HABITAT USE AND FEEDING ECOLOGY OF THE ROAN ANTELOPE AT WEENEN NATURE RESERVE

by

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PREFACE

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The research described in this dissertation was carried out in the Department of Zoology and Entomology, University of Natal, Petermaritzburg, from January 1993 to October 1995, under the supervision of Professor M.R. Perrin and co-supervised by Dr A. Bowland.

These studies represent original work by the author and have not otherwise been submitted in any form for any degree or diploma to any University. Where use has been made of the work of others it is duly acknowledged in the text.

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ABSTRACT

The roan antelope *Hippotragus equinus equinus*, is listed as endangered in the South African Red Data Book. A herd of nine roan were introduced to Weenen Nature Reserve (WNR) in 1988. The herd has since increased to sixteen animals.

The aim of the study was to determine those habitat characteristics which influenced the preference or avoidance of the habitat types available at WNR. The extent to which the antelope's occurrence was correlated with certain habitat elements was determined. The roan preferred open woodland on gently undulating terrain.

Themeda triandra was found to be the most common grass species in the diet of the roan. Cauline grass species such as *Hyparrhenia spp.* were avoided in the dry season. Dicots assumed greater importance in the diet in the dry season.

Several management practices employed at the reserve were assessed to determine their influence on habitat use by the roan. These practices were not found to be incompatible with the goal of conserving roan antelope in the reserve.

CONTENTS

CHAPTER ONE

INTRODUCTION

The relationship between animal and habitat plays a crucial role in the ecology of any species. The association between a herbivore and its habitat not only encompasses the availability of preferred food plants and their particular growth stages in its home range, it is also intimately linked to other features of the habitat (Pienaar 1974). These include *inter alia*, (i) the availability of suitable cover, (ii) adequate nutrition for reproduction, (iii) the absence of excessive intra and interspecific competition, (iv) the frequency of fires, (v) the influence of predation and parasitism and (vi) the extent to which the habitat provides minimum resources to sustain the species.

The above environmental characteristics influence the distribution, survival and reproductive success of the species, and viewed against a backdrop of environmental changes, determine the species richness and carrying capacity of an environment (Riney 1982).

Effective management of multi-species ungulate populations requires knowledge of the habitat requirements of the individual species and should take cognisance of the existence of inter-specific competition. The extent of resources available must also be quantified to prevent environmental degradation.

In the last three decades, numerous studies have been conducted of mammalian herbivores in relation to their environment. These range from qualitative observations of the types of habitats used by particular ungulate species or assemblages to more complex quantitative investigations that attempt to explain why such habitats are used (*e.g.* Williamson 1990, Funston *et al.* 1994). Studies aimed at establishing the habitat preferences and other ecological requirements of herbivorous animals are particularly important for the conservation of vulnerable species (Ben-Shahar 1990)

The roan antelope, *Hippotragus equinus equinus* (Desmarest 1804) is widely distributed south of the Sahara. Despite this wide distribution, it is not an abundant species, comprising a small proportion of the faunal community where it does occur. Over much of its range it is regarded as `insignificant' or `rare' (Joubert 1970). The antelope is believed to have been distributed throughout most of the former Transvaal excluding the southern central sector, extending in the south-east into the north-eastern Cape province, possibly as far south as the Orange and Vaal rivers (Shortridge 1934, Du Plessis 1969). Roan are presently confined to the Northern and Eastern Transvaal in South Africa and are believed to number fewer than 500 (Skinner 1984). Free ranging herds are confined to the Kruger National Park and several provincial and private reserves in the Northern and Western Transvaal (see Figure 1.1). Roan have been listed as endangered in the South African Red Data Book (Smithers 1986, Rowe-Rowe 1991).

Pienaar (1974) believes that roan originally occurred in KwaZulu-Natal, having become extinct in historic times, although this is disputed by Rowe-Rowe (1991). Roan have been introduced to KwaZulu-Natal and have been designated `specially protected game'. Two roan were introduced to Itala Nature Reserve in 1979 (Rautenbach 1981). In August 1988 nine more roan were introduced to Weenen Nature Reserve from the Waterberg Plateau Park in Namibia with the specific aim of establishing another population of this endangered species. It was also believed that roan would not have a detrimental effect on the native biota. This herd increased to 16 by January 1995. Another population of roan occurs on a private farm in KwaZulu-Natal (Bourquin and Matthias 1995).

Populations of roan have declined drastically over the years in Southern Africa. The possible reasons for the reduction of numbers in South Africa are; a natural decline, loss of habitat, encroachment of human activity, and illegal hunting. Disease, particularly anthrax, has also contributed to the decline in roan numbers (Pienaar 1961, Ansell 1972). The roan herd at Weenen Nature Reserve has not shown a satisfactory rate of increase given the reproductive potential of the species, and this may suggest that intervention is neccessary. This could involve the manipulation of habitat to make it as productive and appropriate as possible for the species.

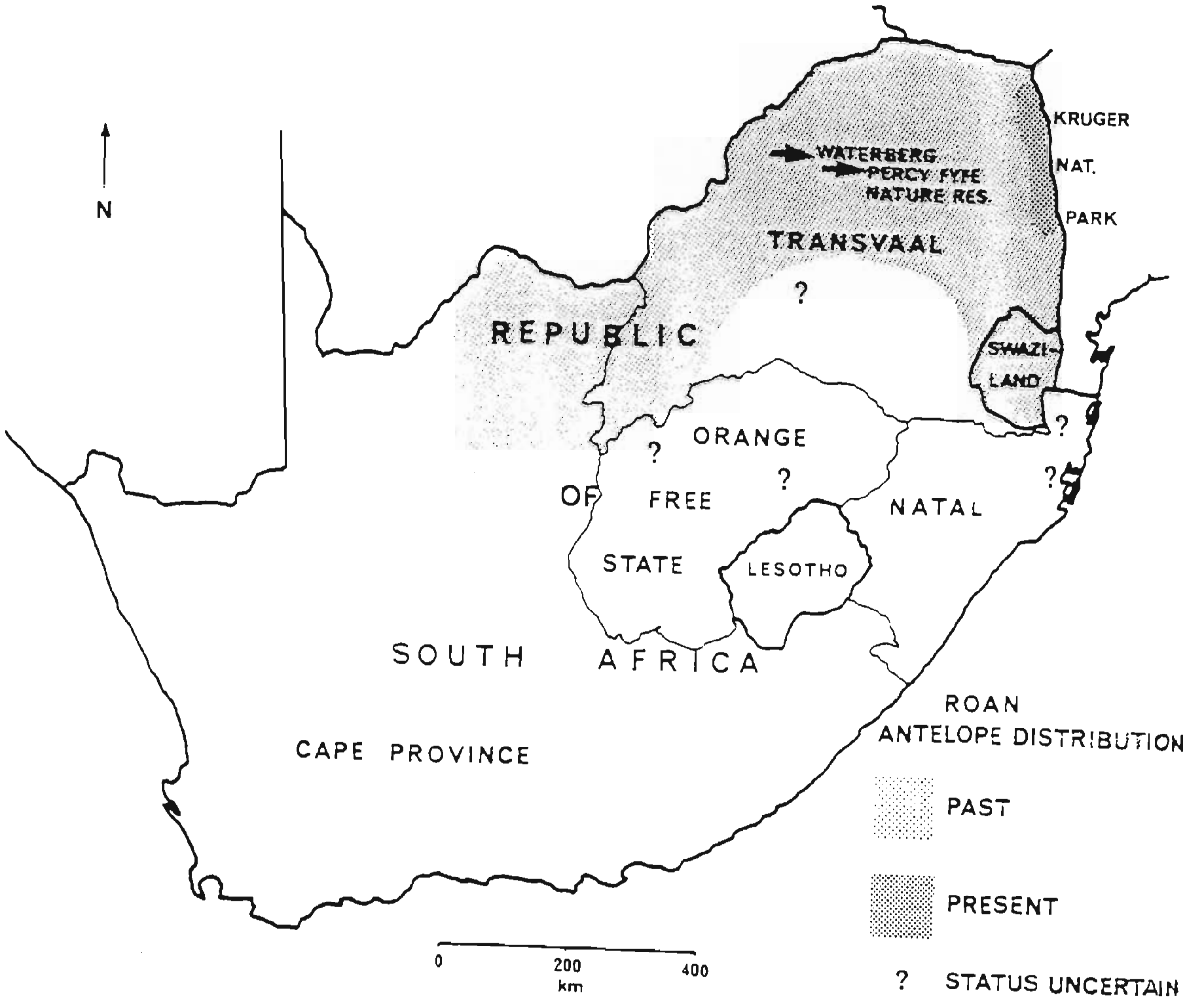

Figure 1.1 The past and present distribution of the roan antelope in South Africa (Joubert 1976).

Literature review

Several intensive studies of the ecology of the roan antelope, have been carried out in Southern Africa in the last thirty years. These studies have been limited to areas where roan still occur naturally, that is, Zambia, Zimbabwe and the North-eastern Transvaal of South Africa (Child and Wilson 1964, Joubert 1976, Wilson and Hirst 1977). Prior to this period references to roan were limited to broad and anecdotal descriptions of herd sizes, structure and habitat preferences (Joubert 1974).

General notes in the literature describe roan as being primarily grazers, although they are known to take some browse (Shortridge 1934, Brynard and Pienaar 1960, Smithers 1986, Estes 1991). Geerling (1979) noted an increase in the quantity of browse taken as the dry season progressed. Joubert (1976) regarded roan as selective grazers that feed on the higher parts of their food plants, seeking green material even in the dry season. Heitkonig (1993) investigated the feeding strategy of roan in dystrophic savannas and pointed out that digestive adaptations, coupled with food selection ranging from habitat to plant parts, enhanced survival in these areas. Wilson and Hirst (1977) in their study in the same region concluded that the diets of roan were deficient in several minerals which explained their poor performance in the area.

On a broader landscape level, roan prefer open woodland areas tolerating taller grass and higher elevations (Estes 1991).

Joubert (1970,1976) descibed roan as an ecotonal species preferring open grass plains with accessible cover and open surface water.

Studies by Joubert (1976) and Wilson (1975) concluded that roan are sensitive to habitat change with bush encroachment and overgrazing tending to render grassland unsuitable for them. Ben-Shahar (1990) found that in his study area in the northwest Transvaal, change in vegetation structure had very little influence on the distribution patterns of roan.

Joubert (1970) examined the social organisation of roan and suggested that herd structure, cohesion and spatial distribution played an important role in their pattern of habitat use. Several social constraints and selective feeding habits ensured that roan were not an abundant species even in favourable habitat.

Very little is known about the performance of roan antelope outside their restricted present-day range in South Africa. While it is possible to extrapolate from studies done elsewhere to predict whether a species may be introduced into a given area, it is vital that the parameters that ensure its survival in its new range are elucidated. This enables the development of a suitable management programme unique to that particular area.

Aims

The objective of this project was to determine the habitat use and feeding ecology of the roan antelope at Weenen Nature Reserve (W.N.R.). The specific aims of the study were as follows;

(i) To determine key habitat characteristics influencing the preference or avoidance of different habitat types available at W.N.R.

(ii) To determine which food species were utilized by roan at W.N.R.

Key management objectives that had to be addressed by results derived from the above findings were as follows;

(i) To identify areas not being utilised by the roan herd and to assess their suitability for additional roan herds.

(ii) To determine whether roan were compatible with the existing ungulate species mix at W.N.R.

(iii) To determine whether another roan herd should be introduced to W.N.R.

The results yielded by the project will form the basis of a management plan for the conservation of roan antelope on the reserve.

Roan antelope are regarded as endangered and it is this grave status that makes it imperative that precise and detailed data sets are built up to ensure their continued survival. The introduction of roan to W.N.R. provided an opportunity to develop and maintain a viable and healthy reservoir population for conservation purposes.

CHAPTER TWO

THE STUDY AREA

2.1 Introduction

Weenen Nature Reserve (WNR: 28° 50' S: 30° 02' E), is situated in the Natal Midlands of KwaZulu-Natal approximately 10 km west of Weenen and 28 km north-east of Estcourt (see Figure 2.1). The reserve encompasses 4183 ha. Prior to 1948 the area was used as tenant labour farms. `This pernicious practice resulted in a great concentration of natives and their stock with the consequent laying waste of the area' (West 1951). In 1948 the state appropriated the two farms which now form the area of the reserve, and they were placed under the jurisdiction of the Department of Agriculture which initiated a programme of rehabilitation of the severely eroded land. This process was continued when the area was proclaimed a nature reserve under the control of the Natal Parks Board in 1975.

