINGH, A.J.T. 2003. Estimation of large herbivore densities in the tropical forests of southern India using distance sampling. Journal of Zoology, London. 261: 285-290.

JARMAN, P.J. 1974. The social organisation of antelope in relation to their ecology. Behaviour. 48(3-4): 215-267

KENWARD, R.E. 2001. A manual for Wildlife Radio tagging. Academic Press, London.

KING, D.R. 1975. Estimation of yew and cedar availability and utilization. Journal of Wildlife Management. 39(1): 101-107.

KINGDON, J. 1982. East African Mammals: An Atlas of Evolution in Africa. Volume 3, Part C (Bovids). London: Academic Press.

LAMPREY, H.F. 1964. Estimation of the large mammal densities, biomass and energy exchange in the Tarangire Game Reserve and the Masai Steppe in Tanganyika. East African Wildlife Journal. 2:1-46.

LANNOY, L., GAIDET, N., CHARDONNETT P. AND FANGUINOVENT, M. 2003. Abundance estimates of duikers through direct counts in a rain forest, Gabon. African Journal of Ecology.41: 108-110.

LAWSON, D. 1986. The ecology and conservation of suni in Natal. Ph.D. Thesis. University of Natal, Pietermaritzburg.

LOW, A.B. AND REBELO, T.G. 1996. Vegetation of South Africa, Lesotho and Swaziland. Department of Environmental Affairs and Tourism, Pretoria.

MACLEOD, S.B. 1992. Habitat use and diet of bushbuck in the Alexandria Coastal Reserve. MSc. Thesis. University of Port Elizabeth.

MARCHANT, A.N. 1991. An evaluation of the wildlife extension service in Natal. MSc. Thesis. University of Natal. Pietermaritzburg.

MENTIS, M.T. 1970. Estimates of natural biomasses of large herbivores in the Umfolozi Game Reserve area. Mammalia. 34: 363-393.

MORRIS, P. 1972. A review of mammalian age determination methods. Mammal Review. 2(3): 69-104.

ODENDAAL, P.B. 1977. Some aspects of the ecology of bushbuck (*Tragelaphus scriptus*, Pallas 1776) in the southern Cape. Unpublished MSc Thesis, University of Stellenbosch.

ODENDAAL, P.B. AND BIGALKE, R.C. 1979.. Home range and groupings of bushbuck in the southern Cape. South African Journal of Wildlife Research. 9: 96-101.

OKIRIA, R. 1980. Habitat exploitation by the bushbuck in Rwenzori National Park. African Journal of Ecology. 18: 11-17.

PATRICK, B.G. 1998. Open space planning: Integrating Shongweni Resources Reserve with the Umlaas river park and parts of the lower Mlazi catchmment. MSc Thesis, University of Natal, Durban.

RICE, R.W. AND HARDER, J.D. 1977. Application of multiple aerial sampling to a mark recapture census of white-tailed deer. Journal of Wildlife Management. 41(2): 197-206.

ROWE-ROWE, D.T. 1994. The ungulates of Natal. Natal Parks Board, Pietermaritzburg.

RUTHERFORD, M.C. AND WESTFALL, R.H. 1994. Biomes of southern Africa – an objective categorisation. Memoirs of the Botanical Survey of South Africa. 63:1-94.

SCHMIDT, J.L. 1983. A comparison of census techniques of common duiker and bushbuck in timber plantations. South African Journal of Forestry 126: 15-19.

SEYDACK, A.H.W. 1984. Application of a photo-recording device in the census of larger-rain forest mammals. South African Journal of Wildlife Research 14:10 14.

SIMBOTWE, M.P. AND SICHONE, P.W. 1989. Aspects of behaviour of bushbuck in the Kafue National Park, Zambia. South African Journal of Wildlife Research. 19 (1):38-41.

SIMPSON, C.D. 1973. Tooth replacement, growth and ageing criteria for the Zambezi bushbuck (*Tragelaphus scriptus ornatus* Pocock). Arnoldia. 6(6): 1-31.

SKINNER, J.D. AND SMITHERS, R.H.N. 1990. The Mammals of the Southern African Subregion (2nd edition). University of Pretoria.

SPINAGE, C.A. 1973. The role of photoperiodism in the seasonal breeding of tropical African ungulates. Mammal Review. 3(3): 71-84.

TABER, R.D. 1969. Criteria of sex and age. In: Wildlife Management techniques, ed. GILES, R.H., Jr., pp.325-401. Washington: The Wildlife Society.

THOMPSON, G.R. 1972. The distribution and habitat preference of bushbuck (*Tragelaphus scriptus ornatus*) within the Victoria Falls National Park. Cert. Field Ecol.,University of Rhodesia, Salisbury.

VAN ROOYEN, A.F. 1992. Diets of impala and nyala in two game reserves in Natal, South Africa. South African Journal of Wildlife Research 22(4): 98-101.

VENTER, J. 1979. Ecology of the southern reedbuck (*Redunca arundinum* Boddaert, 1785), on the eastern shores of Lake St. Lucia, Zululand. MSc.Thesis, University of Natal. Pietermaritzburg.

VINCENT, J. 1979. The population dynamics of impala (*Aepycerus melampus*) in Mkuzi Game Reserve. Ph.D. Thesis. University of Natal, Pietermaritzburg.

VON GADOW, K. 1978. A pellet group count of blue duiker and bushbuck in the Knysna Forest. South African Forestry Journal 107:77-81.

WALTHER, F. 1964. Verhaltensstudien an der gattung (Tragelaphus de Blainville 1816) in gefangenschaft, unter besonderer beruchsichtigung des sozialverhaltens. Zeitschrift fur Tierpsychologie: 21(4): 393-467.

WASER, P. 1975. Spatial associations and social interactions in a "solitary" ungulate: the bushbuck (*Tragelaphus scriptus* (Pallas)). Zeitschrift fur Tierpsychologie: 37(4): 24-36.

WHITE, G.C. AND GARROTT, R.A. 1990. Analysis of wildlife radio-tracking data. Academic Press, California.

WILSON, V.J. AND CHILD, G.F.T. 1964. Notes on bushbuck (*Tragelaphus scriptus*) from a tsetse fly control area in Northern Rhodesia. The Puku. 2: 118-128.

Table 4.1 Bushbuck abundance and density estimates using three methods for Shongweni Dam and Game Reserve

Method	n	N	a	b	c	r	Density ± SE	Abundance ± SE
Simulated drive counts	15	12					6.3 ± 1.1	84.3 ± 5.9
Sighting efforts:								
Spring	8	31						
Var width transect a			18.4				8.2 ± 0.5	64.8 ± 3.5
Var width transect b				17.8			7.5 ± 0.7	70.8 ± 5.3
King's census					24.5		10.5 ± 0.9	50.6 ± 3.1
Combined L-P						1	21.2 ± 1.3	25.0 ± 1.7
Summer	10	30						
Var width transect a			18.8				10.4 ± 0.7	51.1 ± 4
Var width transect b				16.9			9.2 ± 1.0	57.7 ± 3.1
King's census					25.1		13.9 ± 0.9	38.1 ± 3.1
Combined L-P						2	16.9 ± 0.9	31.4 ± 1.1
Winter	7	90						
Var width transect a			26.3				3.4 ± 0.5	156.2 ± 11.1
Var width transect b				22.4			2.9 ± 0.2	183.1 ± 9.8
King's census					34.8		4.5 ± 0.6	118.2 ± 8.2
Combined L-P						8	8.4 ± 0.3	63.3 ± 2.8

n = number of replications
N = number of animals observed
a = mean perpendicular animal sighting distance (m)
b = mean predetermined perpendicular visibility (m)
c = mean straight line animal sighting distance (m)
r = number of marked animals re-sighted

Density = hectares per bushbuck

Table 4.2 Number of bushbuck observed during population estimation at Shongweni Dam and Game Reserve showing associated age structure and population ratios

Method	n	M	F	J	Total	M:F	J:A	J:F
Simulated drive counts	15	5	5	2	12	1:1	1:5	1:2.5
Spring sighting efforts	8	9	16	6	31	1:1.8	1:4.2	1:2.7
Summer sighting efforts	10	7	16	7	30	1:2.3	1:3.3	1:2.3
Winter sighting efforts	7	9	66	15	90	1:7.3	1:5	1:4.4
Total		30	103	30	163	1:3.4	1:4.4	1:3.4

M = Adult males; F = Adult females; A = Adult males and females; J = Juveniles
n = number of replications

Table 4.3 Cost, in terms of man-hours, of conducting population estimation methods for bushbuck at Shongweni Dam and Game Reserve

Method	Semi-skilled	Skilled
Drive counts	450	32
Sighting efforts (variable width transect, King's census, mark-recapture)	62	74

Table 4.4 Comparative sex ratios of bushbuck in southern Africa calculated to a base of 100 females (After Allen-Rowlandson 1986).

Number sexed		Sex ratio	
Males	Females	Males:100 females	Source
740	587	126.1	Odendaal (1977)
N/A	N/A	120.0	Jacobsen (1974)
39	35	111.4	Wilson and Child (1964)
388	359	108.1	Odendaal (1977)
68	64	106.3	Allen-Rowlandson (1986) culled
84	83	101.2	Elder and Elder (1970)
38	40	95.0	Allsopp (1978)
78	83	93.9	Thomson (1972)
249	281	88.6	Morris (1973)
395	478	82.6	Allen-Rowlandson (1986) field
1416	2119	66.8	Mentis (1970)
N/A	N/A	66.0	Simpson (1973)
11	19	57.9	Walther (1964)
26	61	42.6	Dasmann and Mossman (1962)
30	103	29	The present study

Table 4.5 Frequencies of associations of bushbuck from comparative studies throughout Africa. Expressed as percentages of total number of animals (n) observed (After Odendaal and Bigalke 1979).

Source	n	Loctation	M	MM	F	FF	MF	FY	Other
Odendaal (1977)	776	S. Cape, SA	33	6	24	8	14	4	8
Bourliere & Vershuren (1960)	52	Congo	29	-	38	4	15	12	2
Walther (1964)	35	Uganda	31	-	43	-	-	17	9
Wilson & Child (1964)	74	Zambia	37	1	35	6	19	-	2
Allsopp (1978)	642	Kenya	28	5	24	5	8	15	11
Elder & Elder (1970)	232	Botswana	27	4	25	6	11	8	19
Allen-Rowlandson (1986)	3400	KZN, SA	35	4	29	5	5	5	17
Simbotwe & Sichone (1989)	180	Zambia	17	2	30	11	12	13	15
The present study	163	KZN, SA	17	-	36	21	1	14	12

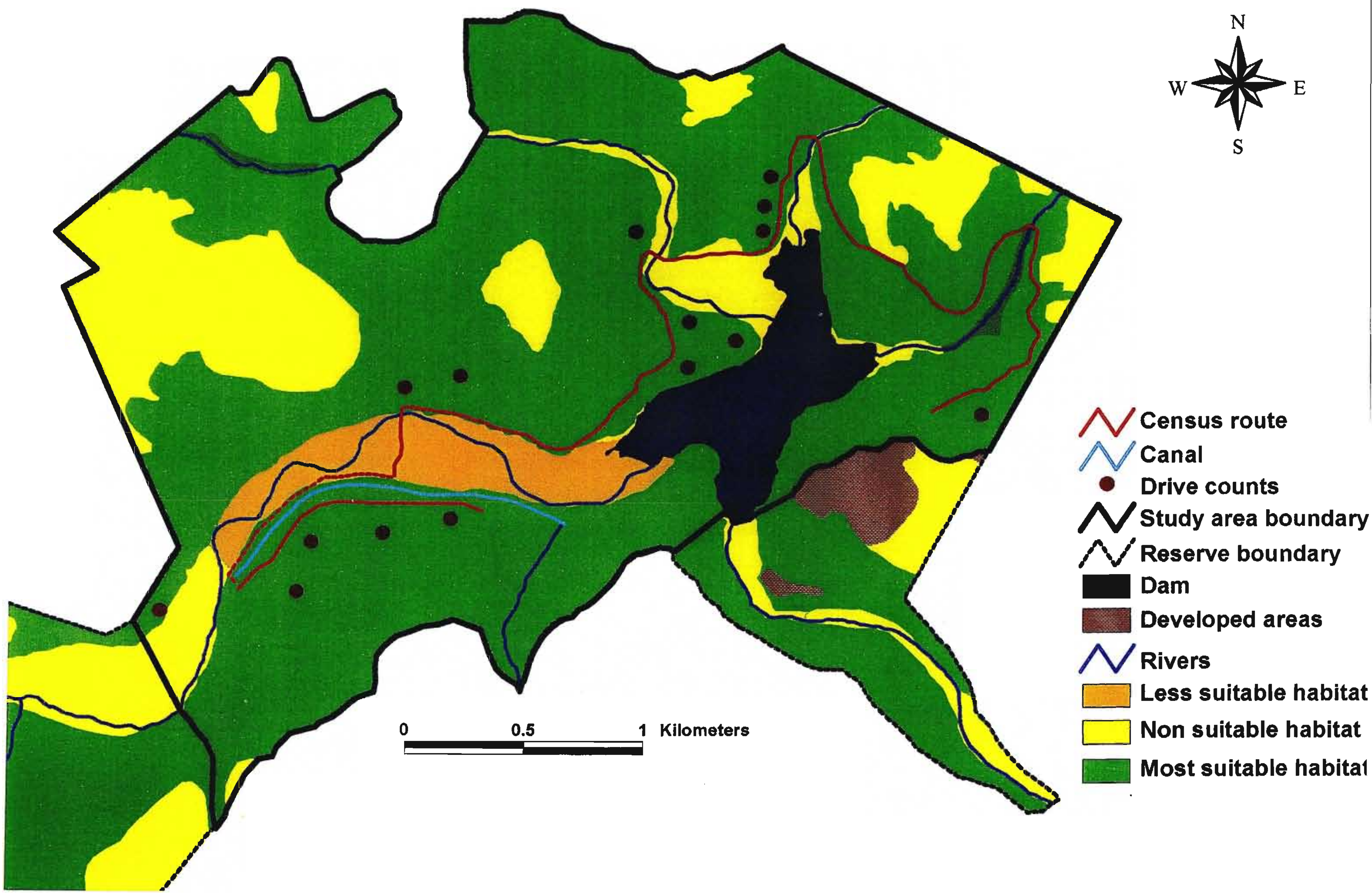


Figure 4.1 Available/suitable habitat for bushbuck at Shongweni Dam and Game Reserve. Positioning of drive counts and census route used during population estimation are also shown.