2.1.1 Physiography

The reserve lies on shales, mudstones and sandstones of the Beaufort Series (Karoo System). It is characterised by low dolorite hills in the south and south-east that are incised by seasonal streams. These have a marked influence on the soils found in the reserve (Hughes 1989). The reserve is divided into three portions, in the west it is transected by a main road and

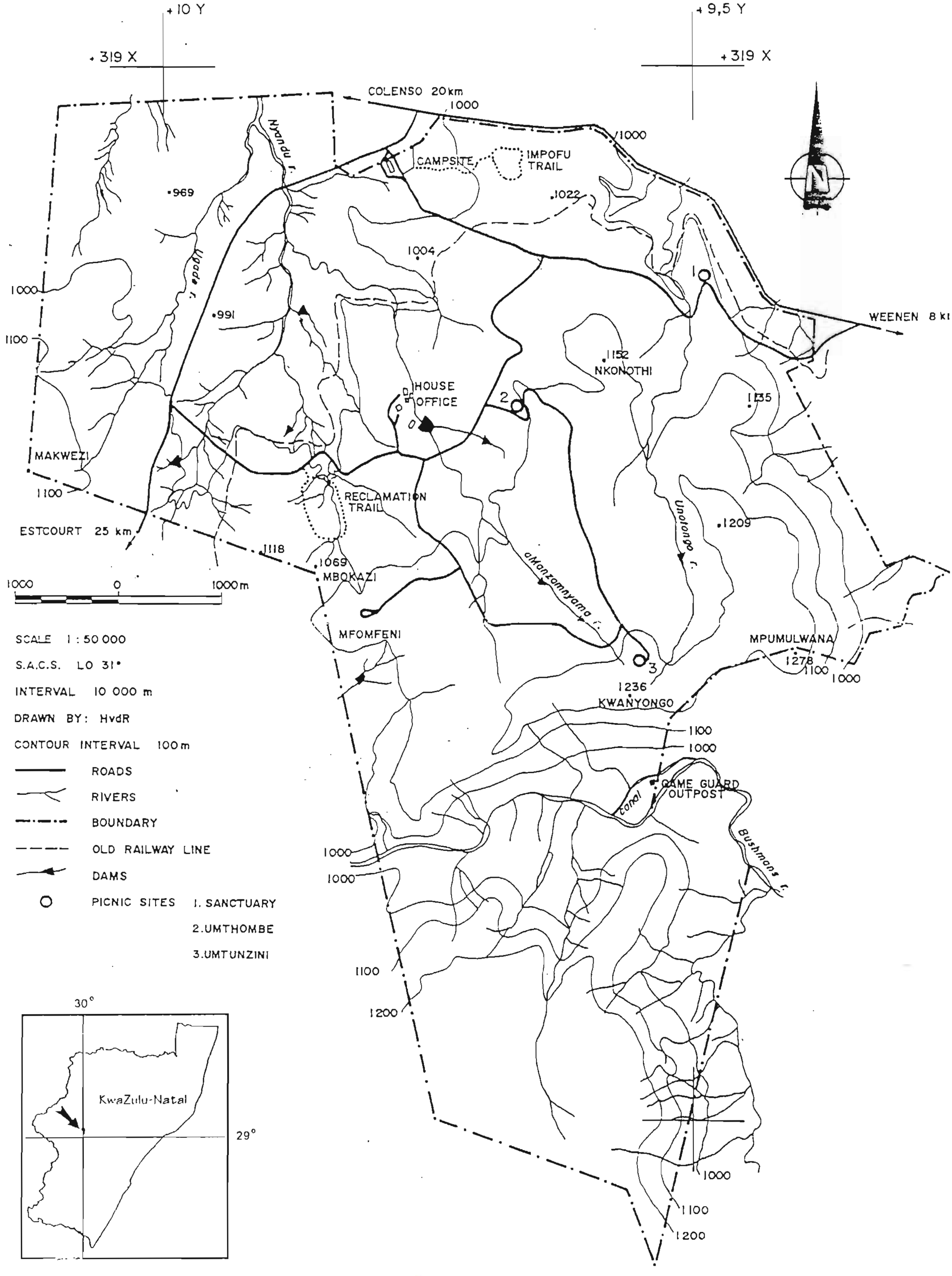

Figure 2.1 Weenen Nature Reserve

in the south, by the Bushman's river. To the south of the river, the reserve comprises a dolorite capped hill which has an extensive plateau on its top. The reserve is located on the Draycott plain with an altitude ranging from 1000 to 1300 m.a.s.l.

2.1.2 Climate

Mean rainfall in the reserve ranges from 601mm to 1000mm with a minimum of 429mm being reported in the period since 1974. Much of the precipitation in the area occurs in falls of high intensity (Edwards 1967). Very little rain is recorded between the months of May and August. Temperatures vary between 1° c in winter and 37° c in summer. Frost occurs on no more than ten days per annum in winter. Because of the rugged topography local climates can differ considerably. The difference in insolation also plays a role in influencing vegetation on various slopes and aspects (Edwards 1967).

2.1.3 Soils

The soils of WNR have two important features in common, namely their lack of depth and their susceptibility to erosion (Hughes 1989). Most of the reserve consists of shallow soils on shale and dolorite. Hughes (1989) reported that the soils in the reserve were alkaline indicating their unleached nature. The soils derived from dolorite are generally fertile. Duplex soils occur particularly in the western part of the reserve adding to the vulnerability of the landscape.

2.1.4 Vegetation

The vegetation is described as Valley Bushveld (type 23 Acocks 1975) and classified as Bioclimatic Group 10 (Sub-arid riverine and lowland mixed thicket and short to medium woodland) by Phillips (1973). The Draycott plain upon which the reserve lies has been described as an ecotonal region which lies between the true climax mountain forest of the little Berg and Tambamhlope Plateau and the semi-deciduous bush formation of the river valleys (West 1951). The ecotonal grassland of the Draycott plain has been referred to as Tall Grassveld based on the presence of *Hyparrhenia spp.*, which are indicative of the latter stages of secondary succession, a sign that disturbance has taken place in the past (Pentz 1938).

The vegetation in the reserve is characterised by *Acacia* woodlands and thickets with tall grasses, for example *Hyparrhenia spp.* and *Themeda triandra* on the shallower dolorite derived soils (see Figure 2.2). Large patches of old cultivated lands dominated by *Hyparrhenia spp.* occur within the reserve (see Figure 2.2). Fire plays a major role in determining the climax and sub-climax formations. Variables such as slope, aspect and soil depth also influence the distribution of vegetation (Bourquin and Mathias 1995).

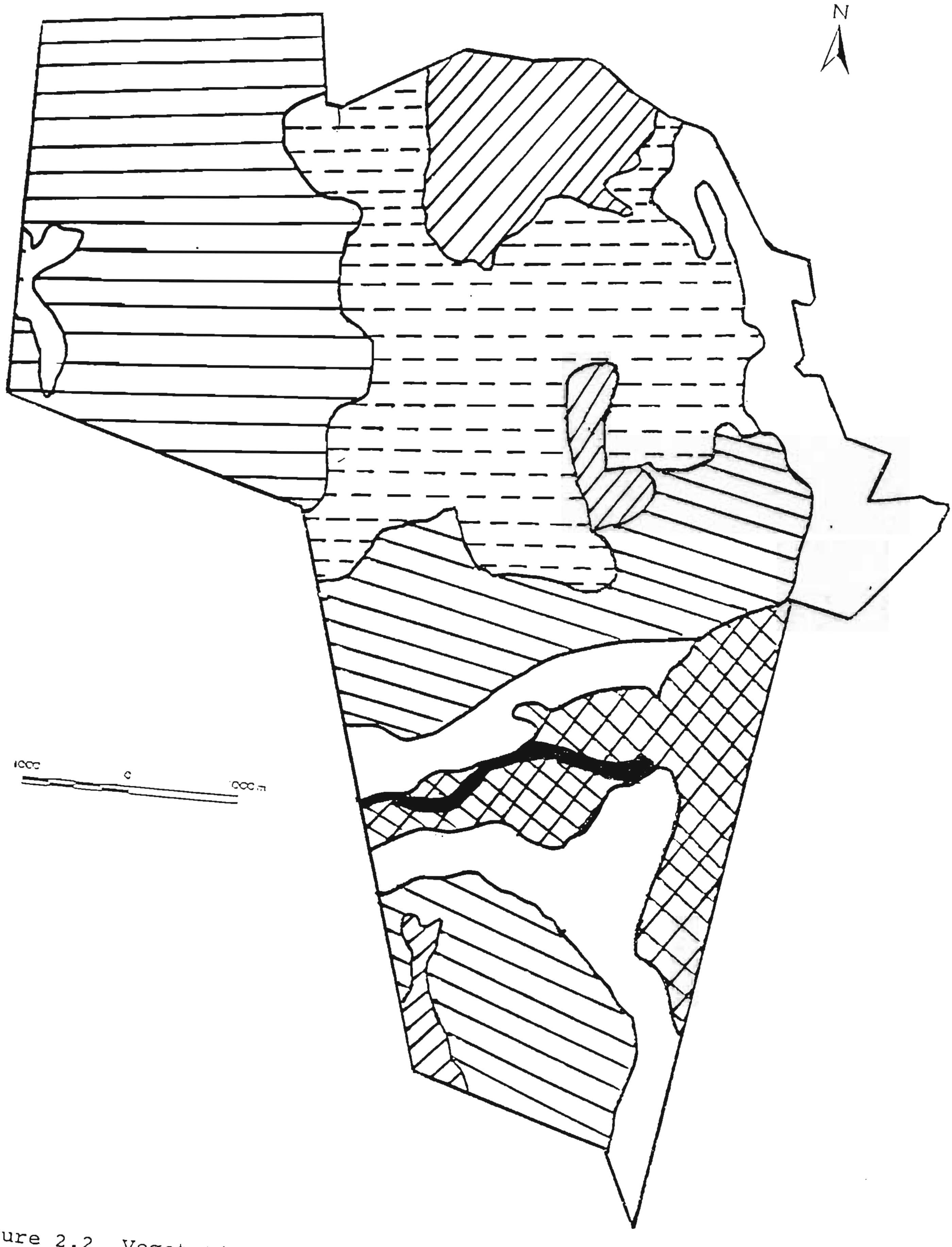

Figure 2.2 Vegetation communities at Weenen Nature Reserve

LEGEND

Themeda-Hyparrhenia Tall grassveld- *Acacia sieberiana, A. karroo, A. caffra* woodland with understory of *Themeda triandra, Hyparrhenia spp., Seteria spp., Bothriochloa insculpta* and *Cymbopogon spp.*.

Acacia karoo-A. nilotica thornveld- the major grass species include *T. triandra, B. insculpta, Sporobolus spp. Eragrostis spp., Heteropogon contortus, Melinis spp.* and *Panicum maximum.*

Acacia karoo-A. caffra thornveld- other trees and shrubs include *A. tortilis, Euclea crispa, Rhus spp.* The major grasses include *T. triandra, Hyparrhenia spp., Sporobolus spp., Cymbopogon spp., Bothriochloa insculpta, Seteria sphacelata.*

Old lands- *Acacia sieberana, A.karoo* with understory of *Hyparrhenia hirta, Hyparrhenia spp.*.

Acacia karoo riverine woodland.

Thicket- Rocky hillside scrub ; *A. sieberiana, Celtis africana, Cussonia spicatus, Ziziphus mucronata, Olea spp.*. with a sparse uderstory of *Bothriochloa insculpta, Cymbopogon validus, Panicum maximum* and *Hyparrhenia hirta.*

2.1.5 Large herbivores

The following large herbivores occur within the reserve and their estimated populations as at 1993 are given below (Bourquin and Mathias 1995).

Equus burchelli (Burchell's zebra)-203
Ceratotherium simum (White rhinoceros)-42
Diceros bicornis (Black rhinoceros)-13
Giraffa camelopardalis (Giraffe)-34
Alcelaphus buselaphus (Red hartebeest)-208
Hippotragus equinus(Roan antelope)-14
Kobus ellipsyprymnus (Waterbuck)-39
Syncerus caffer (Buffalo)-57
Tragelaphus strepsiceros (Kudu)-213
Tragelaphus scriptus (Bushbuck)-30
Taurotragus oryx (Eland)-100
Redunca fulvorufula (Mountain reedbuck)-108
Redunca arundinum (Reedbuck)-30
Sylvicapra grimmia (Grey duiker)-116
Oreotragus oreotragus (Klipsringer)-11
Raphicerus campestris (Steenbok)-50

Blue wildebeest (*Connochaetes taurinus*) formerly occurred in the reserve but they were removed in 1979 because of the grazing pressure they might have posed to the veld as their numbers increased (Bourquin and Mathias 1995). It is the policy of managers of the reserve to maintain a low stocking rate for all ungulate species to avoid degradation of the recovering landscape.

CHAPTER THREE

HABITAT USE

3.1 Introduction

The relationships and interactions between an animal and its environment play a fundamental role in the ecology of any species. To conserve an animal one must take cognisance of the need to identify its habitat requirements and preserve the various elements which constitute the habitat (Williamson 1979). Riney (1982) defined habitat requirements as the minimum requirements for the survival of an animal. Identification of limiting habitat elements allows for the manipulation of these to enhance the survival of threatened or endangered species.

Habitat studies generally involve relating the distribution of an animal to those habitat resources that are considered to be critical for its survival, for example, food, water and shelter (Leopold 1933). Various approaches have been adopted for the purpose of studying habitat use. These include descriptive surveys of the historical distribution of a particular species, qualitative assessments of habitat preferences (Lamprey 1963) and analytical approaches which involve detailed statistical evaluation of the relationship between site occupancy and various habitat elements (Hirst 1975, Ferrar and Walker 1974, Beardall *et al.* 1984).

Geographical information systems are defined as `...an organised collection of computer hardware, software, geographic data and personnel designed to effectively capture, store, update, manipulate, analyze and display all forms of georeferenced data' (ESRI 1990). The data are based on a grid (raster system) or polygons and points (vector system). The former is particularly useful for ecological modelling where several similar environmental characteristics are recorded for all the localities in a study area (Fabricius and Coetzee 1992). Wildlife-habitat models can be particularly useful to elucidate the relationship between animals and their habitats, identify and quantify suitable habitat and provide graphic demonstrations of the consequences of different management policies.

Spatial data bases created by a GIS can be linked by overlay operations to address the fundamental question of how features are related to one another, spatially and temporally (Johnson 1990). The habitat requirements of a species can be predicted by intersecting the location of the animal and habitat variables such as vegetation cover, soil type and water sources. Spatial data can be analysed by a statistical method such as chi-square and logistical regression to determine patterns of non-random association. Once the essential habitat requirements have been identified, the location, quality, quantity of suitable habitat and the occurrence of a given species can be predicted (Johnson 1993).

Habitat selection by the roan nursery herd was expressed in terms of the number of times the herd was observed in association with several habitat elements. Observed habitat use was compared with expected habitat use according to the availablity of each habitat category. Classical hypothesis testing techniques were employed (Mduma and Sinclair 1994, Pienaar *et al.* 1993, Winkler and Owen-Smith 1995).