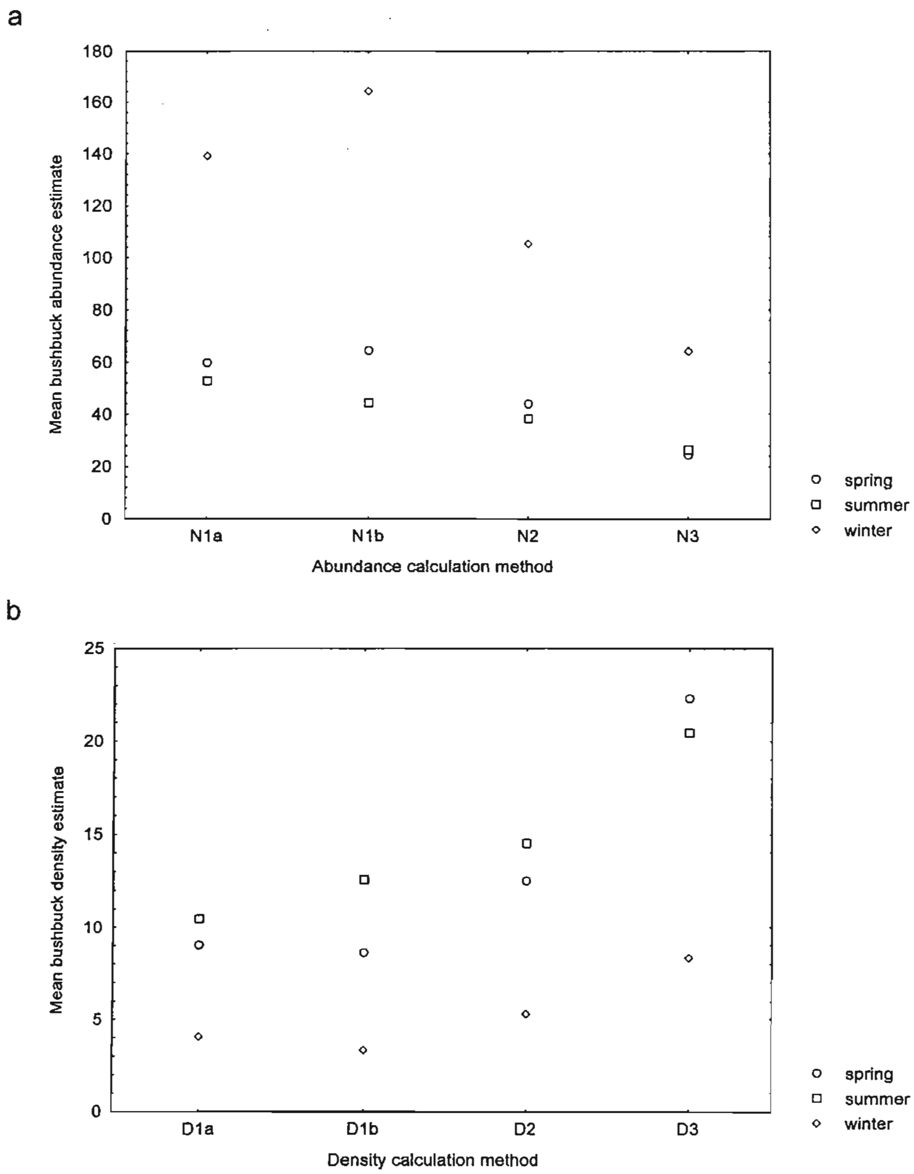
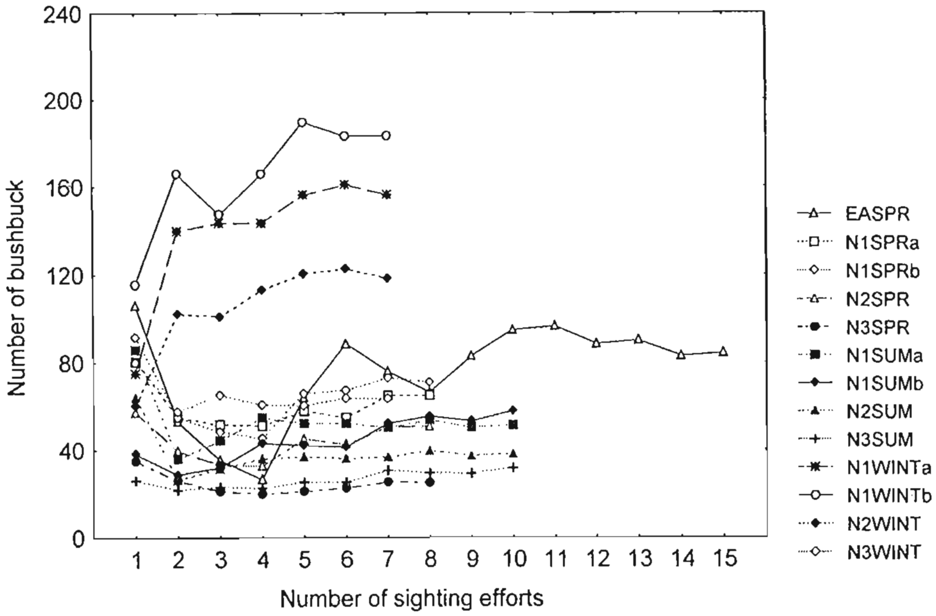


Figure 4.2 Mean estimates of bushbuck abundance (a) and bushbuck density (b) showing variation in estimates between seasons and between methods.
N1 = Variable width transect, N2 = King's census, N3 = combined Lincoln-Peterson estimate, D1 = Variable width transect, D2 = King's census, D3 = combined Lincoln-Peterson estimate, a = using mean perpendicular animal sighting distance, b = using mean predetermined perpendicular visibility.

a.



b.

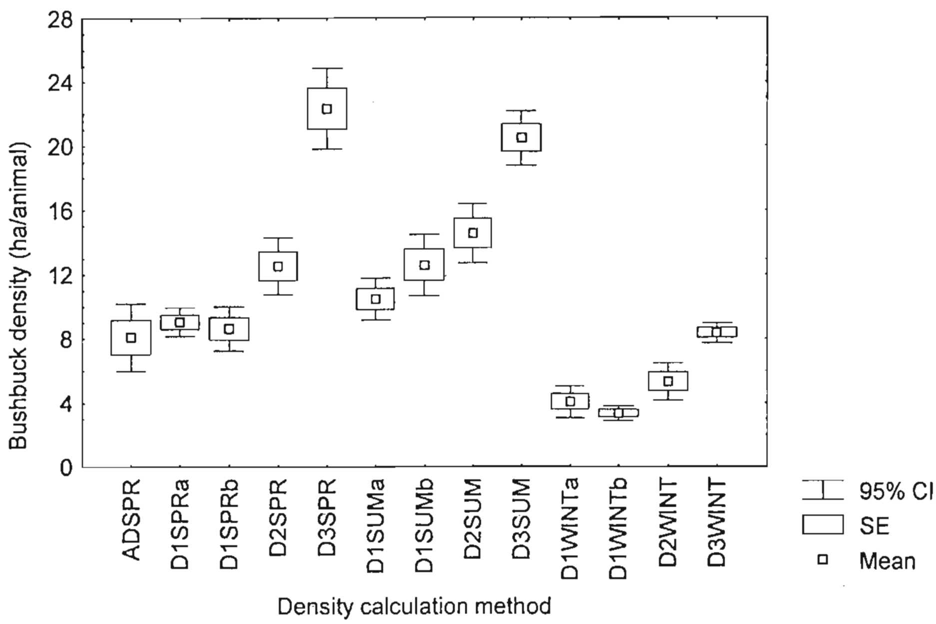


Figure 4.3 Cumulative estimates of bushbuck abundance (a) and estimates of bushbuck density (b) for all sampling periods at Shongweni Dam and Game Reserve. EA = Ecological abundance, N1 = Variable width transect, N2 = King's census, N3 = combined Lincoln-Peterson estimate, ED = Ecological density, D1 = Variable width transect, D2 = King's census, D3 = combined Lincoln-Peterson estimate, a = using mean perpendicular animal sighting distance, b = using mean predetermined perpendicular visibility. Seasons are abbreviated to SPR - spring, SUM - summer, WINT - winter

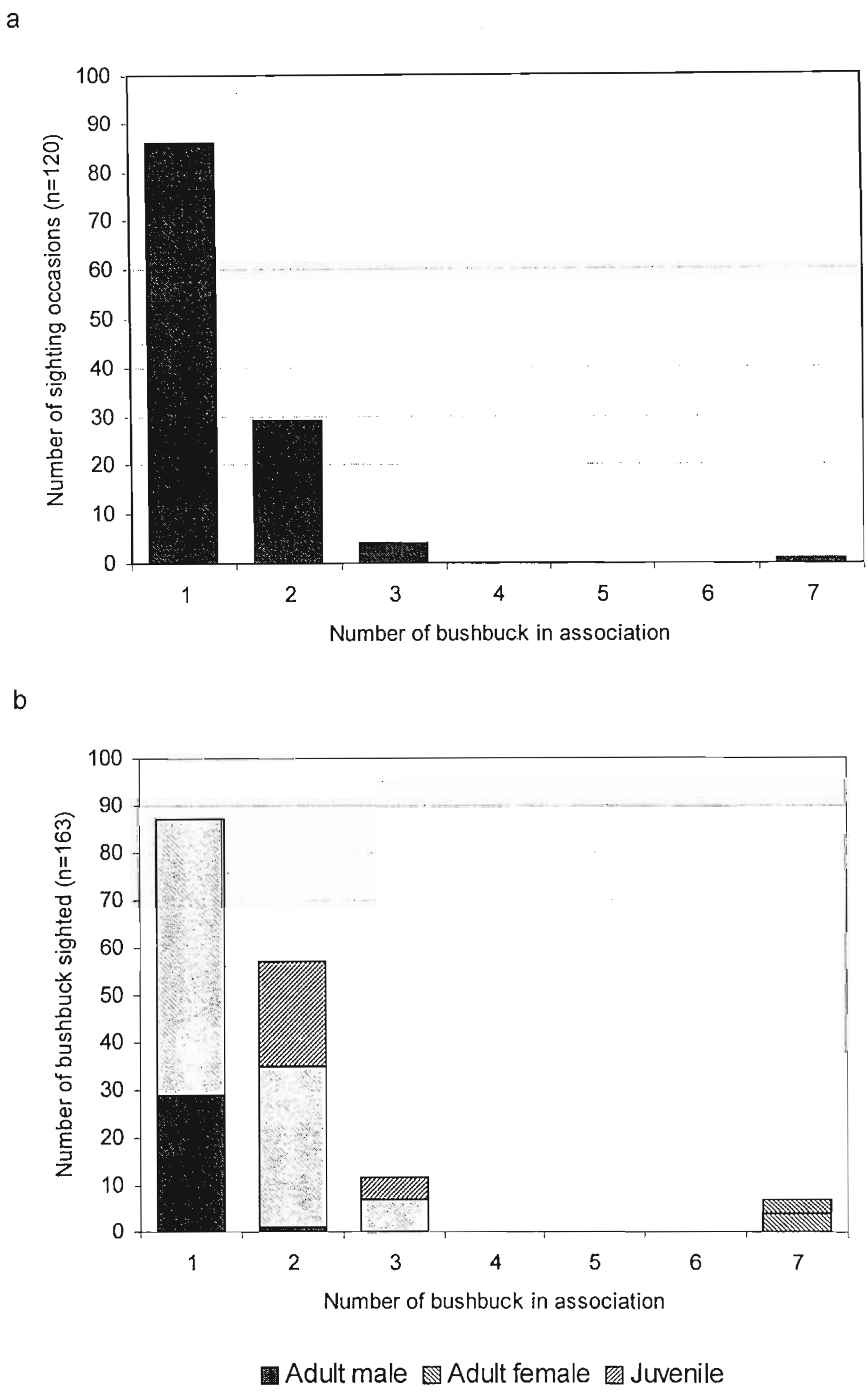


Figure 4.4 Associations of bushbuck observed during sighting efforts for population estimation at Shongweni Dam and Game Reserve, showing frequency of association size (a) and sex and age structure of associations (b).

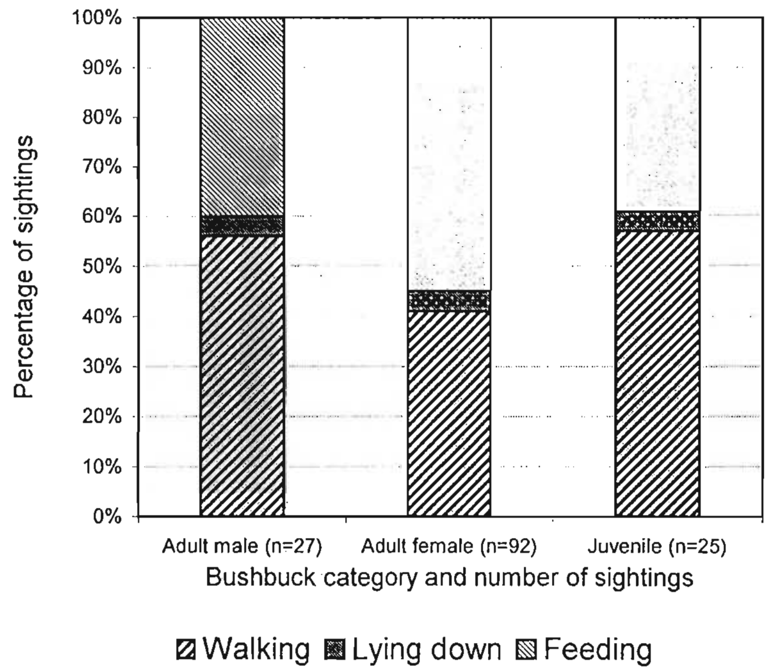


Figure 4.5 Nocturnal activity of observed bushbuck during sighting efforts for population estimation at Shongweni Dam and Game Reserve.

CHAPTER 5

A survey of the status and management of sympatric bushbuck and nyala in KwaZulu-Natal, South Africa

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Abstract

The status and management of sympatric bushbuck and nyala in KwaZulu-Natal was investigated by means of a questionnaire survey. From the opinions of landowners and reserve managers, the status of bushbuck sharing a sympatric relationship with nyala in KwaZulu-Natal (KZN) appeared to be stable to declining, whereas nyala status was increasing. This trend was suggested to be a result of competition for resources between the two species. Northern KZN recorded a higher frequency of this trend (57.7%, n = 26) compared to the Midlands (35.7%, n = 14), as did Ezemvelo KZN Wildlife Reserves (85.7%, n = 7) compared to privately owned properties (42.4%, n = 33). Very little species-specific management for nyala and bushbuck occurred in reserves that participated in the present survey. Only 67% of reserves (n = 40) had population estimates for these species and most reserves indicated that these estimates were vague. Nyala were primarily controlled by hunting (34.7%, n = 40), particularly in the Midlands (63. 2%, n = 14), and live sales (34.7%, n = 40), particularly in northern KZN (40%, n = 26). 50% of reserves in the Midlands regulated bushbuck numbers by hunting, 12.5% by live capture, and 37.5% indicated that they did not need to take animals off as no population excess occurred. This is in contrast to only 3.8% of reserves in northern KZN who regulated bushbuck abundance by hunting, 11.5% by live capture, and 65.5% who did not need to regulate bushbuck abundance because numbers of this species were too low.

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Introduction

Land under game in South Africa has increased dramatically in the past 10 years, driven almost exclusively by the local and overseas demand for hunting (Flack, 2002). KwaZulu-Natal (KZN) is one of the most frequented provinces by sport hunters attracting a large proportion of clients (Eloff, 2002), therefore providing an economic opportunity for many private landowners in KZN. Economic opportunities are increased if the landowner has highly prized trophy species, which has resulted in numerous exotic species being introduced to exploit this economic opportunity (Flack, 2002). One such highly prized trophy is the nyala *Tragelaphus angasi* (Rowe-Rowe, 1994). This antelope is indigenous to the northern coastal areas of KZN (Skinner & Smithers, 1990), but has been introduced to many other areas in the province beyond its historical distribution and is therefore considered to be an exotic in these areas (Rowe-Rowe, 1994; Flack, 2002). Statistics from the Hunting and Extension Division of Ezemvelo KwaZulu-Natal Wildlife (EKZNW) show that in 2002, 546 trophy nyala were shot by foreign clients alone in KZN, generating an estimated R8.2 million or US$820 000. In addition, nyala are also highly sought after at game auctions, providing further economic benefits from live sales, with an estimated R2.8 million or US$280 000 being generated from nyala sales at the annual EKZNW game auction in 2002 (Wagner pers comm.[1]).

In most areas where nyala have been introduced, they have been very successful and their population status has been increasing ever since throughout KZN (Anderson *et al.*, 1996). However, nyala are difficult to manage due to their secretive habits and preference for thick vegetation and this has lead to high concentrations of nyala on many properties (Rowe-Rowe, 1994). High concentrations of nyala have been suspected to negatively influence particularly bushbuck *Tragelaphus scriptus* (Rowe-Rowe, 1994), as well as other naturally occurring forest antelopes such as red duiker *Cephalophus natalensis* and blue duiker *C. monticola* (Bowland, 1990), and suni *Neotragus moschatus* (Lawson, 1986). This negative influence is thought to be brought about by competition for food, where in times of food shortages, nyala are able to out-compete the other species (Rowe-Rowe, 1994). Bushbuck, forest duikers and suni are selective browsers

[1] Wagner, J. Hunting and Extension Division, EKZN Wildlife Queen Elizabeth Park. PO Box 13053, Cascades 3202.

relying almost exclusively on browse during winter (Allen-Rowlandson, 1986; Lawson, 1986; Bowland, 1990) and are also smaller in size than nyala. The nyala is a mixed feeder showing preference for browse during winter (Anderson, 1978; Seymour, 2002) and is suggested to out-compete the other species by having access to forage at a higher feeding level potentially creating browse lines and thereby excluding the smaller species (Rowe-Rowe, 1994; Haschick & Kerley, 1996). Nyala are also able to supplement their diet with graze if browse is in short supply (Anderson, 1978).

Nyala populations are increasing in size and in distribution (Anderson *et al.*, 1996), and possible competition causing localised declines in bushbuck have raised concerns for the future status of bushbuck populations where these species share a sympatric relationship in KZN. This study was, therefore, undertaken to by way of a questionnaire survey, investigate trends in the population status of nyala and bushbuck on properties where they exist together, both naturally, and where nyala have been introduced. The issue of possible competition between these two species was also of concern and attitudes of property managers to this potential threat as well as current management strategies employed to reduce this threat were included. Hypotheses were also set to determine whether location of property, ownership of property, size of property, origin of nyala, time since the introduction of nyala, and hunting have influenced the present status of nyala and bushbuck, and the opinions of property managers, regarding possible competition between the two species in KZN.

Materials and methods

The questionnaire

A draft questionnaire was prepared following the suggestions by Babbie (1973) and Cohen *et al.* (1992) for designing a self-completion questionnaire:

- Avoid the use of leading questions, i.e. questions must be neutral
- Avoid open-ended questions
- Avoid negative questions
- Avoid the use of complex (multiple) questions
- Avoid ambiguous questions

- Avoid irrelevant questions
- Answer categories must be mutually exclusive
- Avoid antagonistic questions
- Questions must be as short as possible

A pilot run was carried out on four farmers not involved in the survey to test the wording, layout and the time taken to fill in the questionnaire. After minor changes, a final questionnaire consisting of 20 questions and 107 variables was concluded (Appendix C). The questionnaire was divided into two sections:

Section A: This section was directed at the present status and management of nyala and bushbuck.

Section B: This section gave insight into the opinions and attitudes of property managers to possible competition between nyala and bushbuck.

An open-ended question, i.e. 'explain' was also included where it was considered necessary. Space was set aside at the top of the questionnaire for the respondents name, the name of the property, the date of completion, and contact details, i.e. e-mails, telephone and fax numbers. Questionnaire return contacts were also included at the top of the questionnaire.

The survey

Only properties that have both nyala and bushbuck (i.e., living together) were considered for this survey. These included properties with both species occurring together within their historic distributions (naturally resident or reintroduced), and properties where nyala have been introduced beyond their natural range and where bushbuck are naturally occurring.

Contact details for properties with both nyala and bushbuck in KZN were obtained using 5 methods:

1. Searching the World Wide Web (internet) and popular magazines for the contact details of favourable reserves from their advertisements.
2. Placing advertisements in 7 popular conservation, tourism and hunting magazines, as well as on a popular wildlife internet website, requesting reserves with both species to contact the authors to assist with the study.
3. Obtaining a list of Ezemvelo KwaZulu Natal Wildlife (EKZNW) game reserves that have both species from their head office at Queen Elizabeth Park in Pietermaritzburg, KZN.
4. Obtaining lists of privately owned properties with nyala and bushbuck from local tourism offices in Hluhluwe (for northern KZN) and Pietermaritzburg (for the midlands).
5. Word of mouth.

Once contacts for a suitable number of favourable properties had been established, they were telephoned to create a personal contact and the managers or landowners were made aware of the study. The questionnaires, along with a covering letter and a short communication outlining the study, was then sent to each property via e-mail, fax or post depending on the contacts technological status. An effort was also made to visit those potential respondents whose property was within a 50km radius of Pietermaritzburg ($n = 3$) and to give them the questionnaire in person. The author went through the questionnaire with these respondents, who were given the choice of either completing their own copy or the author completing it for them. This was done to establish a further personal contact and also to ensure that the questionnaire did not have any unforeseen difficulties for the sample. All potential respondents were telephoned again to ensure that they had received the questionnaire, after which they were given 3 weeks to complete and return it. A first reminder was sent after 3 weeks to those who had not yet responded. These properties were given a further two weeks to respond to the first reminder before a final request was made by telephone.

Data analysis

Questionnaire returns were coded according to the response to each question for the following categories:

1 Property location i.e. northern KZN (N) or midlands (M),
2 Property ownership i.e. government conservation EKZNW (K) or private (P),
3 Property size i.e. less than 5000ha (S) or more than 5000ha (L),
4 Hunting permission i.e. hunting allowed (H) or no hunting allowed (NH),
5 Origin of nyala populations i.e. introduced (I) or natural (R),
6 Time since nyala introduction i.e. less than 10 yrs (A) or more than 10 yrs (B).

Chi-squared goodness-of-fit tests were performed to determine any significant differences for frequency of responses considering all categories together, between and within categories. The null hypothesis set was that no significant difference would occur for frequency of responses between and within categories to questions directed at determining status, management, and possible competition between nyala and bushbuck occurring in sympatry in KZN.

Results and Discussion

The questionnaire return

Contacts for a sample of 48 properties with both nyala and bushbuck in KZN were established from the various sourcing methods (Figure 5.1). This is by no means the total number of properties in KZN that have nyala and bushbuck together and is therefore considered to be a sample thereof. It was originally hoped that a larger sample size would be acquired, however, sourcing favourable properties proved to be more difficult than expected. Word of mouth and the responses to the advertisements requesting assistance from landowners and managers were the most successful methods accounting for more than half of the contacts sourced. This reflected the interest and perhaps the concern that landowners and reserve managers might have had regarding interactions between nyala and bushbuck on their properties.

A total of 40 questionnaires (83%) were returned, of which all returns were usable. Marchant (1991) had a similar percentage of returns during his evaluation of the wildlife extension service in KZN and regarded this as highly successful. As with Marchant (1991), this high response could be accredited to the good communication techniques employed. The importance of follow-up reminders was well illustrated by the fact that after the initial distribution of questionnaires the response rate was 49%, after the 1st reminder it was 72%, and the final reminder brought the total response to 83%. The questionnaire returns expressed as a percentage according to when they were returned are also shown by Figure 5.2.

The proportion of questionnaires distributed using the various contact methods, and also the proportion of questionnaires that were returned using these contact methods, are shown by Figure 5.3. The distribution of questionnaires using e-mail and facsimile were time and cost efficient and were therefore the two methods most utilised for distributing and returning questionnaires. The lower comparative return frequency using e-mail does not necessarily reflect this as being the main contact method responsible for non-returns. Non-returns were evident for all contact methods, however, some respondents preferred to print and complete the questionnaire from e-mail and then return it via facsimile or post. Posting questionnaires as a method of distribution during the present study was avoided, as it was time consuming and required extra stationery, but has also been shown be an efficient method of distributing and returning questionnaires (Marchant 1991).

The questionnaire returns showing the number of properties represented in each category are given in Table 5.1. The same properties were used for each category 1 – 6, therefore, n = 40 for each category, except category 6 where n = 24 as only this number of properties had introduced nyala. The overall frequency of responses to each question for all categories combined is given in Appendix D. Certain questions were selected to specifically illustrate status, management and possible competition between nyala and bushbuck and are presented and discussed further.

Status of nyala and bushbuck

Questions A2 and A3 were directed at determining the present status of nyala and bushbuck where these two species share a synoptic relationship in KZN. The questions and frequency of responses for all categories to these questions are given in Tables 5.2 and 5.3. Only options that were chosen by respondents were included. Options that were included in the questionnaire but not chosen by the respondents can be found in Appendix C.

Overall frequency of responses to question A2 showed that the status of bushbuck on most properties was declining while nyala status was increasing (42.5%) followed by 25% where only nyala were increasing while bushbuck remained the same. In particular, EKZNW reserves indicated declines in bushbuck status while nyala status was increasing. Only properties that had introduced nyala less than 10 years ago suggested little decline in bushbuck numbers, which may support the suggestions that negative interaction between these species are not immediate, but only become apparent after the nyala population has had time to increase in number (Rowe-Rowe 1994). Interestingly, a fair number of properties indicated that bushbuck and nyala status was increasing (overall frequency 17.5%) or had remained the same (overall frequency 15%) on their properties. However, no significant differences were found and no particular category showed a high frequency of response for this option.

Those respondents that indicated a decline in bushbuck status on their properties further suggested that in their opinion competition with nyala (overall frequency 58.6%) was the main reason for this, while drought (overall frequency 17.2%) and poaching (overall frequency 13.8%) were also responsible. Although not significant, EKZNW reserves particularly showed a high frequency of response to competition with nyala being the reason for bushbuck declines in their reserves. Contrary to Rowe-Rowe (1994), habitat loss (overall frequency 6.9%) causing bushbuck declines was shown to be fairly negligible from the respondent's opinions. However, all the reserves participating in this survey were primarily conservation areas where habitat loss would be prevented by conservation. Farms where agriculture is present may implement conservation as a secondary management objective resulting in habitat loss to land under agriculture and subsequent declines in bushbuck status.

Respondents were equally of the opinion (overall frequency 50% for yes and no) as to the general decline of bushbuck status in KZN (question A3). Frequency of responses from category 1 (location of property) appeared to suggest that bushbuck population status was lower in northern KZN (N) than in the Midlands (M). A trend was also apparent from EKZN reserves (all of which are in northern KZN) who suggested that bushbuck population status was declining in general in their part of the province. This corresponded with Anderson *et al.* (1996) who noted a decline in bushbuck status in KZN from the IUCN antelope survey.

As with the previous question (A2), respondents who were of the opinion that bushbuck status had declined were asked to also provide their opinion of what had caused this decline. Similarly to question A2, competition with nyala was the suggestion by the majority of respondents (overall frequency 54.5%) followed by poaching (15.2%), and drought (12.1%).

Management of nyala and bushbuck

Questions A6, A7, A8 and A9 were aimed at determining the present management of nyala and bushbuck in KZN. These questions and the frequencies of responses to these questions are given in Tables 5.4 and 5.5.

Overall frequency of response to question A6 showed that almost half (45%) of the reserves participating in the present survey had estimated population numbers for nyala and bushbuck. A third of the participants, however, had no estimates of population numbers for either species while 22.5% had estimates for only nyala. Although not significant, reserves larger than 5000 ha showed the highest frequency (71.4%) of such data for both species.

Reserves with population estimates for nyala and bushbuck indicated that these were attained using annual game counts from aerial surveys, line transects and frequent report backs of sightings from field rangers. These popular estimation methods are commonly conducted to attain general estimates of abundance for all species in the reserve. However, they have been shown to be largely unsuccessful for estimating abundance effectively of secretive antelopes inhabiting thick bush such as nyala and bushbuck (Schmidt 1983; Collinson 1985; Allen-Rowlandson 1986). For this reason the respondents regarded these estimates as vague with little accuracy or precision.

When asked if the reserve had a specific management plan for nyala and bushbuck (question A7), the overall frequency of response was largely no (85%). This suggested that the majority of reserves were not utilising either species to their full potential. If a reserve does not have a good idea of population abundance and age structure, accurate stocking and offtake rates cannot be estimated accurately (Anderson 1978; Marchant 1991). The remaining 15% of respondents who answered yes to this question were asked to further explain their specific management plans for nyala and bushbuck. One reserve used an onboard GPS system to accurately record locations, abundance, and sex and age structure of any sightings of these species during routine drives through the reserve (game drives, patrols etc.). This method was suggested to be an expensive but worthwhile investment as it provided valuable information from which affective management decisions could be made. Another, more direct approach used by some reserves that had concerns of losing bushbuck due to possible competition with nyala, was shooting nyala on sight in particular areas of the reserve where it was known that bushbuck were locally abundant. This was done to discourage nyala from inhabiting these areas and to keep their numbers down to reduce possible competition. This method has also been used in attempts elsewhere to totally exterminate nyala in order to revive bushbuck populations (e.g. Loskop Dam Nature Reserve). This method, however, is similar to culling which results in a valuable asset not being utilised to its full potential (Bothma 1989).

Questions A8 and A9 were aimed at determining how nyala and bushbuck abundance respectively were being controlled in the reserves participating in the present survey. Overall frequency of responses showed that nyala in KZN were being controlled primarily by hunting and live capture equally with, each accounting for 34.7% of responses. From the significant differences found, reserves that allowed hunting controlled their nyala populations through hunting whereas reserves that did not allow hunting, controlled their nyala populations through live capture and culling. Properties in the Midlands also appeared to control nyala by hunting (63.2%) whereas properties in northern KZN controlled nyala primarily by live sales (40.0%). Only few reserves did not have to control their nyala populations (8.2%) and most of these were reserves where nyala had only been introduced within the last 10 years suggesting that they had not had time to reach and exceed ecological carrying capacity.

The control of bushbuck populations in KZN differed to that of nyala. Overall frequency of response showed that more than half of the reserves (54.8%) did not need to control their bushbuck populations as a result of there being no excess animals. This further suggests the declining status of bushbuck in reserves with nyala in KZN, particularly EKZNW reserves (100% frequency of response). Only few properties controlled bushbuck by hunting (overall frequency 21.4%) of which most occurred in the Midlands. No bushbuck were culled on any properties and a select few (11.9%) had excess bushbuck which they preferred to remove by live capture rather than hunting.

Possible competition between nyala and bushbuck

Questions B15, B16 and B17 were aimed at determining the opinions and attitudes of landowners and reserve managers to possible competition between synoptic bushbuck and nyala in KZN. The questions and frequency are given in Table 5.6 and Table 5.7. Only options that were chosen by respondents to question B17 were included. Options that were included in the questionnaire but not chosen by the respondents can be found in Appendix C.

The overall frequency of responses to question B15 were almost unanimously yes (90%) for all categories which indicated that the majority of respondents were of the opinion that bushbuck and nyala do compete for key resources on their properties. The opinion of respondents to question B15 were also based primarily on personal observations (60.9%) which further supports the possibility of competition between bushbuck and nyala.

Frequency of responses to question B16 showed that even though all categories had previously indicated a high opinion of competition between nyala and bushbuck, most had no concerns of having nyala on their properties (overall frequency 85%). A significant difference ($\chi^2 = 28.1$, 11 df, $p < 0.01$) was however found for the yes option of this question which indicated that a significant number of properties did have concerns about nyala. These appeared to be properties that had introduced nyala more than 10 years ago ($\chi^2 = 7.17$, 1 df, $p < 0.01$).

From the frequency of responses to question B17, most respondents would still consider introducing nyala to their property if they did not already have them (90%). This majority of respondents then indicated various reasons for this, of which introductions for only ecological reasons (χ^2 = 29.3, 11 df, $p < 0.01$) were shown to be significantly different. It appeared that EKZNW reserves (χ^2 = 14.63, 3 df, $p < 0.01$) showed preference for ecological reasons while properties with natural populations of nyala (χ^2 = 8.53, 3 df, $p < 0.05$) for economical more than ecological reasons. Although not significant, a trend favouring the introduction of nyala for economic reasons was also evident for other categories (introduced nyala populations, nyala introduced more than 10 years ago, hunting allowed). EKZNW is a conservation organisation that only allows hunting in one of their reserves involved in the present survey, so the significance of their response of introductions for ecological reasons was expected. The value of nyala for hunting was emphasised by the significantly high frequency of response to economical reasons for introductions of nyala from reserves that allow hunting. Only a small number ($n < 4$) of properties indicated that they would not introduce nyala and the dominant reason was for concern of losing bushbuck due to competition with nyala. However, the sample size was too small for χ^2 to be effective for this question.

The variety of responses to questions concerning possible competition between sympatric nyala and bushbuck in KZN, suggest that further investigation is required.

Acknowledgements

The National Research Foundation (NRF) are thanked for providing funding for this study and so are the various landowners and reserve managers who participated in the survey. The assistance of the EKZN Wildlife tourism office and the Hluhluwe tourism office, as well as the various magazines who kindly published the letter requesting assistance for this study are also acknowledged.

References

ALLEN-ROWLANDSON, T.S. (1986) *An autecological study of bushbuck and common duiker in relation to forest management.* Ph.D. Thesis. University of Natal, Pietermaritzburg.

ANDERSON, J.L. (1978) *Aspects of the ecology of the nyala (*Tragelaphus angasi Gray, 1849) *in Zululand.* PhD Thesis, London University.

ANDERSON, J.L., KNIGHT, M., LOYD, P., EILLY, B., ROWE-ROWE, D., VAN DER WALT, P.T., VILJOEN, P. & VRAHIMIS, S. (1996) *Chapter 3: South Africa.* In East R. *Antelope Survey Update number 3.* IUCN/SSC Antelope Specialist Group Report. Pp 8-33.

BABBIE, E.R. (1973) *Survey Research Methods.* Wadsworth Publ. Co. Inc. California.