3.2 Methods

A grid of 200x200m pixels was constructed on 1000x1000m grid of X and Y National Mapping System coordinates on a 1:10 000 map of WNR. The location of the roan nursery herd was located relative to each grid cell each time the herd was located during searches of the reserve. The location of the roan herd was noted relative to the grid each time it was found. A total of 404 observations of the herd were made over the study period of 16 months. Each grid cell was categorised in terms of five habitat characteristics namely, slope, altitude, aspect, soil type and vegetation type. This was done with the assistance of a Geographical Information System (GIS).

The derivation of the numeric data involved the capture of vegetation, soils and topographical information which were captured by ArcInfo through digitisation (see Appendix 3). The data sets were originally in a vector format (lines and polygons). For the purpose of the analysis, however, the data were converted into raster format. The grid of 200x200m was used for this purpose. The boundaries of the map elements were generalized in the process to a `nearest fit' approximation of the map given the cell size. In order to develop a surface for altitude data, an interpolation was selected that accurately reflected the actual landscape. A Triangular Irregular Network was generated from the contours, which were then converted into a 200m grid using a quintic interpolation. The method emphasized the relationship between the sample points. The altitude grid was used to model slope and aspect (Fabricius and Coetzee 1992, Horswell, 1995, pers. comm.).

A composite map of potential roan habitats within the reserve was created by overlaying the digitised maps. Habitat characteristics identified as being important to the roan by the Bonferroni-*z*-statistic, were assigned equal ranking in the model.

3.2.1 Slope

The average slope in each grid cell was provided in 5% intervals.

3.2.2 Aspect

16 categories were used for aspect representing each of the cardinal compass points.

3.2.3 Altitude

The mean altitude for each pixel was provided, although these were subsequently categorized in altitude intervals of 500m to simplify data handling and interpretation.

3.2.4 Soil type

The major soil type for each pixel was obtained from the map of soil types for WNR (Hughes 1989).

3.2.5 Vegetation type

Tree and shrub density was obtained for each pixel based on categories used by Hatch *et al.* (1989).

3.2.6 Vegetation composition

This variable was derived from the location of each observation relative to the vegetation communities indicated in Figure 2.2. The size of each category was calculated using a planimeter.

3.3 Data Analysis

The Bonferroni-*z*-statistic (Neu *et al.* 1974, Byers *et al.* 1984) was employed to determine which habitat categories were used more or less frequently than expected. Confidence intervals were calculated to test the hypothesis that the roan herd used the available habitat categories in proportion to their occurrence.

Bonferroni confidence intervals are often used in tandem with a chi-square goodness-of-fit test. The latter is used to determine which habitat categories are utilised more than would be expected based on availability. When those habitat categories that are utilised significantly more or less than expected have been identified, Bonferroni confidence intervals are then used to determine which categories are being preferred. These probability statements remain relevent even if chi-square tests have been performed or not (Byers *et al.* 1984).

Once the expected and actual proportions of usage, P_{io} and P_i respectively, of the various habitat categories were calculated, simultaneous confidence intervals were calculated in the following manner,

$$P_i - Z_{\alpha/2k}\ (P_i\ (1-P_i)/n)^{1/2} < pi < P_i + Z_{\alpha/2k}(P_i\ (1-P_i)/n)^{1/2}$$

Where $Z_{\alpha/2k}$ is the upper standard normal table value corresponding to a probability tail area of $\alpha/2k$; k is the number of categories tested; n=404

A set of simultaneous confidence intervals was then calculated for the true proportion of utilisation (P_i) of each of the habitat categories. If the expected proportion of usage did not fall within the interval, it was concluded that the expected and actual utilisation were significantly different. If the expected proportion of usage was greater than the limits of the confidence interval then the habitat type was used less than expected by chance. Conversely, if the value was smaller than the limits calculated then it was utilised significantly more than expected by chance alone.

The values of expected use generally had to exceed five *i.e* ($nP_{io}>5$) to demonstrate significance (Scogings *et al.* 1990). The manner of data collection influences the effectiveness of the above technique. Data collection had to be such that the study animals had equal opportunity of being observed in each habitat category. The assumption that the study animals moved independently of one another was met by considering the roan herd as a single unit.

3.4 Results

3.4.1 Slope

The results of slope selection by the roan herd for the dry and wet seasons are presented in Tables 3.1a and 3.1b respectively.

The herd showed positive selection for slopes between 5% and 10% and negative selection for slopes less than 5% in the dry season ($p<0.05$). Slopes greater than 15% were used less than expected in the dry season ($p<0.05$). In the wet season slopes greater than 10% were used less than expected ($p<0.05$) and the observed use of slopes less than 5% was not significantly different from expected usage.

Table 3.1a Simultaneous confidence intervals to determine utilisation and preference of slope categories in the dry season.

Slope Interval (%)	Expected Proportion of usage (Pi_o)	Observed Proportion of usage (P_i)	Bonferroni interval
0-5	0.607	0.451	0.359<p<0.543*
5-10	0.276	0.503	0.411<p<0.595*
10-15	0.057	0.046	0.007<p<0.085
15-20	0.029	-	-
Others	0.031	-	-

Z=2.58;n=195

* indicates a difference at the 0.05 level of significance.

Table 3.1b Simultaneous confidence intervals to determine utilisation and preference of slope categories in the wet season.

Slope Interval (%)	Expected Proportion of usage (P_{io})	Observed Proportion of usage (P_i)	Bonferroni interval
0-5	0.607	0.617	0.530<p<0.704
5-10	0.276	0.349	0.264<p<0.434
10-15	0.057	0.005	0<p<0.018*
15-20	0.029	0.010	0<p<0.028*
Others	0.031	0.019	0<p<0.043

Z=2.58;n=209

* indicates a difference at the 0.05 level of significance.

3.4.2 Aspect

The observed use of aspect categories were compared with expected use for wet and dry seasons in Tables 3.2a and 3.2b.

In the dry season slopes facing west-northwest were positively selected ($p<0.05$). Slopes facing north north-west, north and those facing southwards were used less than expected ($p<0.05$). In the wet season slopes facing northwards and west-southwest were utilised significantly more than would be expected by chance alone ($p<0.05$). Slopes facing north-eastwards and southwards were used less than expected ($p<0.05$). The use of other aspect categories was not significantly different from expected usage.

3.4.3 Altitude

Selection for altitude by the roan herd as determined by the calculation of simultaneous confidence intervals for dry and wet seasons is presented in Tables 3.3a and 3.3b.

The roan herd showed positive selection for altitudes ranging from 951-1000m ($p<0.05$) in the dry season. Altitudes greater than 10000m were used less than expected ($p<0.05$). In the wet season habitats ranging from 1101-1150m were positively selected ($p<0.050$. Altitudes higher than 1150m were used less than expected ($p<0.05$).

Table 3.2a Simultaneous confidence intervals to determine utilisation and preference of aspect categories in the dry season.

Aspect	Expected Proportion of Usage (P_{io})	Observed Proportion of Usage (P_i)	Bonferroni interval
N	0.088	0.123	0.056<p<0.190
NNE	0.090	0.067	0.016<p<0.118
NE	0.101	0.097	0.037<p<0.157
ENE	0.087	-	-
SW	0.032	-	-
WSW	0.091	0.113	0.049<p<0.177
W	0.103	0.169	0.093<p<0.245
WNW	0.112	0.303	0.210<p<0.396*
NW	0.114	0.092	0.033<p<0.151
NWN	0.112	0.026	0<p<0.058*
Others	0.07	0.010	0<p<0.030*

Z=2.84;n=195

Table 3.2b Simultaneous confidence intervals to determine utilisation and preference of aspect categories in the wet season.

Aspect	Expected Proportion of usage (P_{io})	Observed Proportion of usage (P_i)	Bonferroni interval
N	0.088	0.187	0.110<p<0.264*
NNE	0.090	0.105	0.045<p<0.165
NE	0.101	0.010	0<p<0.030*
ENE	0.087	-	-
SW	0.032	0.010	0<p<0.030*
WSW	0.091	0.211	0.131<p<0.291*
W	0.103	0.120	0.056<p<0.184
WNW	0.112	0.115	0.052<p<0.178
NW	0.114	0.124	0.059<p<0.189
NNW	0.112	0.120	0.056<p<0.184
Others	0.07	-	-

Z=2.84;n=209

Table 3.3a Simultaneous confidence intervals to determine utilisation and preference of altitude categories in the dry season.

Altitude (m)	Expected Proportion of usage (P_{io})	Observed Proportion of usage (P_i)	Bonferroni interval
<1000	0.566	0.010	0<p<0.029*
1001-1050	0.214	0.395	0.301<p<0.489*
1051-1100	0.223	0.472	0.376<p<0.568*
1101-1150	0.166	0.123	0.060<p<0.186
1151-1200	0.143	-	-
1201-1250	0.141	-	-
>1250	0.057	-	-

Z=2.69;n=195

* indicates a difference at the 0.05 level of significance.

Table 3.3b Simultaneous confidence intervals to determine utilisation and preference of altitude categories in the wet season.

Altitude (m)	Expected Proportion of usage (P_{io})	Observed Proportion of usage (P_i)	Bonferroni interval
<1000	0.566	-	-
1001-1050	0.214	-	-
1051-1100	0.223	-	-
1101-1150	0.166	0.072	0.024<p<0.120*
1151-1200	0.143	0.177	0.106<p<0.248
1201-1250	0.141	0.560	0.468<p<0.652*
>1250	0.057	0.191	0.118<p<0.264*

Z=2.69;n=209

* indicates a difference at the 0.05 level of significance.

3.4.4 Soil type

The results of observations of the roan herd in different soil types compared with expected usage for both dry and wet seasons are presented in Tables 3.4a and 3.4b.

The roan herd showed positive selection for the Mispah soil type while the Shortlands soil type was used less than expected in the dry season ($p<0.05$). In the wet season the herd selected against the Avalon soil type and Mispah-rock outcrops ($p<0.05$). The observed use of Shortlands and Shortlands-rock outcrops was not significantly different from expected usage. Other soil types in the study area were used less than expected.

3.4.5 Vegetation type

Observed use of vegetation type categories compared with expected use for dry and wet seasons is shown in Tables 3.5a and 3.5b. The herd selected medium open woodland and used sparse open woodland less than was expected in the dry season ($p<0.05$). Utilisation of the other vegetation categories was not significant. The herd showed positive selection for medium open woodland and medium closed woodland in the wet season ($p<0.05$). The herd selected against sparse open woodland, dense closed woodland and thickets. Dense open woodland was not utilised in a significant manner in the dry and wet seasons.

Table 3.4a Simultaneous confidence intervals to determine utilisation and preference of soil types in the dry season.

Soil Type	Expected Proportion of usage (P_{io})	Actual Proportion of usage (P_i)	Bonferroni interval
Mispah	0.566	0.790	0.713<p<0.867*
Shortlands	0.210	0.062	0.016<p<0.108*
Avalon	0.062	-	-
Mispah/Rock outcrops	0.042	-	-
Shortlands/Rock outcrops	0.038	0.005	0<p<0.018*
Others	0.081	0.144	0.078<p<0.210

Z=2.64;n=195
* indicates a difference at the 0.05 level of significance.

Table 3.4b Simultaneous confidence intervals to determine utilisation and preference of soil types in the wet season.

Soil Type	Expected Proportion of usage (P_{io})	Actual Proportion of usage (P_i)	Bonferroni interval
Mispah	0.566	0.641	0.553<p<0.729
Shortlands	0.210	0.273	0.192<p<0.354
Avalon	0.0.062	0.005	0<p<0.018*
Mispah/Rock outcrops	0.042	0.010	0<p<0.028*
Shortlands/Rock outcrops	0.038	0.067	0.021<p<0.113
Others	0.081	0.005	0<p<0.018*

Z=2.64;n=209
* indicates a difference at the 0.05 level of significance.

Table 3.5a Simultaneous confidence intervals to determine utilisation and preference of vegetation types in the dry season.

Vegetation Type	Expected Proportion of usage (P_{io})	Observed Proportion of usage (P_i)	Bonferroni interval
Sparse open woodland	0.103	0.051	$0.009<p<0.093$ *
Medium open woodland	0.194	0.405	$0.310<p<0.500$ *
Dense open woodland	0.226	0.282	$0.195<p<0.369$
Medium closed woodland	0.041	0.010	$0<p<0.029$*
Dense closed woodland	0.137	0.236	$0.154<p<0.318$
Thicket	0.133	-	-
Others	0.165	0.015	$0<p<0.038$*

Z=2.69;n=195

* indicates a difference at the 0.05 level of significance.

Table 3.5b Simultaneous confidence intervals to determine utilisation and preference of vegetation types in the wet season.

Vegetation Type	Expected Proportion of usage (P_{io})	Observed Proportion of usage (P_i)	Bonferroni interval
Sparse open woodland	0.130	0.033	$0<p<0.066$*
Medium open woodland	0.194	0.278	$0.195<p<0.361$ *
Dense open woodland	0.226	0.287	$0.203<p<0.371$
Medium closed woodland	0.041	0.120	$0.060<p<0.180$ *
Dense closed woodland	0.137	0.048	$0.008<p<0.088$ *
Thicket	0.133	0.005	$0<p<0.018$*
Others	0.165	0.230	$0.152<p<0.308$

Z=2.69;n=209

3.4.6 Vegetation communities

The results of observed utilisation of the different vegetation communities are shown in Tables 3.6a and 3.6b for the dry and wet seasons respectively.

The roan herd showed positive selection for the *Acacia tortilis* and *Acacia nilotica* valley bushveld in the dry season ($p<0.05$). The intermediate *Acacia caffra*, *Acacia tortilis* and *Acacia karoo* woodlands were selected against as were the *Acacia sieberana* tall grassveld, old lands and thicket ($p<0.05$). In the wet season the herd showed positive selection for the *Acacia sieberana* tall grassveld ($p<0.05$). The other communities were used less than is expected.

The composite map of roan preference areas is shown in Figure 3.1.

Table 3.6a Simultaneous confidence intervals to determine utilisation and preference of vegetation communities in the dry season.

Vegetation Community	Expected Proportion of usage (P_{io})	Observed Proportion of usage (P_i)	Bonferroni interval
Old Lands	0.125	-	-
Acacia tortilis/A. nilotica woodlands	0.183	0.836	0.768<p<0.904 *
A.tortilis/A.karoo/ A.caffra woodlands	0.375	0.164	0.096<p<0.232 *
A.sieberana/A.karoo woodlands	0.212	-	_
Thicket	0.106	-	_

Z=2.58;n=195

* indicates a difference at the 0.05 level of significance.

Table 3.6b Simultaneous confidence intervals to determine utilisation and preference of vegetation communities in the wet season.

Vegetation Community	Expected Proportion of usage (P_{io})	Observed Proportion of usage (P_i)	Bonferroni interval
Old lands	0.125	0.014	0<p<0.035*
Acacia tortilis/A. nilotica woodlands	-	-	-
A.tortilis/A.karoo/ A.caffra woodlands	0.375	0.234	0.158<p<0.310 *
A.sieberana/A.karoo woodlands	0.212	0.751	0.674<p<0.828 *
Thicket	0.106	-	-

Z=2.58;n=209

* indicates a difference at the 0.05 level of significance.

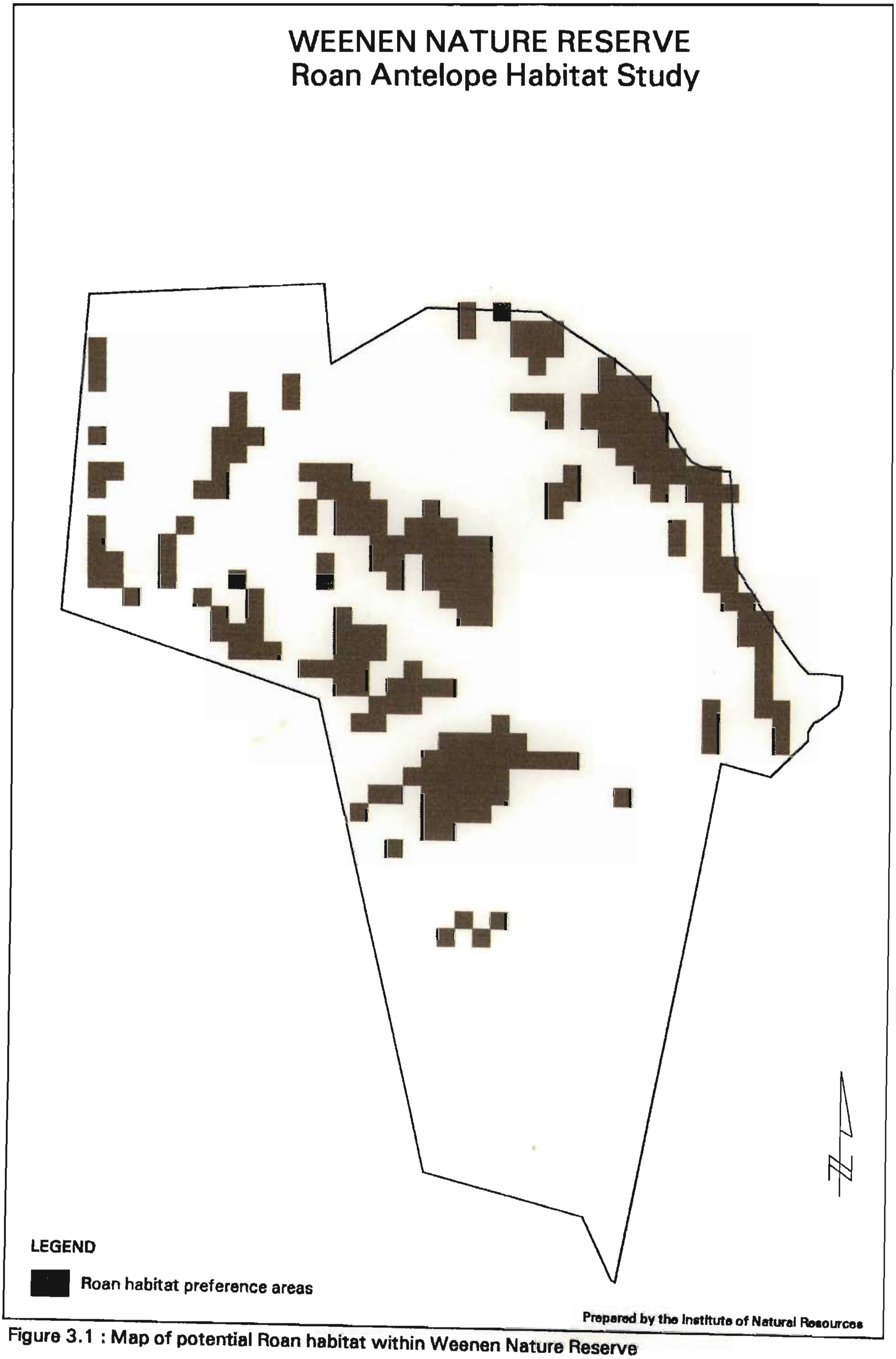

Figure 3.1 : Map of potential Roan habitat within Weenen Nature Reserve

3.5 Discussion

The roan herd at WNR showed a preference for lower-lying medium open *Acacia nilotica* and *Acacia karoo* bushveld in the dry season whereas it was associated with the upland *Acacia sieberana* tall grassveld, which had a relatively taller grass layer comprising *Themeda triandra* and *Hyparrhenia spp*. in the wet season. The dry season areas had a grassland field layer which included species such as *Themeda triandra*, *Bothriochloa insculpta*, *Heteropogon contortus*, *Panicum maximum*, *Sporobolus spp*. and *Eragrostis spp*..

The valley bushveld at lower altitude is relatively semi-arid and tends to be frost-free during winter (Edwards 1967, Tainton 1981). The higher lying tall grassveld areas were much more open and supported more mesophytic, nutritious grass species suited to the roan's feeding habits and breeding requirements.
The WNR roan herd selected grasslands growing on the most common soil types, that is Mispah and Shortlands. In the dry season Mispah, which occurred on shale and was found in association with rock outcrops was preferred, while Shortlands, formed from dolerite, were not utilised. Both the shale and dolerite grasslands were used in proportion to their availability in the wet season. A feature of both soil types at WNR is their shallow nature with the shale areas having been most affected by erosion that occurred prior to the proclamation of the reserve (Hughes 1989).

Dense closed woodland, thicket and old lands were avoided by the roan which is consistent with the negative selection for heavily wooded and very sparsely wooded habitats. In the case of the old lands areas, the dominant grass species present and not its physiognomy, may have been the primary factor which influenced its utilisation.

The WNR roan herd showed a preference for gently undulating terrain and avoided very flat and steep slopes. This avoidance of flat land, as evidenced by the negative selection of the Avalon soil type found in the western part of the reserve, may be correlated with a difference in woodland density. The better drained dolerite derived Shortlands and the shale derived Mispah were preferred to other soil types. The roan generally selected north and northwest facing slopes and avoided south and southeast facing slopes. The latter, mesocline slopes, tend to be successionally more advanced with taller, sourer grasses occurring *e.g. Cymbopogon spp.*. Grasses on north and northwest slopes (xerocline) are shorter with lower basal cover and are more xerophytic in nature (Edwards 1967).

The preference of roan for more open woodlands and savannas has been observed by other authors (Pienaar 1963, Joubert 1976, Wilson and Hirst 1977) and was substantiated by this study. Joubert (1976) in his study at Kruger National Park found that the preference for physiognomically open areas with a well developed grass layer was consistent irrespective of the geographical areas inhabited by this species. Wilson and Hirst (1977) corroborated this preference of roan for areas of low canopy cover at Percy Fyfe Nature reserve in the Northern Transvaal. Although roan were found to be tolerant of low shrub growth, they tended to be sensitive to bush encroachment (Joubert 1976). Ben-Shahar (1990) was unable to show that vegetation structure had any effect on the distribution pattern of roan in the Northwest Transvaal. Roan in his study area, however, showed an affinity for moderate slopes. Favoured roan habitat in KNP was on slightly undulating flats consisting of heavy clay soils derived from basalt although hillier areas on clay-loam soils derived from dolerite were also utilised, but to a lesser extent (Joubert 1976).

Habitat requirements of the WNR roan herd are in agreement with those of roan in the other studies cited, although it has to be remembered that the majority of the latter studies were conducted in dystrophic environments where roan still occur naturally. These are areas of low nutrient availability which support low densities of herbivore populations (Bell 1982). WNR occurs in a more nutrient rich environment which accordingly influences habitat use by herbivores.

CHAPTER FOUR

FEEDING ECOLOGY

4.1 Introduction

A thorough knowledge of the feeding habits of a species contributes significantly to broadening the knowledge used in making management decisions (Riney 1982). Several techniques exist for examining the diets of vertebrates ranging, from those involving the culling of individual animals to methods that involve little or no disturbance of the study animals. The latter non-intrusive methods include observations of animal foraging behaviour, analysis of removal rates and the analysis of faeces (Morrison *et al.* 1992). These methods are particularly useful in situations where the destruction of animals is not possible, for instance when the subjects of the study are rare or endangered.

Roan antelope are described as bulk and roughage grazers (Hofmann 1973). Several studies of the feeding ecology of roan have been undertaken by workers in Southern Africa (Wilson and Hirst 1977 and Joubert 1976). Given the rarity of the antelope in the sub-continent, direct observation was used in this study to determine feeding preferences. Geerling (1979) used faecal analysis in his study on roan in West Africa. In the present study, faecal analysis was also employed to avoid the need for handling these endangered animals and also because of the need to obtain year-round data on the feeding habits of a particular herd of animals.

4.2 Faecal Analysis

4.2.1 Introduction

The most readily obtainable samples of diets come from faeces (Morrison *et al.* 1992). Faecal analysis avoids the difficulties associated with other non-destructive methods, for example, disturbance of the study animals' behaviour and movements and the need for intensive observations (Everett 1991). Furthermore, droppings can be collected throughout the year from animals of any age or reproductive state, and repeated sampling of known individuals under natural conditions is possible (Morrison *et al.* 1992).

Faecal analysis involves the microscopic analysis of the epidermal structure of plant leaves which persist undigested in the faecal matter in sufficiently large fragments. Interspecific anatomical variation provide diagnostic criteria for the identification of plant species (Kok *et al.* 1973, McAllister 1967). This method has been used in a number of studies (Storr 1961), (McAllister 1967, *Aepyceros melampus*), (Scotcher 1978, *Hippopotamus amphibius*) and (Everett 1991, *Ourebia ourebi*).

Several workers have pointed out the shortcomings of the above method. Stewart (1967) cautioned that given the different digestive anatomy of animals and the differences in the digestibility and rates of passage through the digestive tract of grasses, it is advisible to limit studies to obtaining quantitative data on a frequency basis. Barker (1986) concluded that the method was flawed and that correction factors derived to cope with the effects of differential digestibility were only partly successful. Despite these shortcomings, other authors have indicated the value of the method in determining which grass species are utilized most and which are avoided. This level of information was found to be sufficient for management purposes (Riney 1982).

4.2.2 Methods

4.2.2.1 Reference Collection

A reference collection against which grass fragments found in the droppings could be compared, was prepared for 20 of the most common grass species occurring in the areas of the reserve where the roan herd are known to graze. Species that were very similar in terms of epidermal characteristics were lumped together at the generic level.

Reference slides were prepared by epidermal scrapes (Scotcher 1974). A piece of leaf was placed on a glass slide, flooded with water and the adaxial surface scraped away with a scalpel blade until only the abaxial surface remained. Grass species with particularly tough leaves were placed in bleach for a few minutes before scraping commenced. The fragments were then mounted in glycerine jelly. A specialised dichotomous key based on several readily identifiable epidermal characteristics was constructed for each species/genus.

4.2.2.2 Collection of faecal samples

Faecal samples were collected in areas where the roan herd was observed to be grazing (Figure 4.1). To avoid confusing the faecal pellets of the roan with those of other ungulates only fresh pellets were collected. Five faecal samples were collected from each location every month. The number of samples was limited to five because of the difficulty of locating more than this number in some of the areas in which the herd was observed to be grazing. The samples were dried and stored for later analysis.

4.2.2.3 Preparation of faecal samples

The method of Barker (1986) was used to prepare the faecal samples. The faecal pellets were placed in formol acetic alcohol for a few days prior to treatment to soften them. One pellet selected at random from each sample was then placed in a mortar and crushed with a pestle. Commercial bleach (sodium hypochlorite) was added and the particles, stirred and allowed to settle. When all the plant particles had sunk, the supernatant was decanted and the beaker filled with water. The bleached particles were stored in the fluid which acted as a preservative. The sample was then washed twice and mixed before a small random sub-sample was placed on a slide and dried. Glycerine jelly was used to make permanent slides for each sample.