BOWLAND, A.E. (1990) *The Ecology and Conservation of Blue duiker and Red duiker in Natal.* PhD thesis. University of Natal. Pietermaritzburg.

BOTHMA, J. du P. (1989) The dynamics of game populations. In: BOTHMA, J. du P. (Ed).*Game Ranch Management.* Van Schaik, Pretoria.

COHEN, L. & MANION, L. (1992) *Research Methods in Education* 3rd Edition. Routledge, London and New York.

COLLINSON, R.H.F. (1985) Selecting Wildlife Census Techniques. Monograph 6, Institute of Natural Resources, University of Natal, Pietermaritzburg.

ELOFF, T. (2002) The economic realities of the game industries in South Africa. In: FLACK, P.H. (2002) Exotic Game-Catching up with Texas. *Man*MAGNUM October 2002.

FLACK, P.H. (2002) Exotic Game-Catching up with Texas. *Man*MAGNUM October 2002.

HASCHICK, S.L. & KERLEY, G.I.H. (1996) Experimentally determined foraging heights of bushbuck (Tragelaphus scriptus) and boergoats (Capra hircus). *African Journal of Ecology* 26(2): 64-65.

LAWSON, D. (1986) *The ecology and conservation of suni in Natal.* PhD thesis. University of Natal, Pietermaritzburg.

MARCHANT, A.N. (1991) *An evaluation of the wildlife extension service in Natal.* MSc.Thesis. University of Natal. Pietermaritzburg.

ROWE-ROWE, D.T. (1994) *The ungulates of Natal.* Natal Parks Board, Pietermaritzburg.

SEYMOUR, G. (2002) Ecological separation of greater kudu, nyala and bushbuck at Londolozi. *CC Africa Ecological Journal*. 4: 137-146

SCHMIDT, J.L. (1983) A comparison of census techniques of common duiker and bushbuck in timber plantations. *South African Forestry Journal* 126: 15-19.

SKINNER, J.D. & SMITHERS, R.H.N. (1990) *The Mammals of the Southern African Subregion* (2nd edition). University of Pretoria.

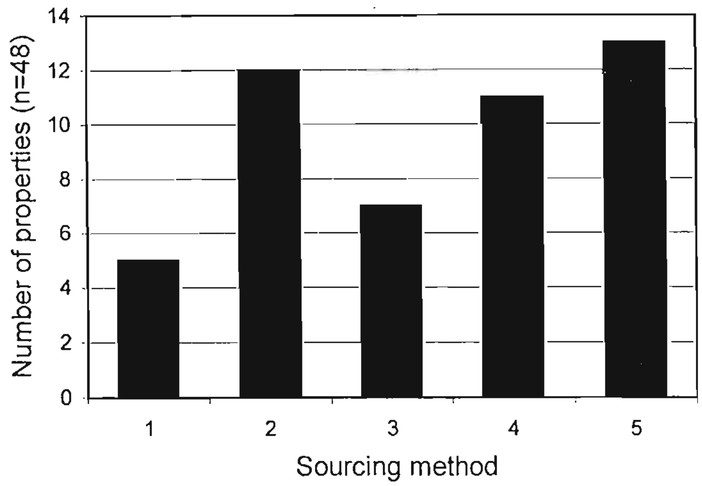

Figure 5.1 Source of contacts for properties used in this survey where:
1 = searching internet and magazines; 2 = replies to adverts; 3 = EKZNW tourism office; 4 = local tourism offices; 5 = word of mouth.

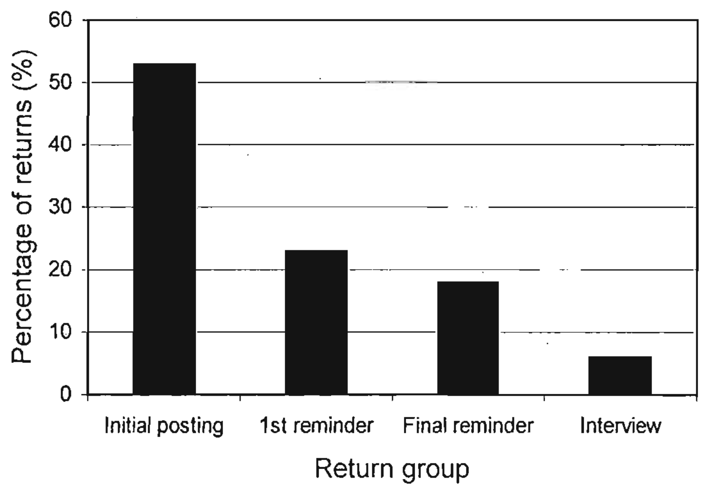

Figure 5.2 Returned questionnaires expressed as a percentage of the 40 usable returns and categorised according to when they were returned i.e., after the initial distribution, after the first reminder, after the final request, in person after a personal interview.

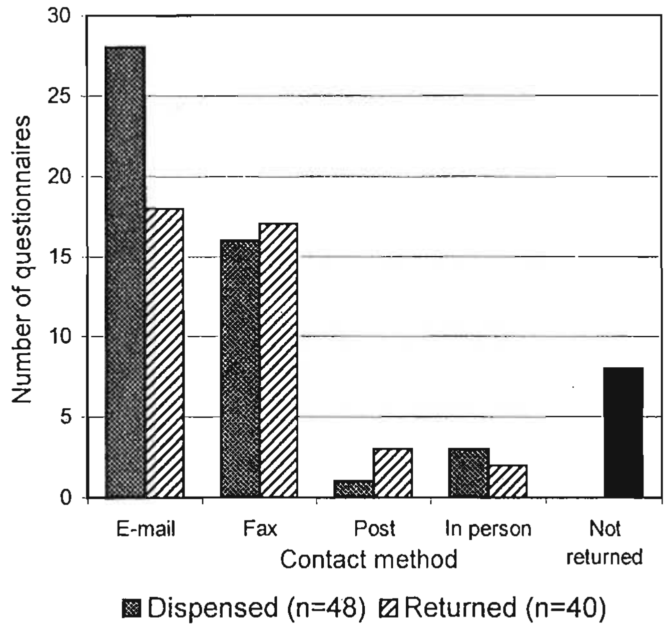

Figure 5.3 Contact methods used to distribute and return questionnaires. Options available were e-mail, facsimile, post or in person.

Table 5.1 Number of properties represented in each category (the same properties were used for each category 1 – 6, therefore, n = 40 for each category, except category 6 where n = 24 as only this number of properties had introduced nyala.)

Category	n	Category	n
1. Property location		4. Hunting permission	
N (northern KZN)	26	H (hunting allowed)	18
M (Midlands)	14	NH (no hunting)	22
2. Property ownership		5. Origin of nyala population	
K (EKZNW)	7	I (Introduced)	24
P (Private)	33	R (Natural)	16
3. Property size		6. Time since nyala introduction	
S (< 5000ha)	26	A (< 10 years)	10
L (> 5000ha)	14	B (> 10 years)	14

Table 5.2 Frequency of responses to question A2: 'Has either of the nyala or bushbuck populations on your property increased or decreased?' and 'if there has been a decrease, what might be the possible reasons?' See Table 5.1 for explanation of category.

Category		Response frequency (%)												
		n	A2b	A2e	A2g	A2h	χ^2 (3 df)	n	A2j	A2k	A2l	A2m	A2n	χ^2 (4 df)
1.	N	26	19.2	46.2	19.2	15.4	1.2	12	9.5	57.2	9.5	23.8	0.0	2.2
	M	14	35.7	35.7	7.1	21.5	1.2	5	25.0	62.5	0.0	0.0	12.5	4.2
2.	K	7	14.3	85.7	0.0	0.0	6.4	6	12.5	75.0	0.0	12.5	0.0	1.6
	P	33	27.3	33.3	18.2	21.2	2.1	11	14.3	52.4	9.5	19.0	4.8	0.6
3.	S	26	26.9	30.8	19.2	23.1	1.2	8	12.5	50.0	12.5	25.0	0.0	2.6
	L	14	21.4	64.4	7.1	7.1	3.6	9	15.4	69.2	0.0	7.7	7.7	2.2
4.	H	18	22.2	44.4	11.2	22.2	0.5	8	13.3	53.3	6.7	20.0	6.7	0.5
	NH	22	27.3	40.9	18.2	13.6	0.5	9	14.3	64.3	7.1	14.3	0.0	0.6
5.	I	24	37.5	25.0	16.7	20.8	1.9	6	22.2	66.7	0.0	0.0	11.1	3.5
	R	16	6.2	68.8	12.5	12.5	5.9	11	10.0	55.0	10.0	25.0	0.0	2.4
6.	A	10	50.0	10.0	30.0	10.0	6.5	1	100.0	0.0	0.0	0.0	0.0	0.7
	B	14	28.6	35.7	7.1	28.6	1.4	5	25.0	62.5	0.0	0.0	12.5	4.2
χ^2 (11 df)			6.7	14.2	5.6	5.9			2.7	1.6	4.9	7.9	7.9	
All categories		40	25.0	42.5	15.0	17.5		17	13.8	58.6	6.9	17.2	3.5	

b – only nyala increased
e – nyala increased while bushbuck decreased
g – nyala and bushbuck remained the same
h – nyala and bushbuck increased

j – poaching
k – competition
l – habitat loss
m – drought

n – over predation

Table 5.3 Frequency of responses to question A3: 'In your opinion, has the bushbuck population in your part of the province decreased over the years?' and 'if there has been a decrease, what might be the possible reasons?' See Table 5.1 for explanation of category.

Category		Response frequency (%)										
		n	A3 yes	A3 no	χ^2 (1 df)	n	A3c	A3d	A3e	A3f	A3i	χ^2 (4 df)
1.	N	26	57.7	42.3	0.8	11	13.0	56.6	8.7	13.0	8.7	0.2
	M	14	35.7	64.3	1.1	9	20.0	50.0	10.0	10.0	10.0	0.2
2.	K	7	85.7	14.3	3.6	6	9.1	54.5	9.1	18.2	9.1	0.7
	P	33	42.4	57.6	0.6	19	18.2	54.5	9.1	9.1	9.1	0.2
3.	S	26	38.5	61.5	0.9	10	17.5	47.1	11.8	11.8	11.8	0.5
	L	14	71.4	28.6	0.9	10	12.5	62.5	6.3	12.4	6.3	0.06
4.	H	18	38.9	61.1	0.7	7	22.2	66.7	0.0	11.1	0.0	2.1
	NH	22	59.1	40.9	0.9	13	12.5	50.0	12.5	12.5	12.5	0.8
5.	I	24	41.7	58.3	0.6	10	17.6	52.9	11.8	5.9	11.8	0.8
	R	16	62.5	37.5	1.1	10	12.5	56.3	6.3	18.8	6.1	1.4
6.	A	10	30.0	70.0	1.5	3	20.0	40.0	20.0	0.0	20.0	1.8
	B	14	50.0	50.0	1.6	7	16.7	58.4	8.3	8.3	8.3	0.2
χ^2 (11 df)			7.1	6.9			1.4	1.0	2.2	2.4	2.8	
All categories		40	50.0	50.0		20	15.2	54.5	9.1	12.1	9.1	

c – poaching
d – competition with nyala
e – habitat loss
f – drought
i – uncontrolled dogs

Table 5.4 Frequency of response to question A6: 'Do you have population estimation numbers for nyala and bushbuck on your property?' and question A7: 'Do you have a specific management plan for nyala and bushbuck?' See Table 5.1 for explanation of category.

Category		Response frequency (%)											
		n	A6a	A6b	A6c	A6d	χ^2 (3 df)	n	A7a	A7b	A7c	A7d	χ^2 (3 df)
1.	N	26	26.9	46.2	0.0	26.9	0.3	26	7.7	7.7	3.8	80.8	0.6
	M	14	14.2	42.9	0.0	42.9	0.9	14	7.1	0.0	0.0	92.9	1.2
2.	K	7	14.2	42.9	0.0	42.9	0.4	7	14.3	0.0	0.0	85.7	1.1
	P	33	24.2	45.5	0.0	30.3	0.1	33	6.1	6.1	3.0	84.8	0.3
3.	S	26	30.8	30.8	0.0	38.4	2.6	26	3.8	3.8	3.8	88.6	0.9
	L	14	7.2	71.4	0.0	21.4	3.9	14	14.3	7.1	0.0	78.6	1.2
4.	H	18	22.2	44.4	0.0	33.4	0.1	18	5.6	5.6	0.0	88.8	0.7
	NH	22	22.7	45.5	0.0	31.8	0	22	9.2	4.5	4.5	81.8	0.6
5.	I	24	16.7	54.2	0.0	29.1	0.7	24	8.3	8.3	0.0	83.4	0.9
	R	16	31.3	31.3	0.0	37.4	1.6	16	6.3	0.0	6.3	87.6	1.8
6.	A	10	30.0	50.0	0.0	20.0	0.8	10	0.0	0.0	0.0	100.0	1.8
	B	14	7.1	57.2	0.0	35.7	1.9	14	14.3	14.3	0.0	71.4	3.1
χ^2 (11 df)			6.0	5.0	-	2.3			3.5	5.3	4.3	0.9	
All categories		40	22.5	45.0	0.0	32.5		40	7.5	5.0	2.5	85.0	

a – only nyala
b – both nyala and bushbuck
c – only bushbuck
d – neither

Table 5.5 Frequency of response to question A8: 'How do you regulate the numbers of nyala on your property?' and question A9: 'How do you regulate the numbers of bushbuck on your property?' See Table 5.1 for explanation of category.

Category		Response frequency (%)														
		n	A8a	A8b	A8c	A8d	A8e	χ^2 (4 df)	n	A9a	A9b	A9c	A9d	A9e	χ^2 (4 df)
1.	N	26	16.7	40.0	6.7	20.0	16.6	6.5	26	3.8	11.5	65.5	0.0	19.2	6.1
	M	14	63.2	26.3	10.5	0.0	0.0	8.9	14	50.0	12.5	37.5	0.0	0.0	7.1
2.	K	7	0.0	44.4	0.0	55.6	0.0	21.2**	7	0.0	0.0	100.0	0.0	0.0	6.1
	P	33	42.5	32.5	10.0	2.5	12.5	3.8	33	25.7	14.3	45.7	0.0	14.3	0.9
3.	S	26	46.9	31.3	12.5	0.0	9.3	5.6	26	28.6	10.7	50.0	0.0	10.7	0.5
	L	14	11.8	41.2	0.0	35.2	11.8	13.2*	14	7.1	14.3	64.3	0.0	14.3	1.9
4.	H	18	68.0	32.0	0.0	0.0	0.0	15.3**	18	42.0	11.1	41.4	0.0	5.5	5.8
	NH	22	0.0	37.5	16.7	25.0	20.8	17.1**	22	0.0	13.6	68.2	0.0	18.2	6.7
5.	I	24	44.9	31.0	10.3	3.5	10.3	2.6	24	34.6	15.4	38.5	0.0	11.5	2.8
	R	16	20.0	40.0	5.0	25.0	10.0	7.7	16	0.0	6.3	81.3	0.0	12.4	6.6
6.	A	10	30.8	38.4	15.4	0.0	15.4	2.8	10	27.3	18.2	36.3	0.0	18.2	1.3
	B	14	47.4	21.1	5.3	5.3	5.3	3.2	14	40.0	13.3	40.0	0.0	6.7	6.3
χ^2 (11 df)			37.7**	2.5	8.4	49.9**	10.1			31.7**	2.8	10.9	-	6.8	
All categories		40	34.7	34.7	8.2	12.2	10.2		40	21.4	11.9	54.8	0.0	11.9	

** significant difference ($p < 0.01$)
* significant difference ($p < 0.05$)
a – hunting
b – live capture
c – do not need to (no excess animals)
d – culling
e – predator controlled

Table 5.6 Frequency of responses to question B15: 'do you believe that nyala and bushbuck compete for key resources?' and question B16: 'Do you have concerns about having nyala on your property?' See Table 5.1 for explanation of category.