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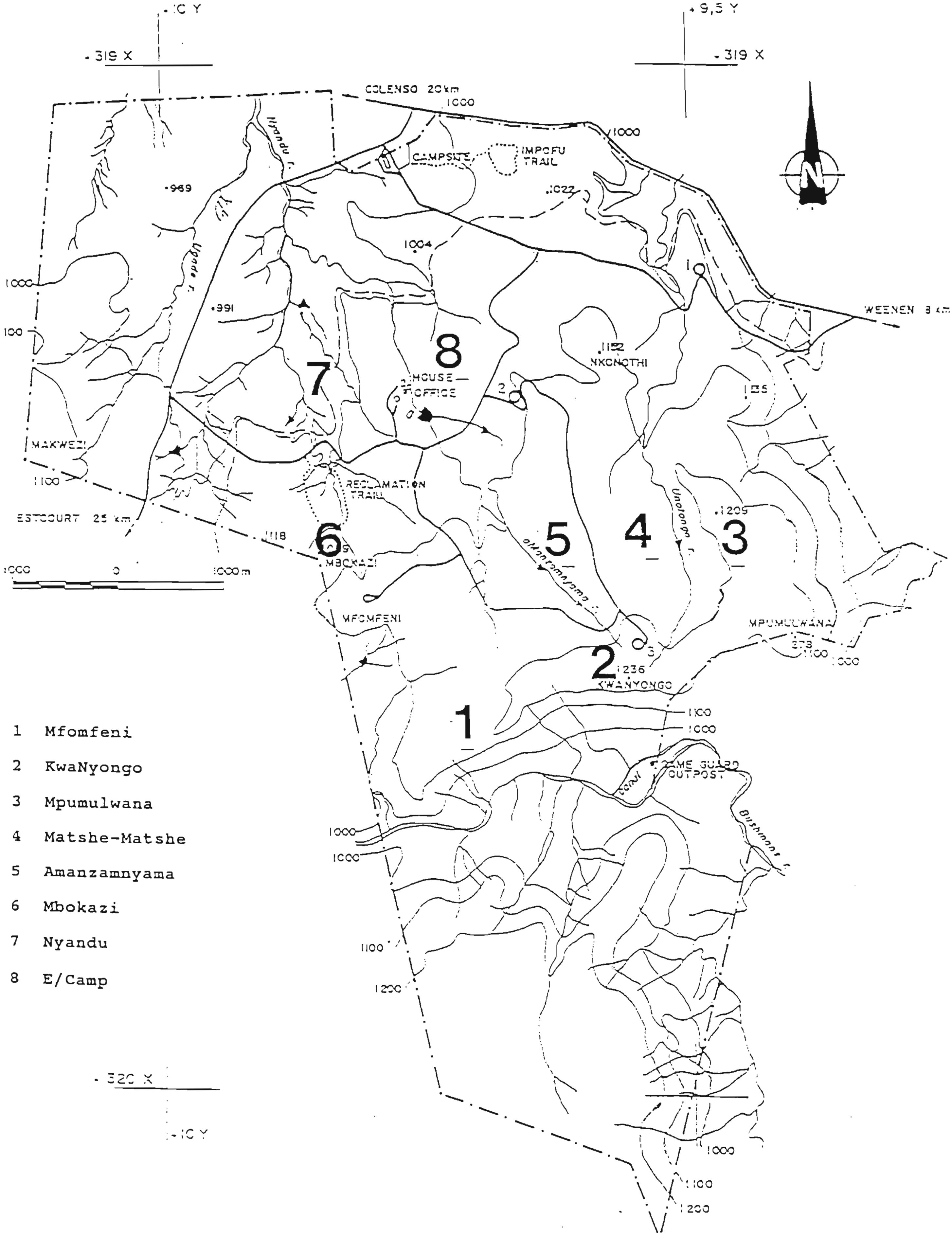

Figure 4.1 Location of the roan herd feeding areas.

4.2.2.4 Analysis of faecal samples

The method of Sparks and Malachek (1968) was used to examine the slides. Five permanent slides of each faecal sample were prepared and twenty fields of view of each slide were examined. All species present in each field were recorded, including those fragments which were unidentifiable in spite of containing sufficient diagnostic features. A fragment had to have at least two diagnostic features in order to be recorded.

4.2.3 Results

Table 4.1 shows the most common grass species that were identified in roan faecal pellets found at ten locations over the period of a year, within the study area. No attempt was made to lump the data from each location in order to emphasize the changes in the relative proportions of the different grass species in the different locations. For faecal samples collected in the wet season, the species with the greatest proportions of fragments were *Themeda triandra*, *Hyparrhenia spp.*, *Heteropogon contortus* and dicotyledonous forbs. In the dry season *T.triandra*, while remaining the dominant grass species in the roan's diet, experienced a slight decline in occurrance. The proportion of *Hyparrhenia spp*. declined to zero in the diet at the height of the dry season. Species that demonstrated an increase included *Panicum maximum*, *Sporobolus fimbriatus*, *Eragrostis curvula* and *Melinis spp*. The proportion of dicotyledonous forbs increased in the dry season.

Table 4.1 The proportions by volume of plant species in roan faeces at each feeding area.

Species	FEEDING AREA Mfomfeni October	Mfomfeni December	KwaNyongo February	Mpumulwana March	Matshe-Matshe March	Amanzamnyama April	Nyandu May	Mbokazi June	Nyandu July	E/Camp August	
Themeda triandra	51.4	47.5	46.8	45.7	52.1	53.7	37	36.6	39.8	44.2	*
Heteropogon contortus	6.2	2.9	5.1	5.1	3.6	1.8	5.3	6.3	7.2	4.8	*
Panicum maximum	2.2	2.7	0.4	1.1	0	2.8	3	4	7.2	3.6	*
Digitaria spp	1.1	2.9	0.4	3.1	0.8	2.1	1.6	1.3	2.7	0.8	
Aristida spp	0.8	0.3	0.8	2.7	0.6	1.4	0.9	1.5	0.2	0.6	
Seteria spp	0.6	3.4	1.5	2.7	1.2	4.1	1.6	0.2	1.2	1.7	
Sporobolus fimbriatus	1.4	5.1	0.4	0.7	0.2	3.5	6.8	5.6	5.8	4.6	*
Eragrostis curvula	2.1	1.5	1.9	2.6	2.6	1.4	2.7	6.3	6	1.6	*
Eragrostis superba	0.1	0.5	2.8	0	0.5	0.4	0.7	2	1.3	1.1	*
Melinis spp	0.1	0.9	3.5	8.2	3.3	6.7	7.1	7.9	6.3	1.1	*
Hyparrhenia spp	10.5	10.1	8.9	9	14	2.3	0.9	0	0	0	*
Eragrostis plana	0.1	0.5	1.6	0.7	0.8	1.4	5	4	1.6	2.3	*
Dicots	5	4.9	4.6	5.8	6.5	5.7	20.6	12.3	9	5.5	*

* Species that were found to be significantly different between feeding areas ($p<0.05$) using anova of faecal data in Appendix 2.

Table 4.2 shows the combined data for the year for those grass species that occurred in more than 50% of the samples. Figure 4.2 shows the frequency abundance curve for the combined faecal data for the study area. *T. triandra* was the most important grass species in the roan herd's diet over the entire study period. *T. triandra, H. contortus, Eragrostis curvula, Melinis spp., Panicum maximum* along with dicotyledonous forbs occurred with a frequency of greater than 80%.

Table 4.2 Frequency of observations for all faecal samples and the proportion of the total number of fragments counted for all faecal samples (n=50). Only major dietary species (>50%) of the roan herd at Weenen Nature Reserve are considered.

Species	Frequency of occurrence (%)	Percent occurrence of species*
Themeda triandra	100	45.9
Eragrostis curvula	90	4.0
Heteropogon contortus	88	5.2
Melinis spp.	86	4.3
Panicum maximum	80	2.6
Sporobolus fimbriatus	78	3.2
Digitaria spp.	72	1.8
Eragrostis plana	70	1.7
Hyparrhenia spp.	64	6.1
Seteria spp.	64	1.8
Aristida spp.	62	0.9
Eragrostis superba	60	1.1
Dicot	100	6.7

* refers to relative percent occurrence of plant fragments in roan faeces.

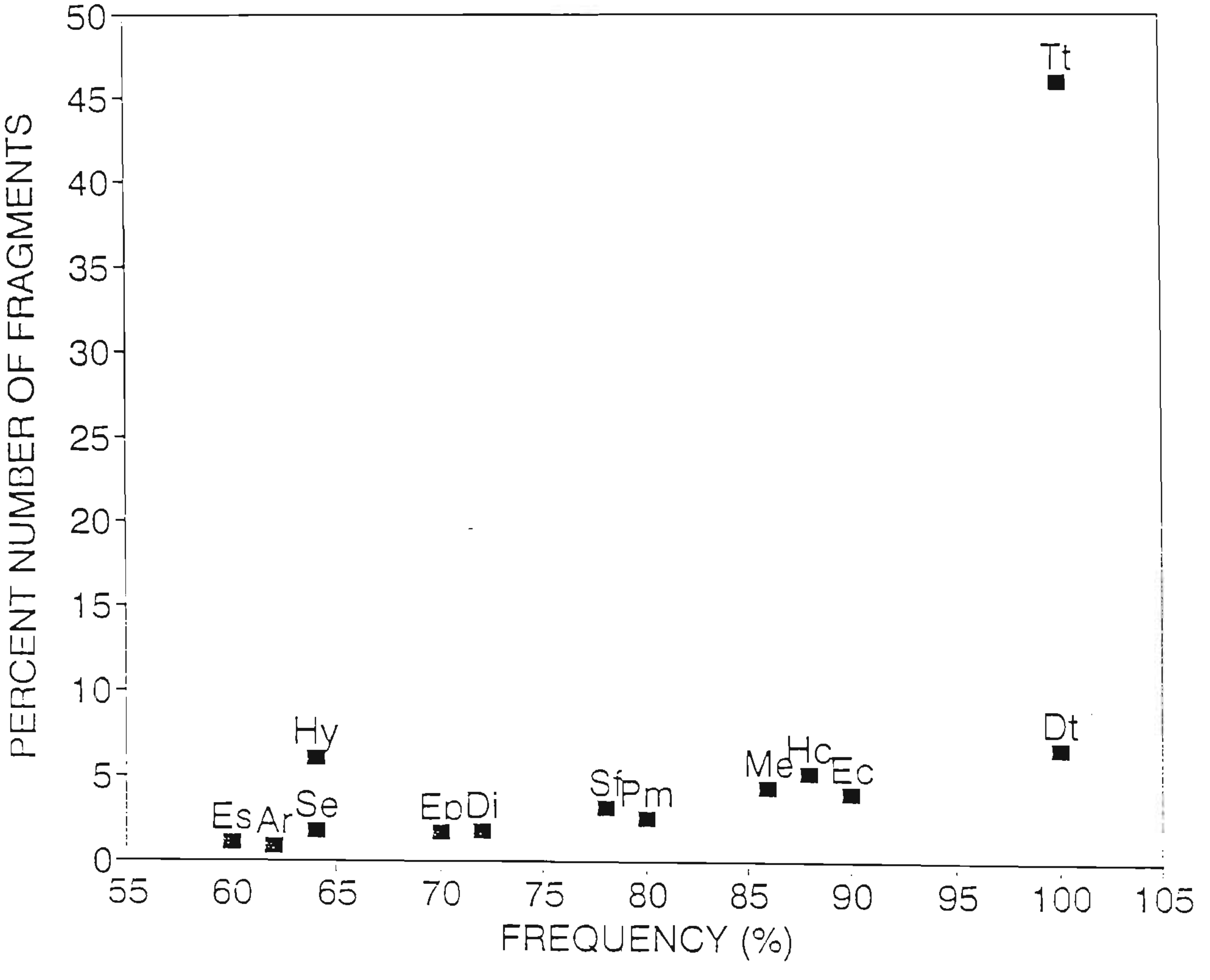

Figure 4.2 The overall importance of the major grass species (>50% frequency) in the diet of the roan herd at Weenen Nature Reserve. The frequency (%) represents the frequency of observation of a species for all faecal samples (n=50) and percent number of fragments represents the proportion of a species of the total number of fragments.

Tt: Themeda triandra

Hc: Heteropogon contortus

Ec: Eragrostis curvula

Me: Melinis spp.

Pm: Panicum maximum

Sf: Sporobolus fimbriatus

Di: Dicots

Ep: Eragrostis plana

Hy: Hyparrhenia spp.

Se: Seteria spp.

Ar: Aristida spp.

Es: Eragrostis superba

Di: Digitaria spp.

The results of a two-way analysis of variance of the monthly number of grass fragments of each species (Appendix 2) in the roan's diet in the different feeding areas are presented in Table 4.3.

Table 4.3 Analysis of variance of the number of fragments of grass species in roan faeces.

	DF	SS	MS	F
Species	19	136426.3	7180.33	98.79**
Areas	9	347	38.56	0.53 NS
Interaction	171	12427.94	72.68	8.13**
Residual	800	7149.6	8.94	
Total	999	156350.9		

The significant variance ratio for grass species eaten indicated a marked selection of some species in preference to others ($p<0.01$). The non-significant F-value for areas implied that the same species were selected by the roan herd in each feeding area. significant interaction between species and areas was observed ($p<0.01$) which indicated that the grass species were not consumed in the same proportions in the different feeding areas.

4.3 Vegetation structure and composition of roan habitat

4.3.1 Introduction

The diet of grazing ungulates is dependant upon the food species available to them in their environment. In order to assess the factors influencing graze selection it is necessary to examine the relationship between grazing and the availability of grass species in the environment (McAllister 1967).

The diet of ungulates can be divided into two categories namely, principal foods and preferred species (Riney 1982). Principal foods are those that make up the largest percentage composition of the diet. The preferred species, however, are those that are proportionally more frequent in the diet than they are in the environment. An index of grass species preference was used that combined data taken from the immediate areas where the roan herd was observed grazing and the level of utilisation of grass species in those areas as determined by faecal analysis.

4.3.2 Methods

4.3.2.1 The Step Point Method

The vegetation composition of the areas where fresh roan faecal pellets were collected was assessed by the Step Point method (Walker 1976). The method is regarded as quick, reasonably accurate and free from observer bias. A pointer was pushed into the ground at every step (1 m interval). The species of the nearest grass tuft was recorded. Forbs were recorded as such without any further attempt at identification.

A 200m transect was randomly laid out in what was perceived to be relatively homogeneous vegetation in the vicinity of the areas where the roan herd was observed to be grazing and where faecal pellets were collected routinely. Two hundred points were assessed in each sampling area.