Category		Response frequency (%)							
		n	B15 yes	B15 no	χ^2 (1 df)	n	B16 yes	B16 no	χ^2 (1 df)
1.	N	26	92.3	7.7	0.2	26	11.5	88.5	0.4
	M	14	85.7	14.3	0.3	14	21.4	78.6	0.3
2.	K	7	100.0	0.0	0.8	7	0.0	100.0	1.3
	P	33	87.9	12.1	0.2	33	18.2	81.8	0.1
3.	S	26	84.6	15.4	0.9	26	11.5	88.5	0.4
	L	14	100.0	0.0	1.5	14	21.4	78.6	0.3
4.	H	18	88.9	11.1	0.1	18	16.7	83.3	0
	NH	22	90.9	9.1	0.1	22	13.6	86.4	0.1
5.	I	24	91.7	8.3	0.1	24	25.0	75.0	1.4
	R	16	87.5	12.5	0.1	14	0.0	100.0	2.2
6.	A	10	90.0	10.0	0	10	0.0	100.0	1.9
	B	14	92.9	7.1	0.1	14	42.9	57.0	17.2**
χ^2 (11 df)			0.4	3.8			28.1**	2.7	
All categories		40	90.0	10.0		40	15.0	85.0	

** significant difference ($p < 0.01$)

Table 5.7 Frequency of response to question B17: 'If you did not have nyala on your property, would you still consider introducing them?' and 'if yes, what is your reasoning' and 'if no what is your reasoning' See Table 5.1 for explanation of category.

Category		Response frequency (%)													
		n	yes	no	χ^2 (1 df)	n	B17c	B17d	B17e	B17f	χ^2 (3 df)	n	B17g	B17k	χ^2 (1 df)
1.	N	26	88.5	11.5	0.1	23	17.4	8.7	39.1	34.8	2.4	3	66.7	33.3	0.1
	M	14	92.9	7.1	0.2	13	0.0	23.1	7.7	29.2	4.9	1	100.0	0.0	0.4
2.	K	7	85.7	14.3	0.1	6	50.0	0.0	50.0	0.0	14.6**	1	0.0	100.0	2.3
	P	33	90.9	9.1	0.1	30	3.3	16.7	23.3	56.7	1.9	3	100.0	0.0	0.1
3.	S	26	96.2	3.8	1.3	25	4.0	16.0	24.0	56.0	1.2	1	100.0	0.0	0.4
	L	14	78.6	21.4	1.7	11	27.3	9.1	36.3	27.3	5.1	3	66.7	33.3	0.1
4.	H	18	94.4	5.6	0.5	17	0.0	23.5	5.9	70.6	7.1	1	100.0	0.0	0.4
	NH	22	86.4	13.6	0.2	19	21.1	5.3	47.3	26.3	5.7	3	66.7	33.3	0.1
5.	I	24	83.3	16.7	0.8	20	0.0	15.0	15.0	70.0	7.7	4	75.0	25.0	0.1
	R	16	100.0	0.0	1.9	16	25.0	12.4	43.8	18.8	8.5	0	0.0	0.0	-
6.	A	10	100.0	0.0	1.2	10	0.0	20.0	20.0	60.0	1.6	0	0.0	0.0	-
	B	14	71.4	28.6	0.8	10	0.0	10.0	10.0	80.0	7.3	4	75.0	25.0	0.1
χ^2 (11 df)			1.0	7.8			29.1**	4.9	15.1	17.4			2.6	2.7	
Overall		40	90.0	10.0		36	11.1	13.9	27.8	47.2	2.2	4	75.0	25.0	

** significant difference ($p < 0.01$)
c – only ecological (management of vegetation etc.)
d – only economical (tourism, hunting etc.)
e – more ecological than economical
f – more economical than ecological

* significant difference ($p < 0.05$)
g – concern of losing bushbuck due to competition with nyala
k – beyond their natural range

CHAPTER 6

Synthesis and Management Recommendations

Limitations of the Present Study

The present study experienced many difficulties, most notably in the areas of capture and telemetry (Appendix B). The fact that bushbuck are largely solitary, nocturnal, secretive and inhabit thick vegetation also affected the quality and quantity of the data collected during the present study. Previous telemetry studies of bushbuck and other forest dwelling antelopes have noted similar difficulties (Odendaal 1977; Allen-Rowlandson 1986; Lawson 1986; Bowland 1990), and as a result, the present study suffered three notable limitations:

1. Lack of seasonal investigation

The original intention of the present study was to collect data over a full seasonal cycle. However, complications with capture and telemetry hampered the progress of the present study to the extent that usable data from telemetry was only collected for largely the summer season of 2002/3. Bushbuck have been shown to display some seasonal variation in movement, habitat and food preferences, and behaviour. Most of this seasonal variation occurs with food preferences which are directly related to food availability according to variations in seasonal productivity of the vegetation, whereas movements and habitat preferences are fairly stable throughout the year (Jacobsen 1974; Odendaal 1977; Allen-Rowlandson 1986; MacLeod 1992). Behaviour appears to remain fairly constant throughout the year apart from Allen-Rowlandson (1986) recording a higher degree of diurnal activity during summer and Odendaal and Bigalke (1979) recording a lack of male-male association for three months of the year. Probable seasonal changes in home range size and overlap cannot be concluded from other studies but it does appear as though seasonal variation in home range utilisation may occur (Odendaal 1977; Allen-Rowlandson 1986). Observations of bushbuck during population estimation at SDGR suggested that bushbuck had shifted their core areas to concentrate in the riparian areas along the permanent rivers and the dam. This has also been observed in Mpumalanga (Hiscocks pers comm.[1]) and other studies (Jacobsen 1974; Allsopp 1978; Simbotwe and Sichone 1989). Investigation of this using radio telemetry would have been invaluable during the present study, as this would have provided important information for management on habitat utilisation and possible resource dependence during winter when resources are limited and bushbuck are at their most vulnerable (Allen-Rowlandson 1986). The fact that it was a drought year would also have enhanced the investigation of bushbuck dependence on certain habitat types during this time of stress.

2. Estimates of bushbuck density and abundance

The census methods selected for the present study were based on the suggestions of other studies that have compared numerous methods for enumerating bushbuck and other forest dwelling species (Odendaal 1977; Anderson 1978; Schmidt 1983; Allen-Rowlandson 1986; Lawson 1986; Bowland 1990). None of these methods provided consistent estimates with substantial variation being evident between seasons and methods (Chapter 4). True density and abundance of bushbuck at SDGR could, therefore, not be established with any certainty. This limitation was not unique to the present study or to the study area. However, it is suggested that increased sampling replications for sighting efforts, a higher number of marked animals for mark-resighting, and the use of Programme DISTANCE 4.0 (Buckland *et al.* 1993) to analyse the distance sampling data may have enhanced the present investigation.

3. Determination of bushbuck sex and age structure

The determination of bushbuck age and sex structure during the present study was severely limited by only being able to assess these using field classification. Field classification has been shown to produce a biased ratio toward females for bushbuck as a result of young males being indistinguishable from adult or sub adult females using this technique (Allen-Rowlandson 1986). A similar trend was evident in the present study and, therefore, the sex and age ratios calculated for bushbuck at SDGR in Chapter 4 are suggested to be very subjective.

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Nyala Introductions and Possible Competition with Bushbuck

As discussed in Chapter 5, nyala have been, and are still being introduced extensively beyond their natural range, primarily for economic incentives from hunting and live sales. Most of these nyala populations are reproducing successfully thereby increasing the nyala's status in terms of abundance and future distribution. Trends in past surveys of antelope status in KZN have suggested that the status of bushbuck has changed from being stable to stable-declining (Mentis 1974; Howard and Marchant 1984; Anderson *et al.* 1989; Rowe-Rowe 1994; Anderson *et al.* 1996; the present study). This is largely as a result of habitat loss and modification from agriculture. However, trends particularly on private land where nyala have been introduced are also suggesting a drop in bushbuck status. Numerous bushbuck populations are still conserved on other properties where nyala have not been introduced with most of these populations being very successful and therefore stable or increasing (Rowe-Rowe 1994; Anderson *et al.* 1996). This indicates that no immediate threat to bushbuck status exists considering the population as a whole, however, there is some concern for the status of bushbuck on properties where nyala are present and where nyala introductions are being proposed.

Possible competition between nyala and bushbuck is perceived to revolve around an overlap in feeding strategy, particularly feeding height (du Toit 1990; Haschick and Kerley 1996). Implications of this overlap for interspecific competition would, however, depend on forage production within the respective preferred height ranges, browser population densities, and habitat and feeding preferences (Haschick and Kerley 1996). Only one previous study has documented possible competition between nyala and bushbuck where ecological separation was investigated by determining similarities in habitat and food preferences (Seymour 2002). This study concluded a high similarity for habitat and food preferences between nyala and bushbuck, particularly during the dry season (> 80 %). This suggests a high possibility of competition in terms of habitat and food preferences where conflict is predicted to arise in times of resource scarcity when the abundance of high quality foods that are required by these selective browsers may be limited. If competition does exist, it is likely to prevail in terms of feeding height and species selection whereby it is the larger bodied individual (i.e., nyala) that is able to access additional nutrients due to its greater vertical browsing capacity, and it is the smaller bodied individual (i.e., bushbuck) that suffers the greatest mortalities due to lack of nutrients or physical displacement by the more powerful larger bodied individual (Voeten and Prins 1999). This could be further compounded in reserves with high concentrations of nyala or smaller reserves where reserve boundary fences prevent physical displacement of bushbuck to an allopatric situation leading to a forced sympatric existence of these two species (Chapter 5). This may be the cause of rapid localised declines in bushbuck that suffer high mortality due to starvation when forage availability to bushbuck is exhausted by nyala overutilisation during times of food shortages, effectively excluding the smaller competitor (Chapter 5, pers. obs.).

It is, therefore, suggested that natural competition for space and food exists between nyala and bushbuck. However, this competition only leads to bushbuck declines when nyala stocking rates are too high. High stocking rates of nyala have been suggested to cause modifications to habitats that are critical to species such as bushbuck, suni and forest duikers (Lawson 1986; Bowland 1990; Rowe-Rowe 1994). The problem of bushbuck declines after nyala introductions are therefore suggested to be management related. Economic incentives are suggested to have allowed certain nyala population to exceed carrying capacity to maximise profits on many properties, or the population exceeds carrying capacity undetected as a result of this species being difficult to monitor. Similar suggestions were made by Lawson (1986) and Bowland (1990) who advised nyala introductions to areas where suni and forest duikers (blue and red) naturally occurred be considered with caution. They also advised that nyala numbers should be kept very conservative, perhaps half the suggested stocking rate for this species in that specific area, to prevent negative influences on the suni and forest duiker populations. Problems associated with this are that nyala are difficult to enumerate and therefore it is difficult to monitor their numbers or manage the population effectively.

If landowners considering the introduction of nyala have concerns for possible losses of these species, nyala should not be introduced without an effective monitoring and management plan, which at present is difficult to define. This plan needs to include an efficient, but accurate method of evaluating population status (density, abundance, sex and age ratios). Together with vegetation monitoring and assessment of browse availability, accurate knowledge of population status can determine stocking rates, population performance and offtake rates which enable optimal utilisation of that population (Anderson 1978).

Management Recommendations for Bushbuck at SDGR

Prior species-specific management of bushbuck for conservation purposes in KwaZulu-Natal has been minimal owing to its past satisfactory status throughout the province (Anderson *et al.* 1996). Management on private land however, has been addressed as bushbuck are considered to be valuable in terms of vegetation management and sustainable utilisation by hunting and live sales.

Allen-Rowlandson (1986) extensively outlined the management of bushbuck in timber plantations according to the three problems of population management stated by Caughley (1977) namely conservation, control and utilisation. More recently Rowe-Rowe (1989) and Marchant (1991) have provided management suggestions for bushbuck primarily on farmlands. The management recommendations provided by these authors are largely applicable to the proposed management of bushbuck at SDGR and are therefore used as a basis for the management recommendations of the present study.

Conservation

Caughley (1977) suggests that a conservationist strategy should be applied to small or declining populations to raise its density. Once the population has reached the maximum for the area one can consider other aspects of management, namely control and utilisation of the surplus (Rowe-Rowe 1989). Considering that SDGR was only fenced within the last decade, it is suggested that the bushbuck population in the area prior to the completion of fencing was not at ecological carrying capacity as a result of poaching and dogs (Coulon pers comm.[2]). It was also suggested that the population was significantly smaller then than what has been suggested by the present study. The relatively high number of juveniles sighted during the present study also suggests that the population is reproducing successfully and that the population is increasing.

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[2] Coulon, P. Land and Wildlife Manager, Msinsi Holdings (Pty) Ltd. PO Box X1020, Hillcrest 3650.

Stocking Rate

Rowe-Rowe (1989) suggests that stocking rates for bushbuck in favourable habitat should be between 12 and 20 ha per animal. Marchant (1991) suggests approximately 8 ha per animal. This would indicate that the present bushbuck density estimate of 1 bushbuck per 8.2 ha of suitable habitat calculated for SDGR from the present study is considered to be at the recommended stocking rate. However, this stocking rate is considered to be low when compared to many other conservation areas throughout Africa where bushbuck were conserved in their natural habitat. Jacobsen (1974) recorded 1 bushbuck per 1.5 ha in Zambia and Allsopp (1978) recorded 1 bushbuck per 3.3 ha in Kenya. Equally high densities were evident in KZN where Kenneth Stainbank Nature Reserve had a stocking rate of 1 bushbuck per 2 ha (Marchant 1991). Past densities recorded for areas in the KZN midlands (Chapter 4 and 5) and the Umfolozi area on the north coast (Mentis 1970) have also indicated the ability of bushbuck to exist at high densities where favourable conditions prevail. If SDGR is able to provide similarly favourable conditions for bushbuck, the density of this population may also have the potential to reach equally high densities and may result in a highly profitable population for future utilisation.

However, the limiting factor that controls bushbuck density appears to be availability of forage during winter (Allen-Rowlandson 1986) and suggests that stocking rates should be based on this information. Without knowledge of the seasonal productivity of favourable bushbuck forage, or the ecological carrying capacity of the reserve considering all species that utilise it, it is impossible to determine what the optimum stocking rate of bushbuck at SDGR should be (Anderson 1978). This needs to be determined before accurate estimations of bushbuck stocking rate can be established for SDGR.

Habitat Protection

Rowe-Rowe (1989) states that habitat loss and modification are the leading causes of bushbuck declines in KZN and also advises the careful management of bushbuck habitat when managing the bushbuck population itself. This corresponds with Bowland (1990) who suggested that the management of particular habitats of importance to a certain species should be given at least equivalent management status as the species itself. An ecosystem or holistic view is therefore suggested when considering the conservation and management of bushbuck (and all species according to Soule 1987) at SDGR.

If further studies of carrying capacity at SDGR reveal that bushbuck could be stocked at a higher density than exists presently, management may be aimed at building up a population, which can generally be achieved by habitat improvement and protection (Rowe-Rowe 1989). The important requirements of bushbuck are suitable cover, the right type of food at the right height, and an area from which poachers and dogs are excluded. The present study has identified the short thicket vegetation types as the habitat preferred by bushbuck in terms of the amount of time that this species spends in them (Chapter 3). This is owing to the provision of cover and probable abundance of suitable forage for bushbuck (Patrick 1998) and indicates that bushbuck management should encompass the improvement and protection of this habitat. Bushbuck are also suggested to utilise the riverine areas extensively during winter (Coates pers obs.) which suggests special attention from management for these areas. The ecotone regions or bush margins are also of great importance as these fringe areas provide a large variety of plants at the correct browsing height for bushbuck (Coates pers obs.). Fire frequency and intensity should therefore be carefully implemented so as not to destroy these feeding areas or open up the thicket habitat on which the bushbuck depends.

Alien plant species such as *Chromolaena odorata* and *Lanatana camara* are still locally abundant (Coates pers obs.) at SDGR and although they provide favourable cover, the control of these alien species is vital so as not to limit available forage to bushbuck. Alien invasive control programmes have been and are currently being implemented through Working for Water (Umgeni Water) at SDGR. Patrick (1998) suggests that this programme has been largely successful and should therefore be continued.

SDGR does not have an extensive road network (Coates pers obs.) which limits management options. The construction of additional roads to increase accessibility would assist management of vegetation and bushbuck (and all game species), however, the clearing of vegetation should be considered carefully so as not to remove or cause disturbance to large areas of bushbuck habitat. If additional roads are considered necessary they should avoid replacing areas highly utilised by bushbuck such as bush margins and riverine vegetation.