4.3.2.2 Dry weight rank method

Herbaceous species composition by bulk contribution was determined by the method of Mannetje and Haydock (1963). An estimate was made of the species that contributed the most to the biomass in a series of quadrats. The three species which contributed the most to the biomass were ranked 1, 2 and 3 respectively. The other species within the quadrat were ignored. If only two species occurred in the quadrat then only ranks 1 and 2 were assigned. A $1m^2$ quadrat was considered satisfactory for open swards such as those found in the study area (Walker 1976).

Forbs were recorded as such without considering the species separately. The percentage contribution to the biomass of the different species was calculated using constants derived by Mannetje and Haydock (1963).

A 200m transect was randomly laid out in homogeneous veld where fresh faecal pellets were collected. $1m^2$ quadrats were demarcated with 1 m stakes at every 2 m. The grass species were ranked accordingly depending on whether there were two or three species present. Forbs that occurred in the quadrats were lumped together as one category.

4.3.3 Results

The results of the species composition assessments for each area are shown in Tables 4.4 and 4.5. In all but three areas *T. triandra* was the most abundant species both in terms of composition and dry weight. In the Mfomfeni, KwaNyongo and Matshe-Matshe areas *Hyparrhenia spp.* were abundant with the values for both composition and dry weight exceeding those of *T. triandra* in the latter area. Other productive species (greater than 5%) in terms of dry matter production included *H. contortus*, *Seteria spp.* and *Cymbopogon spp.* in the Mfomfeni and KwaNyongo areas. In the Mbokazi and Nyandu areas `important' species were *T. triandra, Bothriochloa insculpta, Sporobolus fimbriatus, Eragostis curvula* and *Melinis spp.*.

The composition and dry weight data shown in the tables are limited to those species that were identified in the roan faecal pellets. Species composition and abundance data were recorded in those areas where the roan herd was observed grazing intensively, so the data from the faecal analysis provided sufficient evidence for species-specific selection. While some species may have been obtained outside of the areas assessed, this was not believed to have occurred on a significantly large scale to bias the results of feeding selection. Figure 4.3 to 4.12 show the percentages of grass species present at the vegetation sites and in faeces at each sampling location. A Kolmogorov 2-sample test was performed on the dry-weight data and the proportions of grass species in the faeces for each feeding

Table 4.4 Results of the Dry-Weight Rank veld assessment.

SPECIES	%WEIGHT							
	Mfomfeni	KwaNyong	Mpumulwan	Matshe-Matshe	Amanzamnya	Nyandu	Mbokazi	E/Camp
Themeda triandra	41.4	27.7	58.3	3	50.4	9.2	39.7	41.1
Heteropogon contortus	11.6	1.7	2.7	0.7	2.4	14.9	12.9	25
Trachypogon spicatus	0	0	0	0	0	1.1	0.7	0
Bothriochloa insculpta	3.3	9.2	2.7	1.3	3.1	23.1	19.6	0.5
Tristachya leucothrix	0.5	0	0.5	1.3	0	2.4	0	0
Panicum maximum	0.1	0.1	0.4	0	0.8	0.3	0.2	1
Digitaria spp.	0.3	0.4	1	0.3	1	0.2	2	0.5
Cymbopogon spp.	10.9	5.8	7.5	20.1	1.6	0.7	2	2.4
Aristida spp.	5.8	1.7	1.3	2.3	2	17.1	5.1	1.4
Seteria spp.	2.8	4.4	3.6	2.3	2.9	0.2	0.1	0.8
Sporobolus fimbriatus	1	0.2	0.2	0.1	1.6	8.8	6.2	1.4
Eragrostis curvula	0.8	1	2	1	1.6	5.9	2	12
Chloris gayana	0	1	0	0	0	2.6	0	0
Eragrostis superba	0.8	0.7	1.1	0.3	1.6	0.7	2.7	0.8
Sporobolus africanus	0.1	0	0.7	1	2.4	0.3	0.2	0
Melinis repens	0.4	1.3	0.9	2.6	2.4	4.7	1	1
Hyparrhenia spp.	16.9	34	8.1	55	16.1	1	0	3.5
Eragrostis plana	0.3	1	0.4	1.1	0.7	1.2	0.7	0.5
Sporobolus pyrimidalis	1.3	1.3	0.9	1	2.4	2.6	1.5	1.4

Table 4.5 Results of the Step-Point veld assessment.

SPECIES	%FREQUENCY							
	Mfomfeni	KwaNyongo	Mpumulwana	Matshe-Matshe	Amanzamnyama	Nyandu	Mbokazi	E/Camp
Themeda triandra	52.5	21.7	64.9	8.7	50.4	10	34.7	50.8
Heteropogon contortus	9.5	5.4	1.4	1.4	9.1	15.1	14.6	24.2
Trachypogon spicatus	0	0	0	0	0	1.2	0.6	0
Bothriochloa insculpta	0.7	4.4	1.2	1	3.4	27.5	19.8	1
Tristachya leucothrix	0	0	0.3	0.6	0	3.4	0	4
Panicum maximum	0	0	0.1	0	1.2	0.4	0.6	0.6
Digitaria spp.	0	0.2	0.2	0.4	1	0.1	0.9	0.3
Cymbopogon spp.	7	11.3	17.6	24.1	1.1	1.3	2.3	1.7
Aristida spp.	2.1	0.2	0.4	1.8	0.6	9.3	7.3	0.4
Seteria spp.	6.2	5.6	1	3.5	0.6	2.4	0.1	1
Sporobolus fimbriatus	1	0	0.1	0	0	9.8	7.8	1.9
Eragrostis curvula	2.4	0.4	5	1.4	5	6.4	3.3	9.9
Chloris gayana	0	0	0	0	0	1.7	0	0
Eragrostis superba	0	0	0.2	0.2	0.5	0	0.6	0.8
Sporobolus africanus	0.2	0.2	0.4	1.2	1.2	0.1	0.2	0
Melinis repens	0.6	0	1.1	2.1	2.3	6.4	1.7	0.7
Hyparrhenia spp.	12.2	19.8	5	43.6	18.1	0.3	0	2
Eragrostis plana	0	0.8	0.1	0.2	0.2	0.7	1.3	0.1
Sporobolus pyrimidalis	0.6	1.1	0.2	0	0.9	4	0.2	1

Species key for grasses in Figures 4.3 to 4.12

Ttr: *Themeda triandra*

Hco: *Heteropogon contortus*

Tsp: *Trachypogon spicatus*

Bin: *Bothriochloa insculpta*

Tle: *Tristachya leucothrix*

Pma: *Panicum maximum*

Digi: *Digitaria spp.*

Cym: *Cymbopogon spp.*

Aris: *Aristida spp.*

Sete: *Seteria spp.*

Sfi: *Sporobolus fimbriatus*

Ecu: *Eragrostis curvula*

Cga: *Chloris gayana*

Esu: *Eragrostis superba*

Saf: *Sporobolus africanus*

Meli: *Melinis spp.*

Hypa: *Hyparrhenia spp.*

Epl: *Eragrostis plana*

Spy: *Sporobolus pyrimidalis*

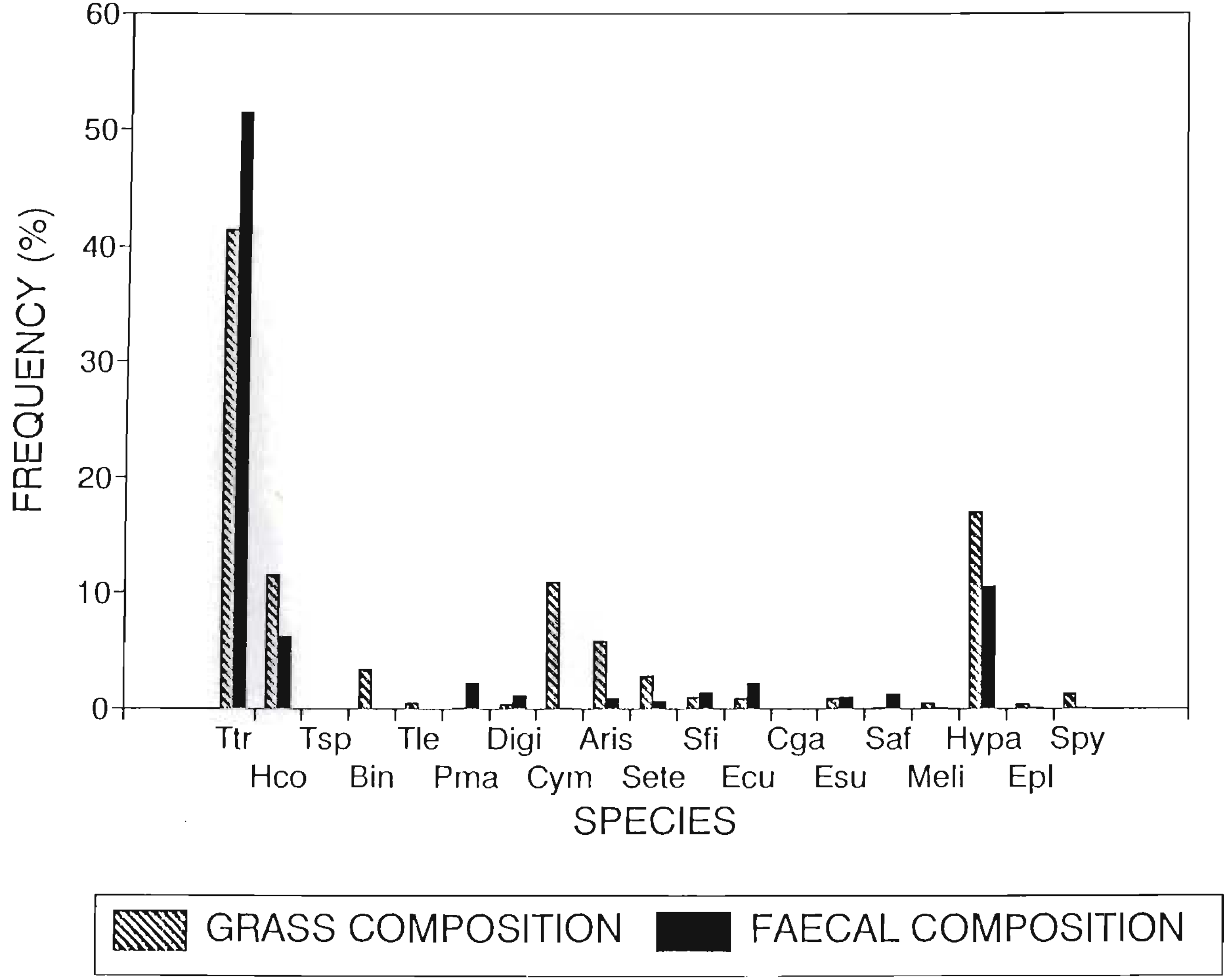

Figure 4.3 The percentages of grass species present in vegetation and faeces in Mfomfeni feeding area for October.

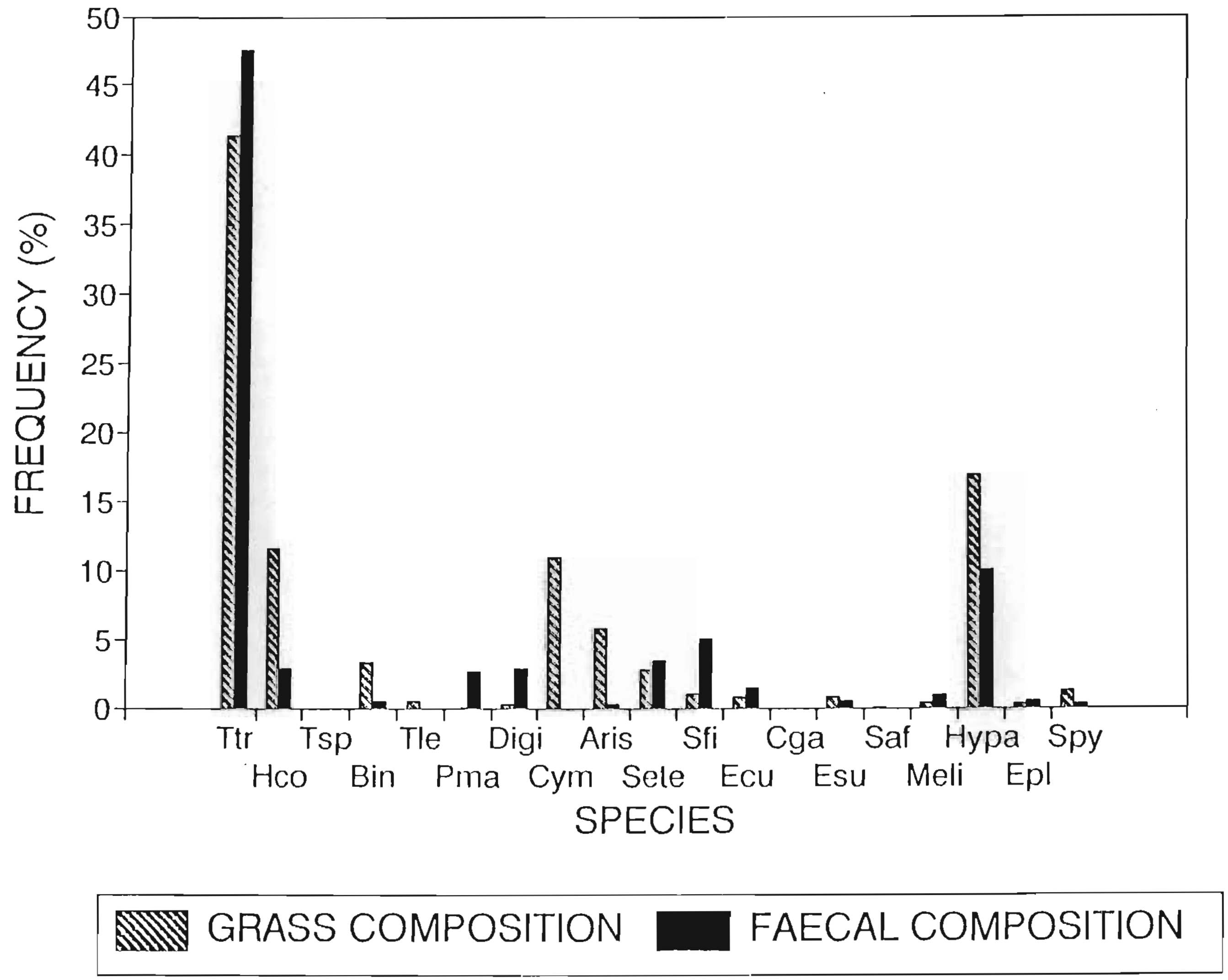

Figure 4.4 The percentages of grass species present in vegetation and faeces in Mfomfeni feeding area for December.