Control of Poaching and Dogs

Negative influences of poaching may not only be induced by direct removal of animals from snares and dogs, but also by the removal of trees and vegetation for fire wood and traditional uses. Extensive removal of this vegetation may cause habitat degradation which has already been identified as a leading cause of bushbuck declines. The level of poaching at SDGR does not seem to be of concern (Coulon pers comm.), however, Allen-Rowlandson (1986) found that data obtained from marked animals killed by poachers during his study indicated that illegal hunting using dogs or snares may have been more serious than was thought at that time at Weza State Forest. No marked animals were poached during the present study and very few carcasses were encountered in the field. This further suggests that illegal hunting is not a major problem at SDGR, however, the reserve is almost completely surrounded by human inhabitancy and this creates the possibility of poaching in all areas of the reserve. This requires that poaching is still an aspect of management that needs considerable attention in order to prevent poaching from becoming a threat to the bushbuck population in the future.

Current measures of restricting access to the reserve, controlling feral and hunting dogs, and searching and removing snares should be maintained. Allen-Rowlandson (1986) suggests that these measures should be employed particularly during and immediately after the Christmas period. Observations by Allen-Rowlandson (1986) in his study and the author in the present study further suggest that the chances of encountering dogs and apprehending poachers are greatest at night. Conducting random spotlight patrols would deter poaching and could also be incorporated into routine surveys to obtain indices of game abundance etc.

Interactions with Other Species

There are concerns about introduced nyala causing localised reductions in bushbuck numbers as a result of competition in many other areas (Chapter 5) and the proposed introduction of nyala to SDGR may be a negative influence on the conservation of bushbuck. It is strongly advised that nyala should not be introduced without further research of possible competition that identifies an effective nyala management plan. Marchant (1991) also advises that cattle activity be strictly moderated in bushbuck habitats as extensive disturbance by cattle causes modifications to the undergrowth. Although the reserve is fenced and cattle are forbidden from entering the reserve, they do get in (Coates per obs.) and may require more intensive monitoring. Other species such as kudu, zebra and bushpig have been suggested to negatively influence duiker populations by modification of the undergrowth through trampling and over utilisation (Bowland 1990). Although no similar influences have been noted on bushbuck populations from these particular species elsewhere, it may be a consideration to keep in mind.

Population Control and Utilisation

Rowe-Rowe (1989) states that habitat modification as a result of over utilisation by bushbuck seldom occurs. However, if the population exceeds ecological carrying capacity, bushbuck have been shown to regulate themselves by moving out of the area (Marchant 1991). Bushbuck have even been suggested to display drastic measures of self population regulation such as self-destruction by drowning themselves in the sea (Keep and Broker 1986). This was, however, an abnormal occurrence that has only ever been recorded once and even after extensive veterinary investigations, it was unclear as to what caused this behaviour.

Where boundary fences restrict movement of animals, control of the population needs take place. Control can be implemented either by habitat modification or by reducing population numbers by removing animals. Although Allen-Rowlandson (1986) suggests that habitat modification is the most effective means of population control, SDGR is a nature reserve and habitat disturbance is to be kept to a minimum. Therefore, after stocking rates have been determined for bushbuck at SDGR and the population reaches this limit, it is suggested that population control be implemented by means of reducing population numbers.

Population reduction may be implemented by culling, hunting or live removals (Allen-Rowlandson 1986). Culling provides no economic benefit and therefore utilisation of the excess population is regarded as minimal (Bothma 1989). Bushbuck are one of the most valued antelopes in KZN (Rowe-Rowe 1994) and economic benefits from hunting and live sales can be valuable to the economic viability of the reserve (Bothma 1989). Live removal of animals is costly, but may become a more profitable investment in the future if local bushbuck status continues to decline. It is assumed that if future bushbuck removals by live capture are necessary, a professional capture team will catch them and so capture and transport methods for bushbuck are not included in the present recommendations.

Most economic benefits from hunting are generated from trophies (Eloff 2002). Since only males carry horns they are the targeted gender for trophy hunters. The female bushbuck is also classified as "protected game" in KZN and may only be shot on a permit issued to the landowner, whereas, the male is "ordinary game" and may be shot by anybody in possession of a hunting license, who has the landowner's permission, during the hunting season. At present, approximately 120 male bushbuck are shot annually by overseas trophy hunters in KZN, fetching up to US$640 per animal (Wagner pers comm.[3]). Controlling the male bushbuck population is therefore suggested to be implemented through hunting. However, the hunting of males only, and generally large mature males, is not considered to be in the best interests of population management (Allen-Rowlandson 1986). The largest, oldest males are key members of a healthy bushbuck population, being most successful at mate acquisition, passing their genes for large trophies to future generations (Rowe-Rowe 1989).

All references agree that because bushbuck are most vulnerable during late winter and early spring, hunting should take place in early winter as the animals will be in much better condition and the reduction of population density will ensure more food availability for those remaining. Annual harvesting levels suggested by Rowe-Rowe (1989) and Marchant (1991) are approximately 10 % - 15 % of the population in general while Allen-Rowlandson (1986) advised a much more conservative level of 4 % at Weza. In some cases annual removals can be as much as 20 % (Rowe-Rowe 1989), however, without accurate estimates of bushbuck abundance, recruitment or ecological carrying capacity, it is impossible to determine the optimum harvesting level (Marchant 1991).

Female bushbuck are generally not hunted as it is considered to be unethical (Rowe-Rowe 1994). It has also been suggested that hunting males only will increase the recruitment rate of the population, as sex ratio at birth is 1:1, for every two males removed at least one female will replace them and provide offspring (Marchant 1991).

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[3] Wagner, J. Hunting and Extension Division, EKZN Wildlife Queen Elizabeth Park. PO Box 13053, Cascades 3202.

However, both Rowe-Rowe (1989) and Marchant (1991) advise the removal of females as well to maintain the gender ratio of approximately 1:1. Allen-Rowlandson (1986) also suggests the inclusion of females in harvesting as this may actually increase the size of the calf crop as more food for the remaining females can increase the birth rate and calf survival.

Of concern from the population ratios determined during the present study at SDGR, is that there may already be a larger number of females in the population than males. This suggests that before males are removed by hunting, a number of females need to be removed to achieve and maintain this balance. However, as discussed in Chapter 4, the population ratios determined from the present study are suggested to be biased towards the female component as a result of the subjectiveness of the method used. Further studies of bushbuck population structure at SDGR need to be conducted in order to determine if there is in fact cause for concern.

Monitoring the effects of management

Despite the obvious advantages of accurate estimates particularly when a population is to be reduced by culling or when proposals regarding hunting are submitted to management and administration staff, the need for absolute estimates is often questionable and such estimates may even be regarded as unnecessary luxuries (Caughly 1977, Allen-Rowlandson 1986). Bothma (1989) strongly advises the selection of a repeatable rather than accurate technique when monitoring trends in the population. For the purpose of monitoring the bushbuck population at SDGR a reliable estimation is required with high consistency from repeatability as the trends in census data over a certain time period will identify changes in population dynamics. A reliable estimation with high consistency does not necessarily mean that an accurate number of individuals will be obtained. Consistency through repeatability will allow for any changes in population trends to be noticed and reliability will ensure that other persons conducting population estimations using this technique in the future will be able to continue this consistency.

Spotlight counts are highly repeatable and is an easy-to-use method as well as efficient with regards to costs, time and man power required. Although this method does not yield necessarily accurate or precise data, it is a reliable method and is highly repeatable ensuring that any error induced will be consistent providing acceptable data for the purpose of monitoring population trends. Various equations can be used to interpret data collected from spot light counts and it is suggested from the findings of Chapter 4 that while the variable width transect equation may provide a more accurate account of bushbuck density, King's census equation provides a more conservative estimate which may be more advisable. Other studies of bushbuck abundance have suggested these counts should be done during winter to minimise the bias created from reduced visibility during the growing seasons (Schmidt 1983; Allen-Rowlandson 1986). However, a possible situation exists at SDGR where bushbuck concentrate in the riverine areas through which the only route available for counts exists. This was shown to produce considerable bias resulting in overestimates of bushbuck abundance during the present study. It is therefore advised that population estimation be done during late spring (October-November) when bushbuck are more likely to be evenly distributed throughout the reserve (pers. obs.). It is also important that counts be done in replicates of greater than 8 or even 10 to reduce the effect of variation, and preferably on consecutive evenings weather permitting (i.e., avoid conducting counts on evenings with rain or heavy winds).

Overall monitoring of vegetation canopy cover, species composition and abundance, and receding or encroaching bush margins should also be implemented to assess the implications of current management.

Future Research

Bushbuck ecology has been well documented to the extent that it is one of the best researched and best understood African antelopes (MacLeod 1992). However, most of this research was conducted prior to the mid 1970's, after which bushbuck were only studied for specific objectives such as species and site specific management (Odendaal 1977; Alen-Rowlandson 1986) or experimental research (Haschick 1994). Further general studies of bushbuck ecology are therefore not considered necessary, however, topics of further research to encompass aspects such as management and conservation are encouraged.

Bushbuck feeding ecology has been widely documented with detailed accounts of species selection and preference being recorded (Jacobsen 1974; Okiria

1980; Odendaal 1983; Allen-Rowlandson 1986; MacLeod *et al.* 1996; Seymour 2002). However, only one of these studies occurred in KZN (Allen-Rowlandson 1986). This study was also conducted primarily in exotic timber plantations and key food species identified from this and previous studies in other provinces and countries may not be the same at SDGR. A record of bushbuck feeding ecology at SDGR would therefore be valuable for management purposes. The present study originally intended to investigate bushbuck feeding ecology including species preference and preferred feeding height at SDGR. Most other studies of bushbuck feeding ecology were based on direct observations during the day. This was attempted at SDGR during the present study but low diurnal bushbuck sightings rendered this investigation fruitless. Observations at night were inconclusive because of difficulties in positively identifying the plant that the focal animal was feeding on. Investigation by faecal analysis was then attempted and samples were collected, however, this method was time consuming and time constraints prevented completion of this part of the project. These samples are still available for analysis and there are intentions for this analysis to be conducted.

It is presumed that if there are excess bushbuck in the future at SDGR, they will be hunted or culled to control their numbers. The carcasses of these animals could provide valuable opportunities to accurately assess bushbuck age and condition at SDGR which could not be determined from the present study. A number of methods could be employed namely: tooth eruption and replacement sequence; tooth attrition; cementum annuli; eye lens mass; and growth parameters (Taber 1969; Morris 1972; Spinage 1973; Simpson 1973; Allen-Rowlandson 1986). Knowledge of accurate age structure and condition of animals during certain seasons would be very valuable to the management of this species (Marchant 1991).

It is important that monitoring of the bushbuck population continues in order to be aware of population trends which would reflect impacts of management. A rigid monitoring technique has not been identified, however, the findings of Chapter 4 of the present study suggest that sighting efforts using King's census equation may be sufficient. This method requires time in the field dedicated specifically to collecting data which when computed provides an estimate of abundance. Specific criteria are inherent with this method to ensure valid estimations, which requires certain knowledge of scientific methodology. Field staff may not have the time or the knowledge to conduct this monitoring technique, therefore, it may be valuable to allow students studying the natural sciences to continue this aspect of the bushbuck management programme at SDGR.

From a veterinary perspective, Dr J Flamand (pers comm.[4]) explains that, "nyala and bushbuck seem to share the same parasite species, and this is particularly true of internal nematodes (nematodes being species specific to a particular host species). Kudu or reedbuck sharing a habitat with nyala would have different nematodes parasite species. Ticks are also parasites but not host specific, although numbers can build up if there are more hosts of the right approximate size, as would be the case if nyala were introduced, which would increase tick burdens on bushbuck. This could be of importance for two reasons:

1. As a result of the greater intraspecies social tolerance of nyala compared to that of bushbuck, one would get a concentration of more nyala in a given area compared to bushbuck which could possibly lead not only to direct competition for resources, but also lead to an increase in parasite numbers, both internal and external.
2. The numbers of parasites successfully establishing themselves in or on a host largely depends on the immune status of that host. Thus, when a calf is born, it withstands the immediate onslaught of parasites thanks to its maternal immunity, which in most species weans at about 5 – 7 months of age, after which its own immune system establishes. At about this age an individual can experience a higher burden of parasites until adult immunity establishes fully. This is effective unless there are enormous and overwhelming numbers of parasites (as could be conceived if there were a new and large population of nyala together with the bushbuck that are generally at lower densities and are probably not equipped to cope immunilogically with such a challenge)."

In addition, if the immune status of an animal drops, as happens in times of stress, then the numbers of parasites increase on it and can lead to fatal consequences for the host animal. Stresses such as malnutrition lead to increased parasite loads, but

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[4] Flamand, J. Project Leader and Veterinarian, Black Rhino Project. PO Box 456 Mtubatuba 3935.

these are generally temporary and of relatively short duration (winter, droughts). However, if the nutritional stress is sustained, possibly due to the presence of a competitor for food, then parasites can become an important cause of fatality.

Keep (1971) recorded some external and internal parasites from nyala at Ndumo in northern KZN. No record of bushbuck parasites has been produced to the authors' knowledge therefore providing a research opportunity to investigate the hypotheses stated previously.

A study investigating competition between nyala and bushbuck was proposed in the 1980's by Richard Bell who hypothesised that competition was determined by the nutrient status of the soil and the quality of the grass layer (du Toit pers comm.[55]). It seems that where the two species coexist the soil is eutrophic, and where bushbuck are outcompeted the soil is relatively dystrophic. Nyala are mixed feeders so if the grass layer is of high quality then nyala do not have to browse as much and can thus allow bushbuck to persist. Where the grass layer is of poor quality then nyala rely more on browse and bushbuck may get outcompeted. A study investigating population data trends for both species from a range of areas where they coexist and where bushbuck have declined after nyala introductions, coupled with grass and soil data, would test this hypothesis.

It is also hypothesised that properties that have both species and a full complement of predators are less susceptible to competition between the nyala and bushbuck as their population numbers are kept in check by natural predation (Anderson pers comm.[6]). This further suggests that competition is related to density, where if a manager is able to keep nyala numbers low, competition will be reduced to the extent that the two species can coexist. Ideally a predictive model could be created from population data. However, this would require extensive records of accurate estimations for both species. These records do not exist as a result of nyala and particularly bushbuck being very difficult to enumerate which may restrict this project, however, it is still worth pursuing as a proposal.

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[5] du Toit , J. Austin Roberts Professor of Mammalogy, Director MRI, University of Pretoria 0002.
6. Anderson, J.L. Director. KaNquane Parks and Environment Affairs Board. P.O. Box 1990, Nelspruit 1200

The issue of possible competition between nyala and bushbuck causing declines and local extinctions of bushbuck is not a new one and yet it has never been investigated from a management perspective. Many academics and conservation managers feel that investigations into this issue are well overdue (Anderson; du Toit; Markham[7]; Coulon; Tredger[8] pers comm.). Indications from the survey in Chapter 5 are that reserve managers feel that this research is important and would be valuable to the management of these species on their properties. Their enthusiasm to participate and assist with this research is also noted which suggests that there is tremendous scope and ability for these investigations to advance. The personnal opinions of respondents to the survey coupled with the findings of Seymour (2002), strongly suggest that competition does exist between nyala and bushbuck and that it has lead to declines or local extinctions of bushbuck in some areas. The fact that nyala introductions are continuing every year, extending their present distribution beyond their historical distribution, and that no particular management of these populations is apparent, [7]reflects that this problem could progress and escalate in the future and substantiates the need for further research in this regard.

References

Allen-Rowlandson, T.S. (1986) *An autecological study of bushbuck and common duiker in relation to forest management.* PhD. Thesis, University of Natal, Pietermaritzburg.

Allsopp, R. (1978) Social biology of bushbuck, *(Tragelaphus scriptus,* Pallas, 1766) in the Nairobi National Park, Kenya. *East African Wildlife Journal.* 16: 153-166.

Anderson, J.L. (1978) *Aspects of the ecology of the nyala (Tragelaphus angasi* Gray, 1849) *in Zululand.* PhD Thesis, London University.

Anderson, J.L., Carr, R.D., Hall-Martin, A.J., Joubert, S.C.J., Keep, M.E., Lloyd, P.H. and Vrahimis, S. (1989) South Africa. In East, R. (Compiler), Antelopes

[7] Markham, R. Business Development Manager, Msinsi Holdings (Pty) Ltd. P/Bag X1020, Hillcrest, 3650.

[8] Tredger, N. Former Reserve Manger, SDGR, Msinsi Holdings (Pty) Ltd. P/Bag X1020, Hillcrest, 3650.

Global Survey & Regional Action Plans, part 2: Southern & South-central Africa; pp. 57-70. IUCN, Gland.

Anderson, J.L., Knight, M., Lloyd, P., Reilly, B., Rowe-Rowe, D., van der Walt, P.T. Viljoen, P. and Vrahimis, S. (1996) *Chapter 3: South Africa*. In East R (compiler). *Antelope Survey Update number 3*. IUCN/SSC Antelope Specialist Group Report. Pp 8-33.

Bothma, J. du P. (1989) The dynamics of game populations. In: Bothma, J. du P. (Ed). *Game Ranch Management*. Van Schaik, Pretoria.

Bowland, A.E. (1990) *The Ecology and Conservation of Blue duiker and Red duiker in Natal*. PhD thesis. University of Natal. Pietermaritzburg.

Buckland, S.T., Anderson, D.R., Burnham, K.P. & Laake, J.L. (1993) *DISTANCE Sampling: Estimating Abundance of Biological Populations*. Chapman & Hall, London.

Caughley, G. (1977) *Analysis of Vertebrate Populations*. Chichester: John Wiley & Sons Ltd.

Du Toit, J.T. (1990) Feeding-height stratification among African browsing ruminants. *African Journal of Ecology* 28: 55-61.

Eloff, T. (2002) The economic realities of the game industries in South Africa. In: Flack, P.H. (2002) Exotic Game-Catching up with Texas. *Man*MAGNUM October 2002.

Haschick, S.L. (1994) *Foraging and digestion by bushbuck (*Tragelaphus scriptus*) and boergoats (*Capra hircus*) in captivity.* MSc. Thesis. University of Port Elizabeth.

Haschick, S.L. and Kerley, G.I.H. (1996) Experimentally determined foraging heights Of bushbuck (*Tragelaphus scriptus*) and boergoats (*Capra hircus*). *African Journal of Ecology* 26(2): 64-65.

Howard , P.C. & Marchant, A.N. (1983) The distribution and status of some large mammals on private land in Natal. *The Lammergeyer* 34:1-58.

Jacobsen, N.H.G. (1974) Distribution, home range and behaviour patterns of bushbuck in the Lutope and Sengwe Valleys, Rhodesia. *Journal of southern African Wildlife Management Association* 4(2): 75-93.

Keep, M.E. (1971) Some parasites and pathology of the nyala *Tragelaphus angasi* and its potential value as a ranch animal. *Lammergeyer* 45-55.

Keep, M.E. and Broker, P.R. (1986) Abnormal behaviour by bushbuck on the Natal north coast. *The Lammergeyer* 37:1-4.

Lawson, D. (1986) *The ecology and conservation of suni in Natal.* PhD thesis. University of Natal, Pietermaritzburg.

MacLeod, S.B. (1992) *Habitat use and diet of bushbuck in the Alexandria Coastal Reserve.* MSc. Thesis. University of Port Elizabeth, Port Elizabeth.

MacLeod, S.B., Kerley, G.I.H. and Gaylard, A. (1996) Habitat and diet of bushbuck (*Tragelaphus scriptus*) in the Woody Cape Nature Reserve: observations from faecal analysis. *South African Journal of Wildlife Research* 26:19-25.

Marchant, A.N. (1991) *An evaluation of the wildlife extension service in Natal.* MSc. Thesis. University of Natal, Pietermaritzburg.

Mentis, M.T. (1970) Estimates of natural biomasses of large herbivores in the Umfolozi Game Reserve area. *Mammalia* 34: 363-393.

Mentis, M.T. (1974) The distribution of some wild animals in Natal. *The Lammergeyer* 20:1-68.

Morris, P. (1972). A review of mammalian age determination methods. *Mammal Review* 2(3): 69-104.

Odendaal, P.B. (1977) *Some aspects of the ecology of bushbuck (Tragelaphus scriptus, Pallas 1776) in the southern Cape*. MSc Thesis, University of Stellenbosch.

Odendaal, P.B. (1983) Feeding habits and nutrition of bushbuck in the Knysna forests during winter. *South African Journal of Wildlife Research* 13(2): 27-31.

Odendaal, P.B., & Bilgalke, R.C. (1979) Home range and groupings of bushbuck in the southern Cape. *South African Journal of Wildlife Research* 9: 96-101.

Okiria, R. (1980) Habitat exploitation by the bushbuck in Rwenzori National Park. *African Journal of Ecology* 18: 11-17.

Patrick, B.G. (1998) *Open space planning: Integrating Shongweni Resources Reserve with the Umlaas river park and parts of the lower Mlazi catchmment.* MSc Thesis. University of Natal, Pietermaritzburg.

Rowe-Rowe, D.T. (1989) Bushbuck biology and management. Wildlife Management Technical Guides 23: 2pp. Natal Parks Board, Pietermaritzburg.

Rowe-Rowe, D.T. (1994) *The ungulates of Natal.* Natal Parks Board, Pietermaritzburg.

Schmidt, J.L. (1983) A comparison of census techniques of common duiker and bushbuck in timber plantations. *South African Journal of Forestry* 126: 15-19.

Seymour, G. (2002) Ecological separation of greater kudu, nyala and bushbuck at Londolozi. *CC Africa Ecological Journal* 4: 137-146

Simbotwe, M.P., and Sichone, P.W. (1989). Aspects of behaviour of bushbuck in the Kafue National Park, Zambia. *South African Journal of Wildlife Research* 19:38-41.

Simpson, C.D. (1973). Tooth replacement, growth and ageing criteria for the Zambezi bushbuck (*Tragelaphus scriptus ornatus* Pocock). *Arnoldia* 6(6): 1-31.

Spinage, C.A. (1973). A review of the age determination of mammals by means of teeth, with especial reference to Africa. *East African Wildlife Journal.* 11: 165-187.

Taber, R.D. (1969). Criteria of sex and age. In: *Wildlife Management techniques*, ed. Giles, R.H., Jr., pp.325-401. Washington: The Wildlife Society.

Voeten, M.M. and Prins, H.H.T. (1999) Resource partitioning between sympatric wild and domestic herbivores in the Tarangire region of Tanzania *Oecologia* 120: 287-294.

APPENDIX A

Mensural Data Collected from Bushbuck Captured at SDGR

All body measurements were recorded according to Skinner and Smithers (1990)*. The horn length of male bushbuck was recorded according to Rowland Ward specifications (Bryant 1984)*.

Date	04-Sep-02	04-Sep-02	04-Sep-02	04-Sep-02	05-Sep-02	23-Oct-02	04-Dec-02	04-Dec-02	14-Jul-03	14-Jul-03	20-Jul-03	13-Aug-03
Capture method	net	net	net	net	net	dart	dart	dart	net	net	dart	dart
Time	09:30	10:40	10:45	17:30	08:25	21:15	23:00	00:20	10:35	10:35	20:45	23:00
Location	SDGR	SDGR	SDGR	SDGR	SDGR	SDGR	SDGR	SDGR	SDGR	SDGR	SDGR	SDGR
Species	Bb	Bb	Bb	Bb	Bb	Bb	Bb	Bb	Bb	Bb	Bb	Bb
Animal. No.	1	2	3	4	5	6	7	8	9	10	11	12
Sex	F	M	F	F	F	F	M	M	F	F	F	M
Approx. age	2yrs	2yrs	4yrs	2yrs	4yrs	2yrs	5yrs	4yrs	6yrs	10 months	1.5yrs	6yrs
Transmitter freq.	150.090	150.170	150.020	150.120	150.000	150.220	150.140	150.200	-	-	-	150.229
Animal ID	SAF1	SAM1	AF1	SAF2	AF2	SAF3	AM1	AM2	-	-	-	-
Total length (cm)	110	123	120	104	124	109	156	140	140	90	103	162
Head and body (cm)	94	107	108	91	107	97	128	116	120	78	85	134
Tail (cm)	16	16	12	13	17	12	28	24	20	12	15	28
Hind foot (cm)	32	31	29	30	33	31	33	32	32	25	28.5	37
Ear (cm)	12	12	13	12	14	12	14	13	13	10	11	14
Horn length (cm)	-	16	-	-	-	-	34	28	-	-	-	38
Comments			pregnant		pregnant				Died	Too young released not collared	Died	Trophy male according to Rowland Ward

* See Appendix B for references

APPENDIX B

Capture and Telemetry

INTRODUCTION

Bushbuck are captured and removed annually from numerous properties in KZN (Ross pers comm.[1]). The suggested method of bushbuck capture is by using nets, however, capture by drug immobilisation has also been used with success (Allen-Rowlandson 1986, Ross pers comm.). The capture of bushbuck during the present study was necessary for telemetry purposes and both net capture and drug immobilisation by darting were attempted. This presented an opportunity to compare the relative success of each capture method at SDGR and also the effectiveness of radio-telemetry at the study site.

MATERIALS AND METHODS

Capture and Immobilisation

Net capture

Net capture was done by Tracey and du Plesis Capture Team[2] and followed a similar method to that described by Lawson (1986). A configuration of nets of 10cm mesh and 2m height was strung on vegetation along paths or roads partially enclosing small areas of suitable bushbuck habitat such that animals breaking sideways would encounter the net. A team of 25 beaters/observers was used where a line of beaters walked through the enclosed area driving animals toward the configuration of nets manned by observers at 15 m intervals. When fleeing animals entangled themselves in the net observers quickly restrained the animal to prevent it from injuring itself. The eyes were covered and a dose of 12ml "Thaloperidol" tranquilliser was administered intravenously via the ear vein to reduce stress. The collar was fastened around the animals' neck while body measurements were taken according to Skinner and

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[1] Ross, M. Ross Game Capture. Stockowners, PO Box 260 Howick 3290.
[2] Stockowners. Pietermaritzburg, PO Box 260 Howick 3290.

Smithers (1990) and Bryant (1984) after which the animal was released. The maximum time that any animal was immobilised was 10 minutes.

Chemical capture

Chemical capture by darting took place along a selected route on convenient evenings from the back of a bakkie. The capture team consisted of a driver, two observers (equipped with 1 000 000 c.p. Cadac spotlights), and a darter. The driver maintained a speed of 10 km/hr while the observers searched for animals from the back of the vehicle. When a suitable animal (adult/sub-adult male or female bushbuck) was spotted the driver manuvered the vehicle into a suitable darting range (less than 40 m) where possible before any attempts were made to dart the animal in the rump.

Darting was done by an experienced veterinarian[3] using the Dan-Inject system. This system comprised of a 05045 MOD IM rifle powered by CO_2 with a totally variable gas pressure and a telescopic sight suitable for use at night. Automatic projectile syringe darts of 2 ml capacity and 20 mm – 30 mm needle length (collared and barbed were used) fitted with custom-built detachable dart transmitters[4]. Dart transmitters weighed 7 g and were powered by a lithium alkaline battery with a 72 hour battery life transmitting between 140.900 MHz and 140.949 MHz. The rifle gas settings were calibrated before each darting evening by shooting a dart filled with water fitted with a dummy transmitter at a target placed at 10 m, 15 m, and 20 m. This was done to accommodate variation caused by the extra weight of the dart transmitter.

When an animal was darted it was tracked by "homing-in" on the animal using a portable spotlight (LeisureQuip rechargeable 1 000 000 c.p.), an Alinco DJ-X10 wide band receiver and a 6-element Yagi antenna until it was found. Immobilising agents used were 1.5 mg – 2 mg etorphine hydrochloride ("M99"), and 15 mg fentanyl mixed with 60 mg – 80 mg azerperone. The same dose of immobilising agent was used for both males and females as darting was done on an opportunistic basis. Dart wounds were treated with commercial wound aerosol and "Terramycin" and lesions were treated with an intramuscular injection of long-acting penicillin "Compropen". Whilst the animal was immobilised a collar containing a transmitter identical to those fitted during net capture were fastened around the animal's neck and

[3] Dr Richard Peterson. Veterinary Clinic. Prince Alfred Street Pietermaritzburg.

standard body measurements taken. Special care was taken to protect the eyes and monitor heart rate. Thereafter an antidote of 4 mg diprenorphrine hydrochloride ("M5050") per ml solvent was given intramuscularly or intravenously via an ear vein. The recovering animal was monitored until the veterinarian was satisfied that the animal had recovered sufficiently without danger to its wellbeing. The maximum time that any animal was immobilised was 25 minutes.

Telemetry

Tagging

Collars were custom made[5] and comprised of a nylon belt 40 cm in length and 2 cm wide with a leather pouch of dimensions 6 cm x 8 cm and weighing approximately 40 g. The transmitters secured inside the pouch of the collar were custom built[2] and weighed approximately 150 g. Total combined mass of the collar and transmitter was therefore approximately 190 g. This represented 0.63 % of the body mass of a female bushbuck (30 kg) and 0.48 % of the body mass of an adult male bushbuck (40 kg). This falls well below the recommended maximum mass of 3 - 5 % of total body mass which can be put on an animal without injury or interference with normal activity (Macdonald and Amlaner 1980) Transmitters were powered by a 3.6 V lithium/alkaline battery providing projected 1 year of continual transmission. Transmitter frequency ranged from 150.000 MHz to 150.220 MHz. Bushbuck readily take to water therefore the transmitter was encapsulated with plastic piping and enclosed with epoxy glue to ensure waterproofing. The transmitter antenna of approximately 30 cm in length was secured on the inside of the nylon collar to prevent irritation to the animal.

Tracking

Alinco DJ – X10 wide band receivers and three element Yagi antennas were used to locate the study animals. Initially a continuous strategy was adopted whereby attempts were made to locate the study animals every 30 minutes for 24 hours using the

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[4] Mr Cliff Dearden. Isabel Beardmore Road. Pietermaritzburg.

triangulation technique described by Andreka (1996). Bearings were taken with a compass from a fixed point secured by a GPS and superimposed onto a map and the location estimated to be where the two bearings crossed. These locations were then plotted on a digitised aerial photo using a GIS (ArcView® version 3.3 ESRI 1996). This strategy, however, proved to be largely inaccurate due to thick vegetation and the steep topography causing substantial reflection of the signal. Consequently, a discontinuous collection strategy was employed thereafter whereby attempts were made to locate animals twice a day, once before dawn and once after dusk, for two weeks of each month until the transmitters failed. The "homing in" technique described by White and Garrott (1990) was adopted during this period. This technique increased accuracy of locations as the animal was tracked until it was either seen or the signal indicated that the animal was very close and enabled an accurate location to be secured with a GPS (Garmin e-trex series) which was later downloaded onto a digitised aerial photo using ArcView® GIS. The continued use of triangulation did however occur in extreme cases where the animal had retreated into inaccessible areas.

RESULTS AND DISCUSSION

Capture

The details of the net capture conducted at SDGR during the present study are shown in Table B1. Net capture resulted in five bushbuck being successfully captured and collared in a space of three days. Four of these animals were females and one was a subadult male. The relative success of net capture was 41.6 % considering seven animals managed to escape. Five of the escaped animals were adult males that either jumped over the net or tore through it. This suggests that while net capture using nets of 10 cm mesh and 2 m height appeared to be successful in capturing female bushbuck, it was not at all effective for capturing male bushbuck. It is suggested that stronger and higher nets than those used in the present study be used in future at SDGR if male bushbuck are required to be captured.

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[5] Allisons Saddlery. Victoria Road. Pietermaritzburg.

Although a fair number of animals were caught within a short space of time using net capture, substantial effort and pecuniary costs in terms of man-hours was required. An average of 3 drives was required to successfully capture a bushbuck during the present study, however, the number may have been lower if more suitable nets had been used to increase chances of restraining males. The study area was also densely vegetated with valley bushveld and had a steep topography in many areas which limited the expanse of favourable ground that could be covered by drives. Bushbuck may also have been undisturbed by drivers in some areas due to thick vegetation and steep topography that provided adequate refuge from which they could not be chased.

A suitable number of female bushbuck were captured and collared using net capture, however, the capture team was not able to return with more adequate nets to capture the required number of males. Even if they had returned the costs would have been increased by the fact that all animals captured have to be paid for. Equal chance of capturing females and males was evident from the first attempts which suggested that the costs would be doubled to catch five males as five females would probably also have been captured in the process. Drug immobilisation by darting was therefore employed, as it is entirely selective allowing only the possibility of males being captured if so desired.