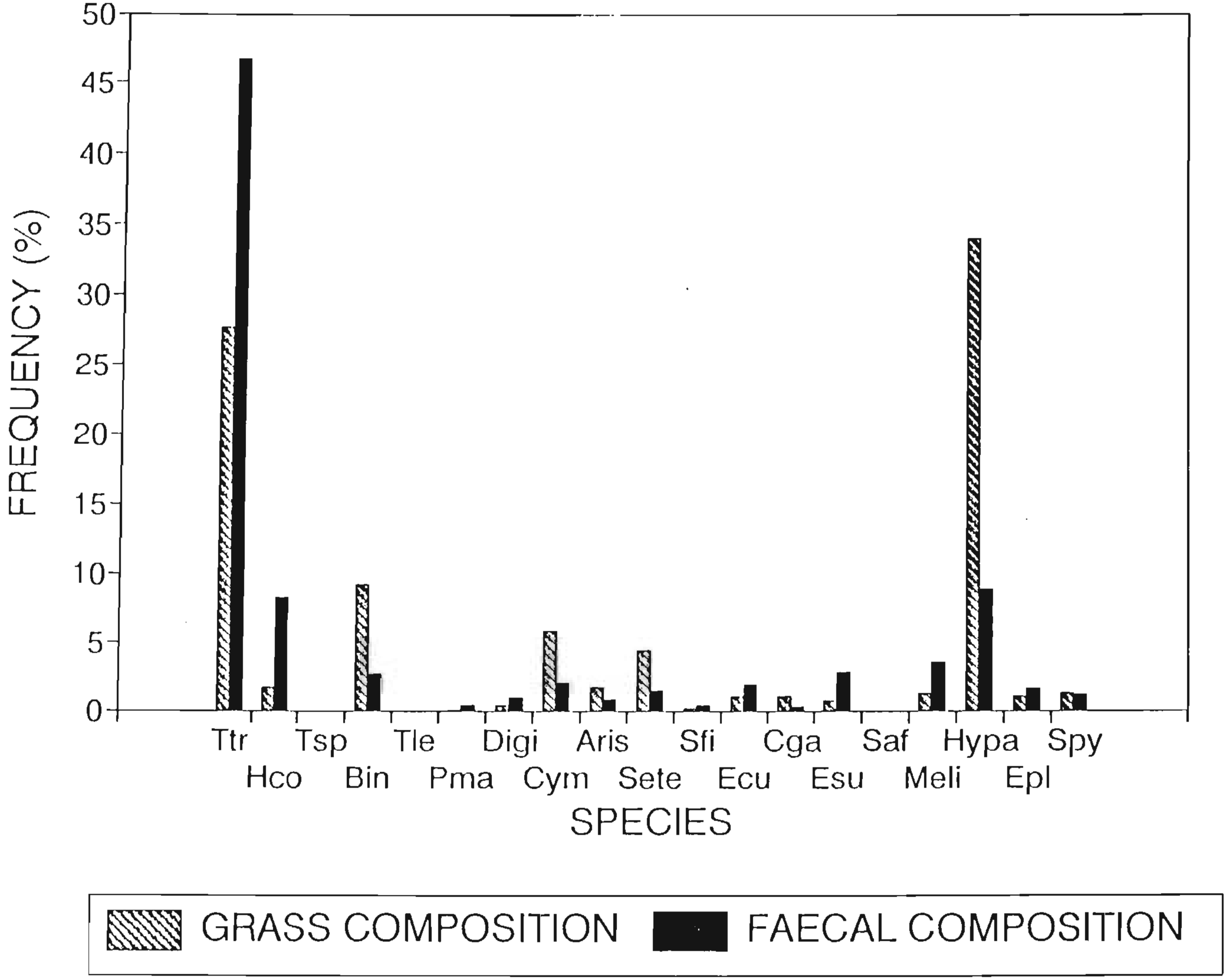

Figure 4.5 The percentages of grass species present in vegetation and faeces in KwaNyongo feeding area for February.

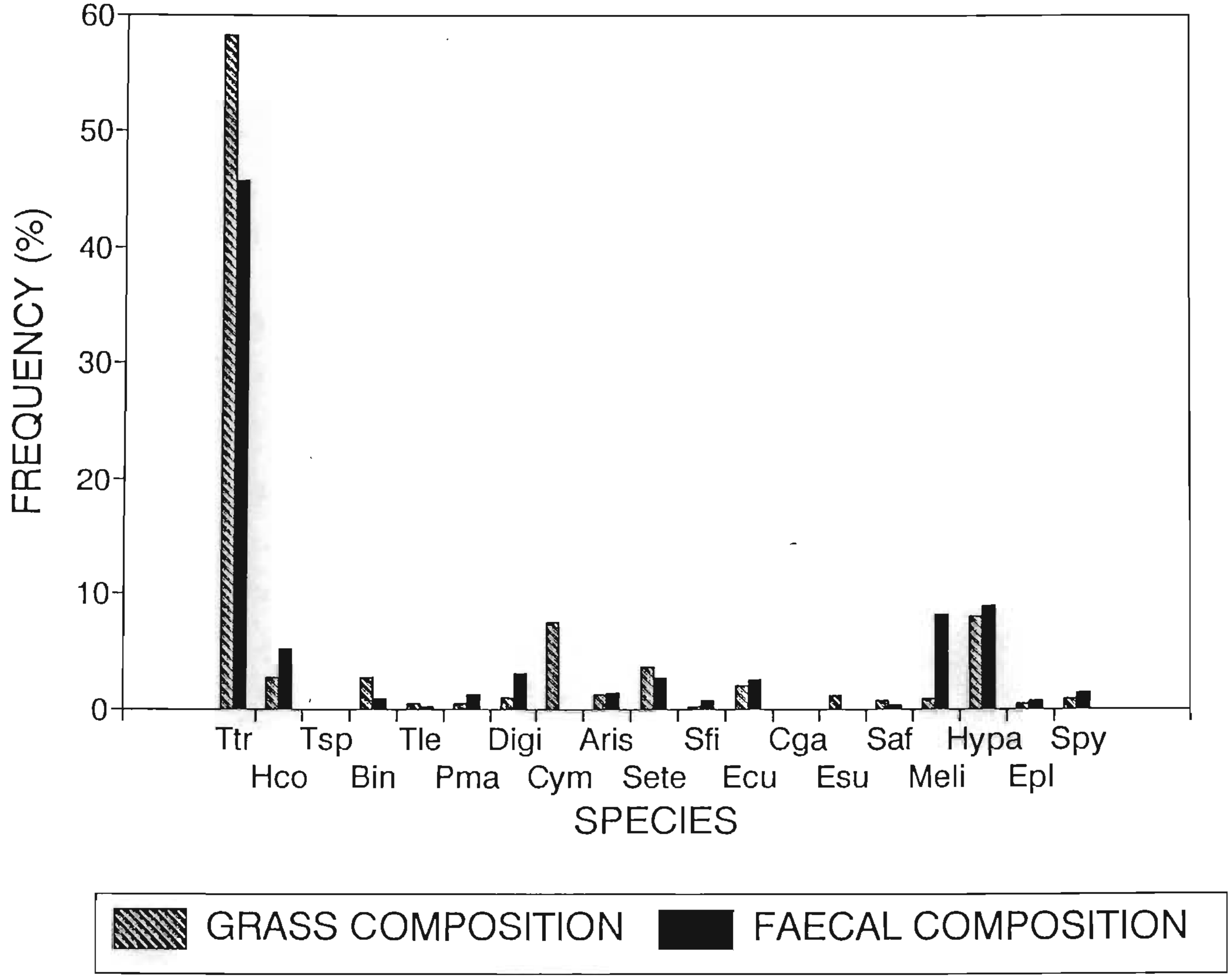

Figure 4.6 The percentages of grass species present in vegetation and faeces in Mpumulwana feeding area for March.

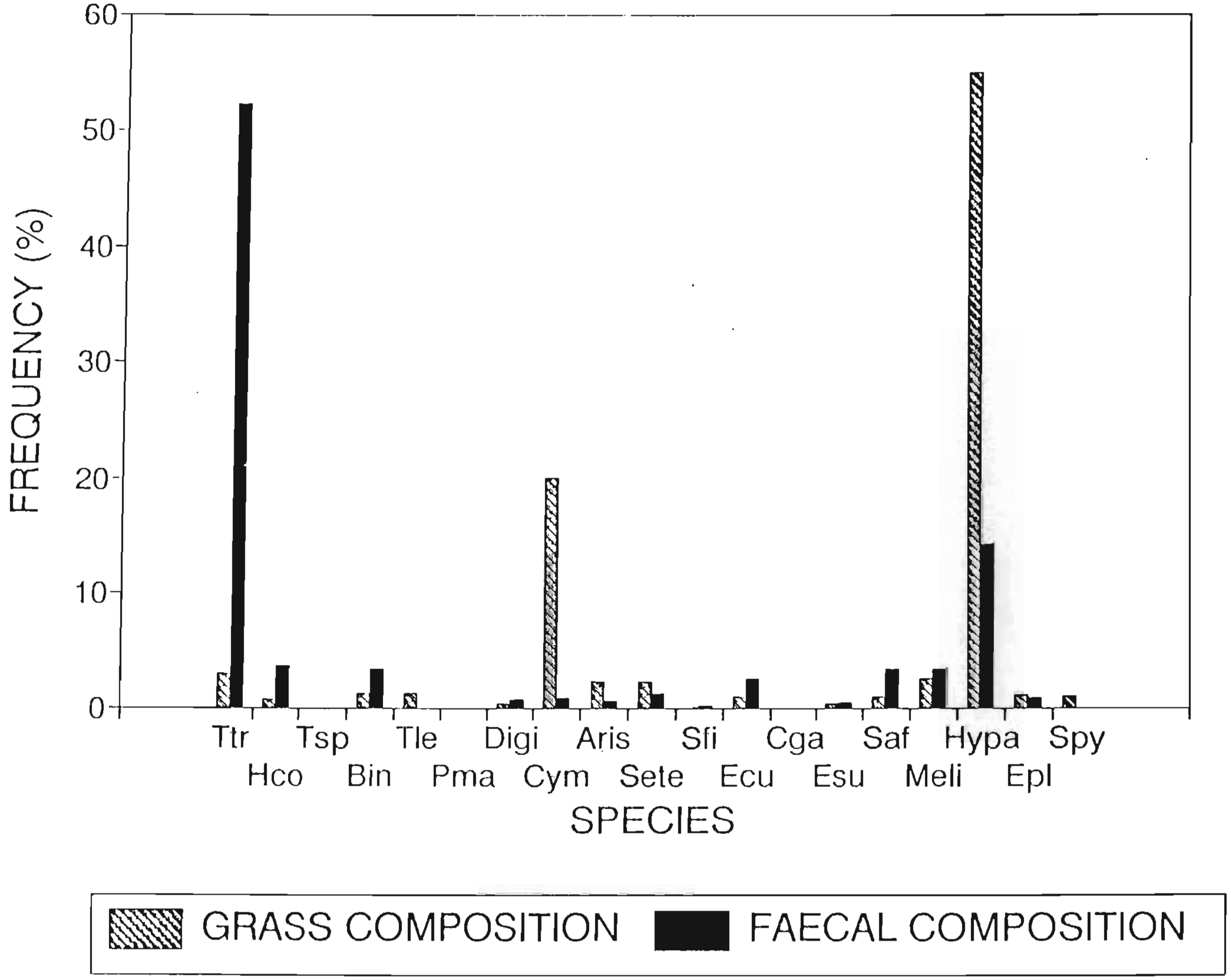

Figure 4.7 The percentages of grass species present in vegetation and faeces in Matshe-Matshe feeding area for March.