The details of the attempts to capture bushbuck by drug immobilisation (darting) at SDGR during the present study are shown by Table B2. Darting was attempted during the evening when bushbuck were most active and so the chances of encountering them was increased. Bushbuck were frequently sighted with over twenty animals being encountered on each darting occasion. However, the dense vegetation and steep topography that hindered net capture also limited the success of darting. The circumstances under which a dart may be fired with any certainty of hitting the animal (the animal was less than 30 m away from the vehicle and it was standing still with a clear view not obstructed by vegetation) were seldom encountered and opportunistic shots had to be fired which resulted in a majority of misses. The relative success of this capture method during the present study at SDGR was therefore poor with a total of 17.2 % of shots fired hitting an animal. Successful immobilisation then further reduced this success rate to 5.7 % and the overall average number of shots per successful immobilisation to 17.4. While this method required less labourers than net capture, the effort required and the expenses incurred were far larger.

Allen-Rowlandson (1986) darted bushbuck in timber plantations and achieved a relative success of 58.6 % of shots fired resulting in a captured animal and only 1.7 shots per successful immobilisation. He used a strategy of luring bushbuck into the open with planted crops of maize and vegetables. If attempts to dart bushbuck at SDGR are ever considered again, it is strongly suggested that a similar strategy be employed so as to avoid a similar failure to that experienced during the present study.

Telemetry

Telemetry had two uses during the present study at SDGR. It assisted with detecting hit animals and missed shots during darting and also for determining locations of radio-collared bushbuck. The dart transmitters used were highly successful with 98 % of darts fired being recovered and timeously. Only one dart was lost as a result of a telemetry failure while the other was lost as a result of the animal not becoming immobilised and therefore unapprehendable. The transmitters provided a substantial range considering the dense vegetation and topography and enabled the animal to be found within a couple of minutes in most instances. The additional weight of the transmitter on the back of the dart did severely effect the gas settings necessary to project the dart, however, the use of a dummy transmitter to calibrate the gas settings before hand minimised the inaccuracies caused by the transmitter.

The transmitters used for the radio collars failed prematurely during the present study, only supplying 6 months of transmission instead of 10-12 months. The dense vegetation and steep topography severely affected the range provided by the transmitters and caused substantial reflection which disabled the use of triangulation in most instances. The use of triangulation during the present would have greatly reduced the effort required to gain locations and would also have provided a larger quantity of locations. However, accuracy of locations was of vital importance in the present study and predictive tracking by homing in on the animal therefore had to be employed. While this method provided more accurate locations, it was time consuming and severely restricted the number of locations that could be determined as each animal had to be followed individually. Concerns with this method were that disturbance created by the persons tracking the animal on foot would alter the animals natural behaviour. This further restricted the number of locations that could be determined for an animal in one day as the animal could only be tracked once in the morning and once in the evening to minimise the effect of tracker disturbance.

REFERENCES

Allen-Rowlandson, T.S. (1986). *An autecological study of bushbuck and common duiker in relation to forest management.* Unpublished PhD Thesis, University of Natal, Pietermaritzburg.

Andreka G.E. (1996). *Spatial utilisation, habitat selection and population status of the wild dog (*Lycaon pictus*) population in Hluhluwe Umfolozi park.* Unpublished MSc Thesis, University of Natal, Pietermaritzburg.

Bryant, E.R. (Ed) (1984). Rowland Wards African Records of Big Game. 19th edition San Antonio: Rowland Ward Publications.

ESRI (1996) Arcview® GIS: the Geographic Information System for everyone. Environmental Systems Research Institute Inc. USA

Lawson D. (1986) *The ecology and conservation of suni in Natal.* PhD thesis. University of Natal, Pietermaritzburg.

Macdonald, D.W. and Amlaner, C.J. (1980) *A handbook on biotelemetry and radio tracking*. Pergamon Press, Oxford.

Skinner J.D. & Smithers R.H.N. (1990) *The Mammals of the Southern African Subregion* (2nd edition). University of Pretoria.

White, G.C. and Garrott, R.A. (1990) *Analysis of wildlife radio-tracking data.* Academic Press, California.

Table B1: Number of bushbuck sighted and caught during net capture at SDGR in spring at SDGR.

Date	Attempt	Bushbuck Sighted Adult Male	Adult female	Juvenile	Total Sighted	Total Caught
02/09/02	1	0	1	0	1	0
	2	0	0	0	0	0
	3	0	0	0	0	0
	4	0	0	0	0	0
04/09/02	5	1	0	0	1	0
	6	0	1	1	2	2
	7	0	0	0	0	0
	8	1	0	0	0	0
	9	0	1	1	2	1
05/09/02	10	1	1	0	2	1
	11	1	0	0	1	0
	12	0	0	0	0	0
	13	1	0	0	1	0
	14	0	1	0	1	1
	15	0	0	0	0	0
Total	15	5	5	2	12	5
Overall success rate (no. of animals caught/no. of animals seen)						41.6%
No. of drives for each successful capture						3

Table B2: Darting details during the attempted drug immobilisation of bushbuck at SDGR

Details of darts fired	
No. of shots fired	87
No. of hits	15
% of hits	17.2%
No. of misses	72
% of misses	82.8%
No. of darts recovered from hit animals	13
No. of darts recovered from misses	72
% of darts recovered	98%
No. of immobilised animals detected	5
No. of animals hit but not immobilised or detected	10
POSSIBLE REASONS FOR MISSED SHOTS	
Incorrect gas setting, misjudgement of distance	38
Dart obstructed by vegetation	34
POSSIBLE REASONS FOR HIT ANIMALS NOT IMMOBOLISED OR DETECTED	
Dart bounced off – dart did not penetrate	3
Dart penetrated – poor placement, individual animal resistance	4
Dart/needle broke – drug not discharged	2
Telemetry failed – animal and dart not found	1
Overall success rate (no. of animals immobilised and detected/no. of shots fired)	5.7%
No. of shots for each successful immobilisation	17.4

Table B3: Details of bushbuck deaths directly attributable to capture and collaring techniques used during the present study at SDGR.

Sex	Age	Details
F	Adult	Animal ran into net at high speed and sustained injuries to its spinal vertebrae causing permanent paralysis of the hind legs, had to be destroyed.
F	Juvenile	Animal was darted and detected successfully, collared and released without complication. Animal found 1 week later with front left leg entangled in collar, died of suffocation.

APPENDIX C
Circulated Questionnaire used in the Chapter 5 Survey

University of Natal MSc Survey: A survey of the status and management of nyala and bushbuck living in sympatry in KwaZulu Natal.

Name: ....
Property: ....
Date: ....
Contact: .... E-mail
.... Tel
.... Fax

Please indicate your choice by marking the corresponding letter in brackets [ ]. Completed questionnaires may be e-mail to 982193698@nu.ac.za or faxed to (033) 260 5105. Please complete applicable questions in both sections A and B. Where applicable you may mark more than one option for a particular question.

Section A

1 Are there both nyala and bushbuck resident on your property?
[a] yes [b] no

2 Has either of these species population decreased or increased over the years?
[a] only nyala decreased
[b] only nyala increased
[c] only bushbuck decreased
[d] only bushbuck increased
[e] nyala increased while bushbuck decreased
[f] bushbuck increased while nyala decreased
[g] nyala and bushbuck remained the same
[h] nyala and bushbuck increased
[I] nyala and bushbuck decreased

If there has been a decrease, what might be the possible reasons?
[j] poaching [n] over predation
[k] competition [o] management decision
[l] habitat destruction [p] dogs
[m] drought

3 In your opinion, has the bushbuck population in general in your part of the province decreased in recent years?
[a] yes [b] no

If yes, what in your opinion has mainly contributed to this decrease?
[c] poaching [g] over predation
[d] competition with nyala [h] management decision
[e] habitat destruction [i] dogs
[f] drought

4 What is the approximate size of your property?
[a] < 1000 ha [c] 1000ha – 5000ha
[b] 5000ha – 10 000ha [d] > 10 000ha

5 Where did your nyala population come from?
[a] introduced [c] naturally resident
[b] encroached from neighbour [d] do not know

If introduced or encroached from neighbour, approximately how long ago were they introduced or did they appear?

[e] 0 – 5 years [g] 5 – 10 years
[f] 10 – 20 years [h] > 20 years

6 Do you have population estimation numbers for nyala and bushbuck on your property?

[a] only nyala [c] only bushbuck
[b] both nyala and bushbuck [d] neither

If yes, how far back do these records date?

[e] after 1990 [g] 1980 – 1989
[f] 1970 – 1979 [h] before 1970

If yes, how accurate are these records?

[i] accurate [j] vague estimation

If yes, what method did you use to get these numbers?

[k] annual game counts [m] frequent report back from rangers
[l] other

7 Do you have a specific monitoring or management plan for either nyala or bushbuck

[a] only nyala [c] only bushbuck
[b] both nyala and bushbuck [d] neither

if yes, please describe

Nyala...
Bushbuck..

8 How do you regulate the numbers of nyala on your property?

[a] hunting [d] culling
[b] live capture [e] predator controlled
[c] do not need to (no excess animals)

9 How do you regulate the numbers of bushbuck on your property?

[a] hunting [d] culling
[b] live capture [e] predator controlled
[c] do not need to (no excess animals)

10 What is the primary economic function of nyala on your property?

[a] financial benefit from hunting [c] financial benefit from live sales
[b] game viewing and aesthetic appeal

11 What is the primary economic function of bushbuck on your property?

[a] financial benefit from hunting [c] financial benefit from live sales
[b] game viewing and aesthetic appeal

If you **do** allow hunting on your property, please answer the following questions. If you **do not** allow hunting, please answer **Section B**.

12 Does hunting provide a large economic benefit for your property?

[a] Yes [b] No

13 Do you hunt nyala and bushbuck on your property?

[a] only nyala [c] only bushbuck
[b] both

If you do not hunt bushbuck, what is your reasoning?
[d] too few animals
[e] prefer to remove bushbuck by other means (live capture etc.)

If you do not hunt nyala, what is your reasoning?
[f] too few animals
[g] prefer to remove nyala by other means (live capture etc.)

14 In your opinion, are nyala or bushbuck more popular/valuable for hunting?
[a] Nyala [b] Bushbuck

Section B

15 Do you believe that nyala and bushbuck compete for key resources (food and habitat)?
[a] Yes [b] No

If yes, what is your reasoning?
[c] personal observation/opinion
[d] what I have heard/read

16 Do you have concerns about having nyala on your property?
[a] Yes [b] No

17 If you did not have nyala on your property, would you still consider introducing nyala to your property?
[a] Yes [b] No

If yes, what is your reasoning?
[c] only ecological (management of vegetation etc.)
[d] only economical (tourism, hunting etc.)
[e] more ecological than economical
[f] more economical than ecological

If no, what is your reasoning?
[g] concern of losing bushbuck due to competition
[h] concern of causing damage to vegetation
[i] too expensive
[j] too difficult to manage
[k] beyond their natural range

18 If you have population estimates for nyala and bushbuck for your property, would you consider making these records available for study purposes?
[a] Yes [c] No
[b] Do not have records

19 Do you think that knowledge of possible competition between nyala and bushbuck would be valuable to the management of a reserve?
[a] Yes [b] No

20 Would the management of your property be interested in the results of this study?
[a] Yes [b] No

Thank you for your time.

APPENDIX D

Overall Frequency of Responses (%) to the Questionnaire Survey

Section A

1 Are there both nyala and bushbuck resident on your property? (n = 40)

[100] yes
[0] no

2 Has either of these species population decreased or increased over the years? (n = 40)

[0] only nyala decreased
[25] only nyala increased
[0] only bushbuck decreased
[0] only bushbuck increased
[42.5] nyala increased while bushbuck decreased
[0] bushbuck increased while nyala decreased
[15] nyala and bushbuck remained the same
[17.5] nyala and bushbuck increased
[0] nyala and bushbuck decreased

If there has been a decrease, what might be the possible reasons? (n = 17)

[13.8] poaching
[3.4] over predation
[58.6] competition
[0] management decision
[6.9] habitat destruction
[0] dogs
[17.2] drought

3 In your opinion, has the bushbuck population in general in your part of the province decreased in recent years? (n = 40)

[50] yes
[50] no

If yes, what in your opinion has mainly contributed to this decrease? (n = 20)

[15.2] poaching
[0] over predation
[54.5] competition with nyala
[0] management decision
[9.1] habitat destruction
[9.1] dogs
[12.1] drought

4 What is the approximate size of your property? (n = 40)

[17.5] < 1000 ha
[47.5] 1000ha – 5000ha
[12.5] 5000ha – 10 000ha
[0] > 10 000ha

5 Where did your nyala population come from? (n = 40)

[50] introduced
[40] naturally resident
[10] encroached from neighbour
[0] do not know

If introduced or encroached from neighbour, approximately how long ago were they introduced or did they appear? (n = 24)

[16.7] 0 – 5 years
[25] 5 – 10 years
[29.2] 10 – 20 years
[29.2] > 20 years

6 Do you have population estimation numbers for nyala and bushbuck on your property? (n = 40)

[22.5] only nyala
[0] only bushbuck
[45] both nyala and bushbuck
[32.5] neither

If yes, how far back do these records date? (n = 27)
[63] after 1990 [18.5] 1980 – 1989
[7.4] 1970 – 1979 [11.1] before 1970

If yes, how accurate are these records? (n = 27)
[3.7] accurate [96.3] vague estimation

If yes, what method did you use to get these numbers? (n = 27)
[35] annual game counts [62.5] frequent report back from rangers
[2.5] other

7 Do you have a specific monitoring or management plan for either nyala or bushbuck? (n = 27)
[7.5] only nyala [2.5] only bushbuck
[5.0] both nyala and bushbuck [85] neither

if yes, please describe

Nyala...
Bushbuck..

8 How do you regulate the numbers of nyala on your property? (n = 40)
[34.7] hunting [12.2] culling
[34.7] live capture [10.2] predator controlled
[8.2] do not need to (no excess animals)

9 How do you regulate the numbers of bushbuck on your property? (n = 40)
[21.4] hunting [0] culling
[11.9] live capture [11.9] predator controlled
[54.8] do not need to (no excess animals)

10 What is the primary economic function of nyala on your property? (n = 40)
[42.5] financial benefit from hunting [15] financial benefit from live sales
[42.5] game viewing and aesthetic appeal

11 What is the primary economic function of bushbuck on your property? (n = 40)
[22.5] financial benefit from hunting [2.5] financial benefit from live sales
[75] game viewing and aesthetic appeal

If you **do** allow hunting on your property, please answer the following questions. If you **do not** allow hunting, please answer **Section B**.

12 Does hunting provide a large economic benefit for your property? (n = 18)
[83.3] Yes [16.7] No

13 Do you hunt nyala and bushbuck on your property? (n = 18)
[50] only nyala [0] only bushbuck
[50] both

If you do not hunt bushbuck, what is your reasoning? (n = 9)
[100] too few animals
[0] prefer to remove bushbuck by other means (live capture etc.)

If you do not hunt nyala, what is your reasoning? (n = 0)
[0] too few animals
[0] prefer to remove nyala by other means (live capture etc.)

14 In your opinion, are nyala or bushbuck more popular/valuable for hunting? (n = 18)
[100] Nyala [0] Bushbuck

Section B

15 Do you believe that nyala and bushbuck compete for key resources (food and habitat)? (n = 40)

[90] Yes [10] No

If yes, what is your reasoning? (n = 4)

[60.9] personal observation/opinion

[39.1] what I have heard/read

16 Do you have concerns about having nyala on your property? (n = 40)

[15] Yes [85] No

17 If you did not have nyala on your property, would you still consider introducing nyala to your property? (n = 40)

[90] Yes [10] No

If yes, what is your reasoning? (n = 36)

[11.1] only ecological (management of vegetation etc.)

[13.9] only economical (tourism, hunting etc.)

[27.8] more ecological than economical

[47.2] more economical than ecological

If no, what is your reasoning? (n = 4)

[75] concern of losing bushbuck due to competition

[0] concern of causing damage to vegetation

[0] too expensive

[0] too difficult to manage

[15] beyond their natural range

18 If you have population estimates for nyala and bushbuck for your property, would you consider making these records available for study purposes? (n =40)

[65] Yes [0] No

[35] Do not have records

19 Do you think that knowledge of possible competition between nyala and bushbuck would be valuable to the management of a reserve? (n =40)

[100] Yes [0] No

20 Would the management of your property be interested in the results of this study? (n =40)

[100] Yes [0] No

Thank you for your time.