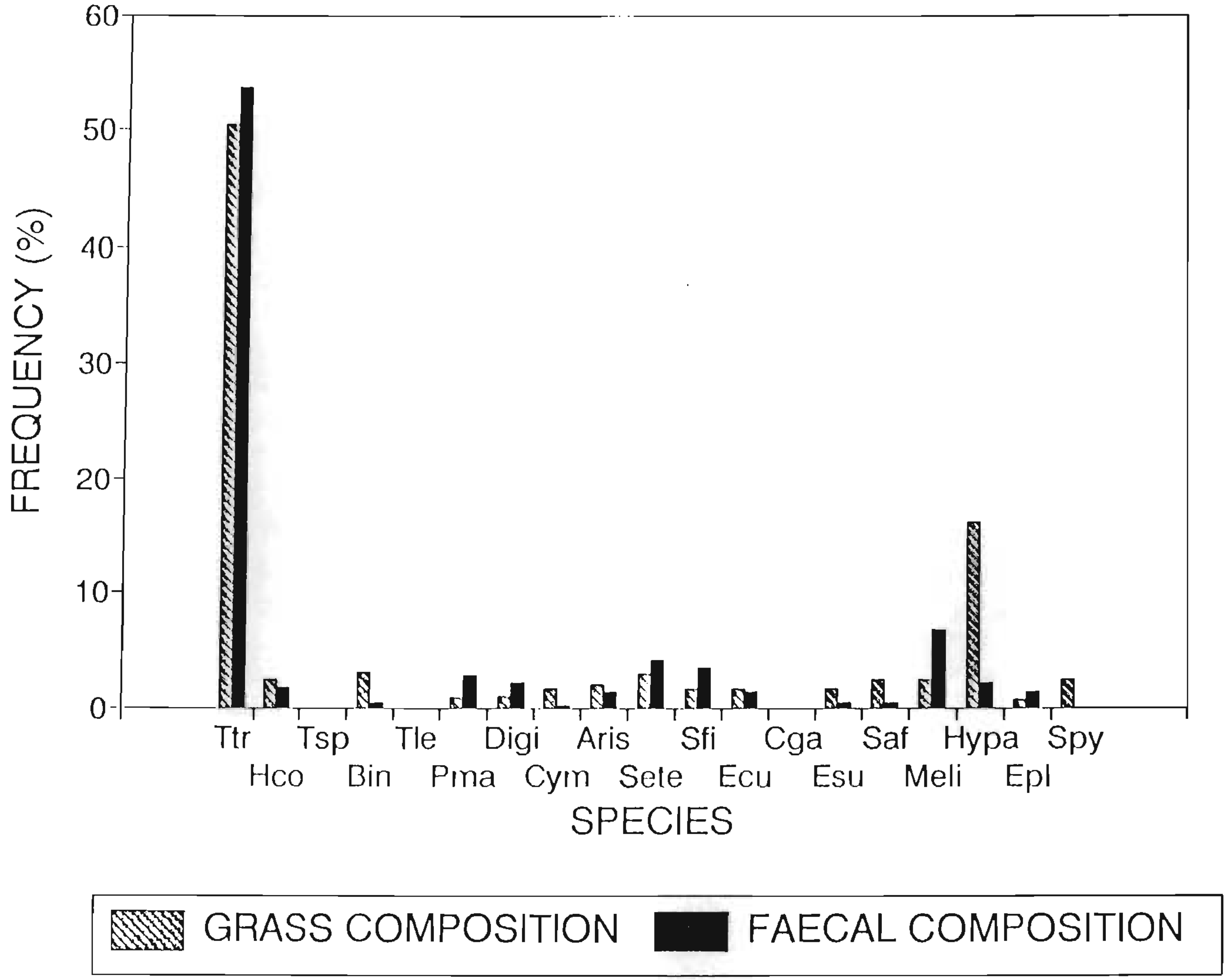

Figure 4.8 The percentages of grass species present in vegetation and faeces in Amanzamnyama feeding area for April.

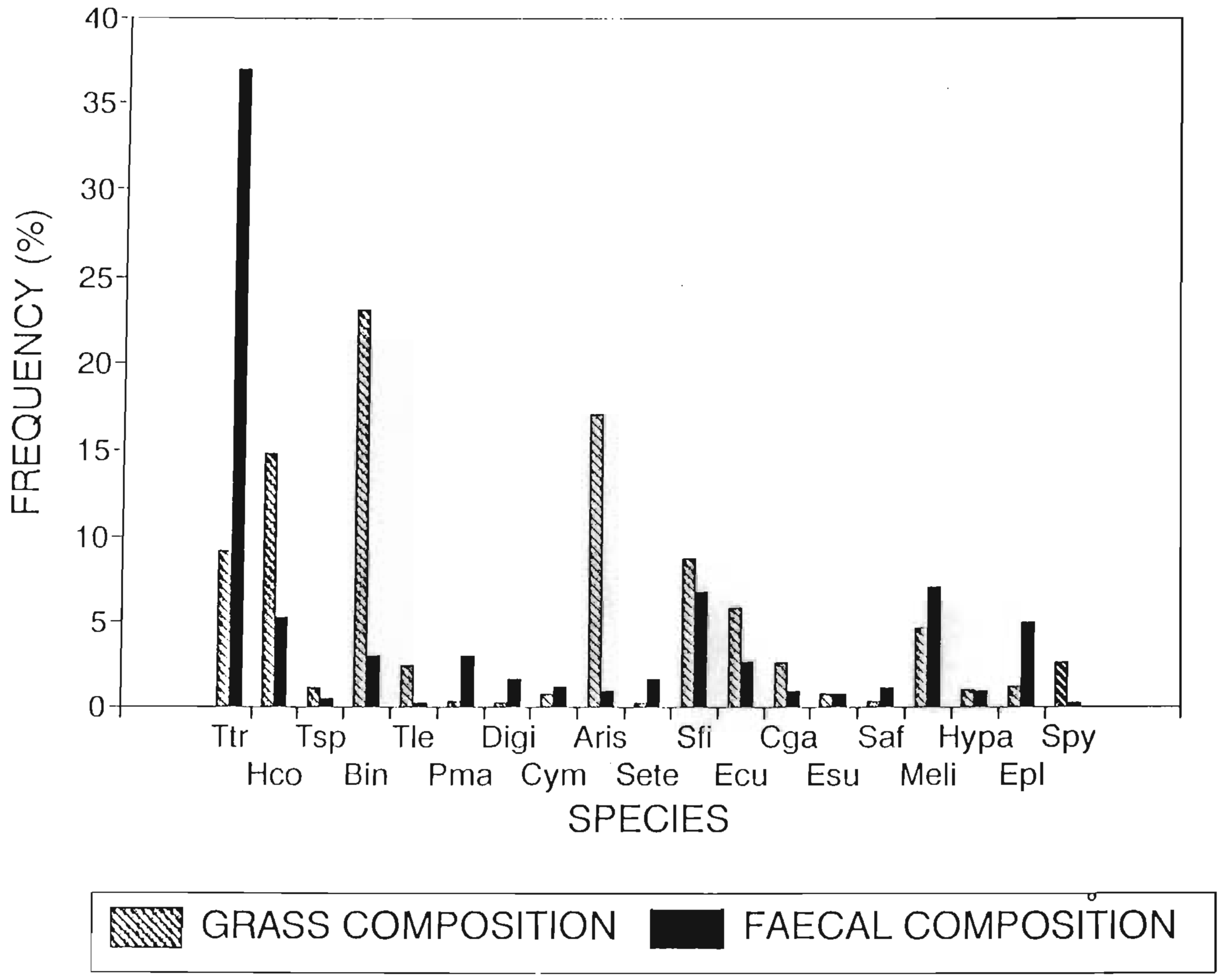

Figure 4.9 The percentages of grass species present in vegetation and faeces in Nyandu feeding area for May.

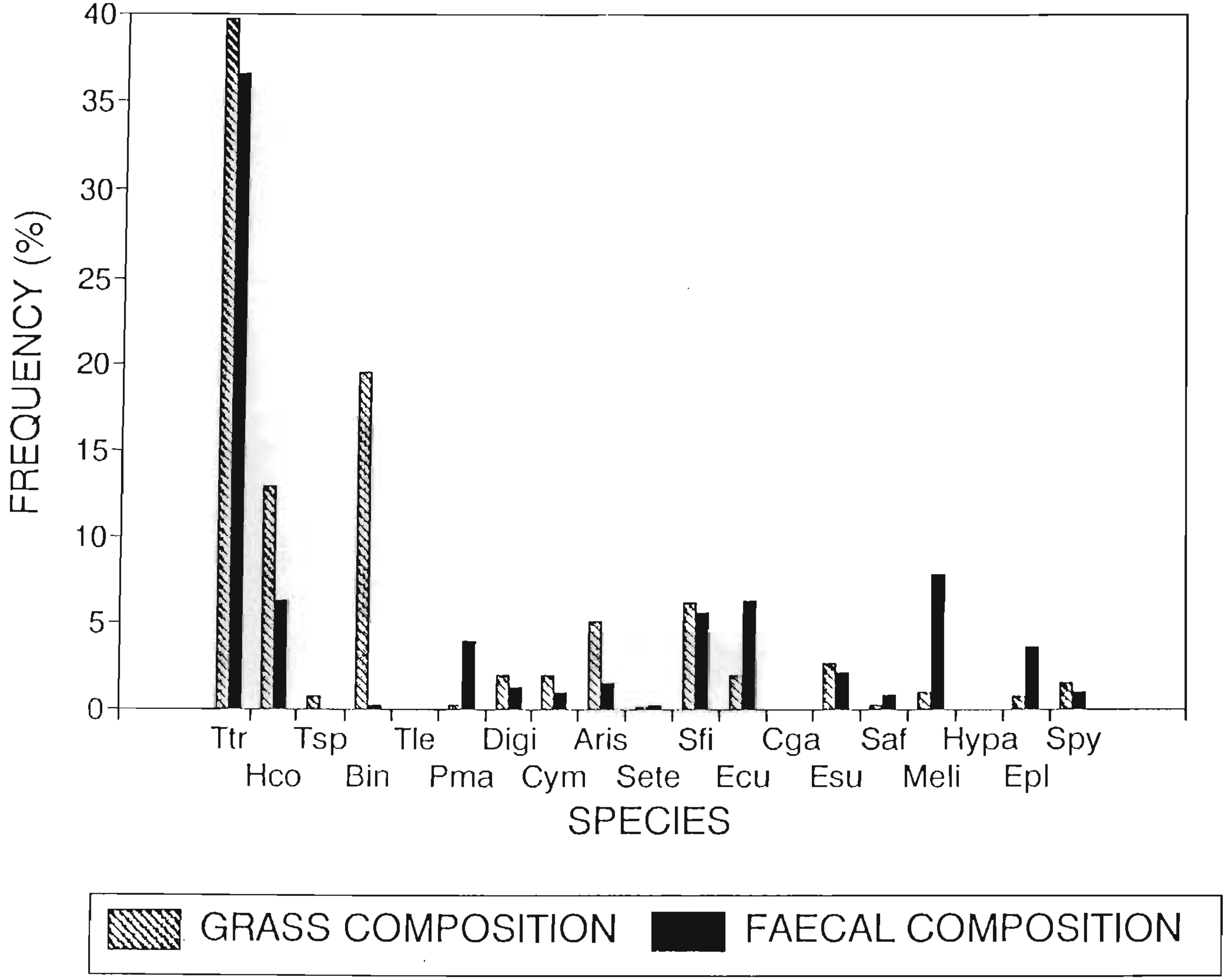

Figure 4.10 The percentages of grass species present in vegetation and faeces in Mbokazi feeding area for June.

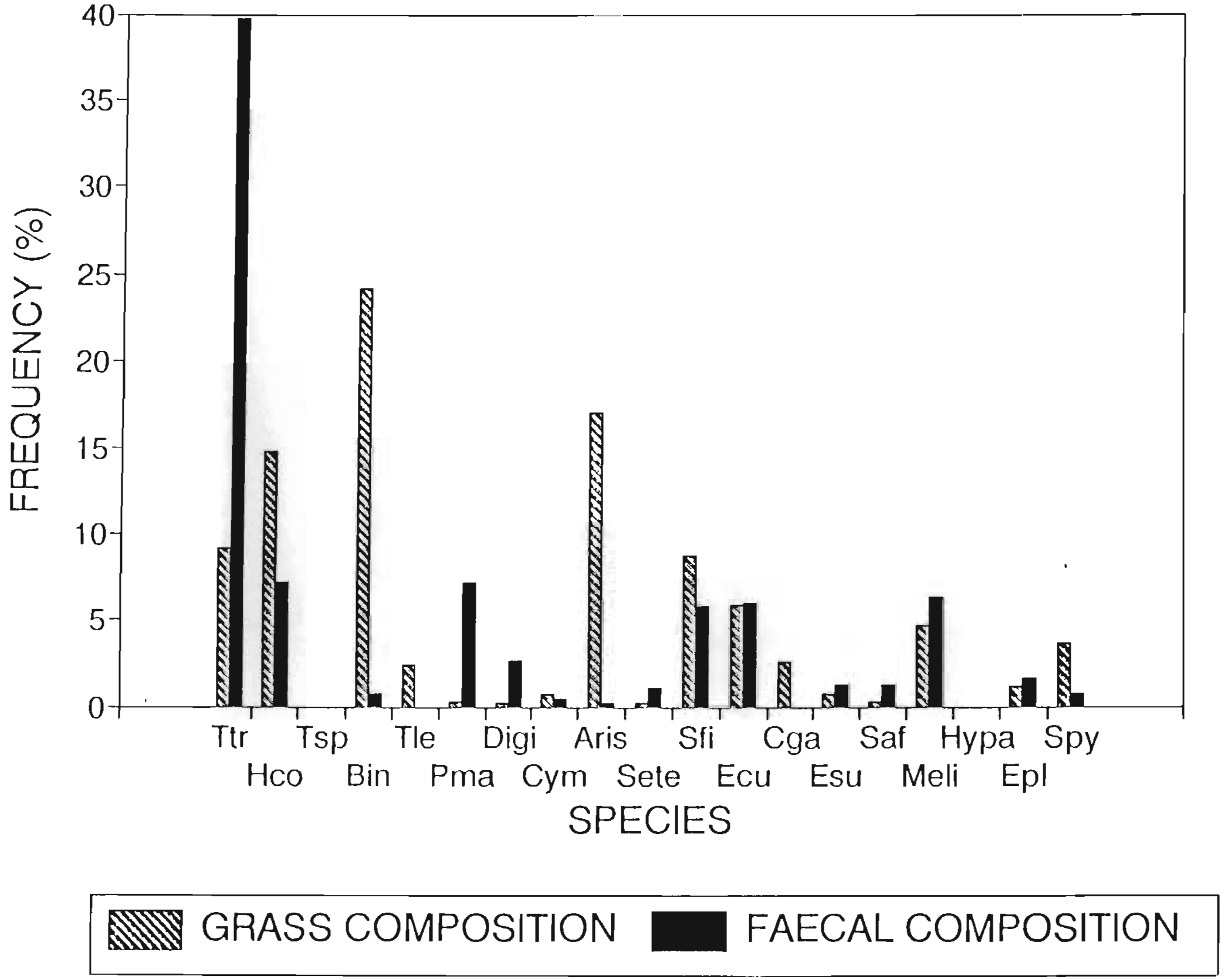

Figure 4.11 The percentages of grass species present in vegetation and faeces in Nyandu feeding area for July.

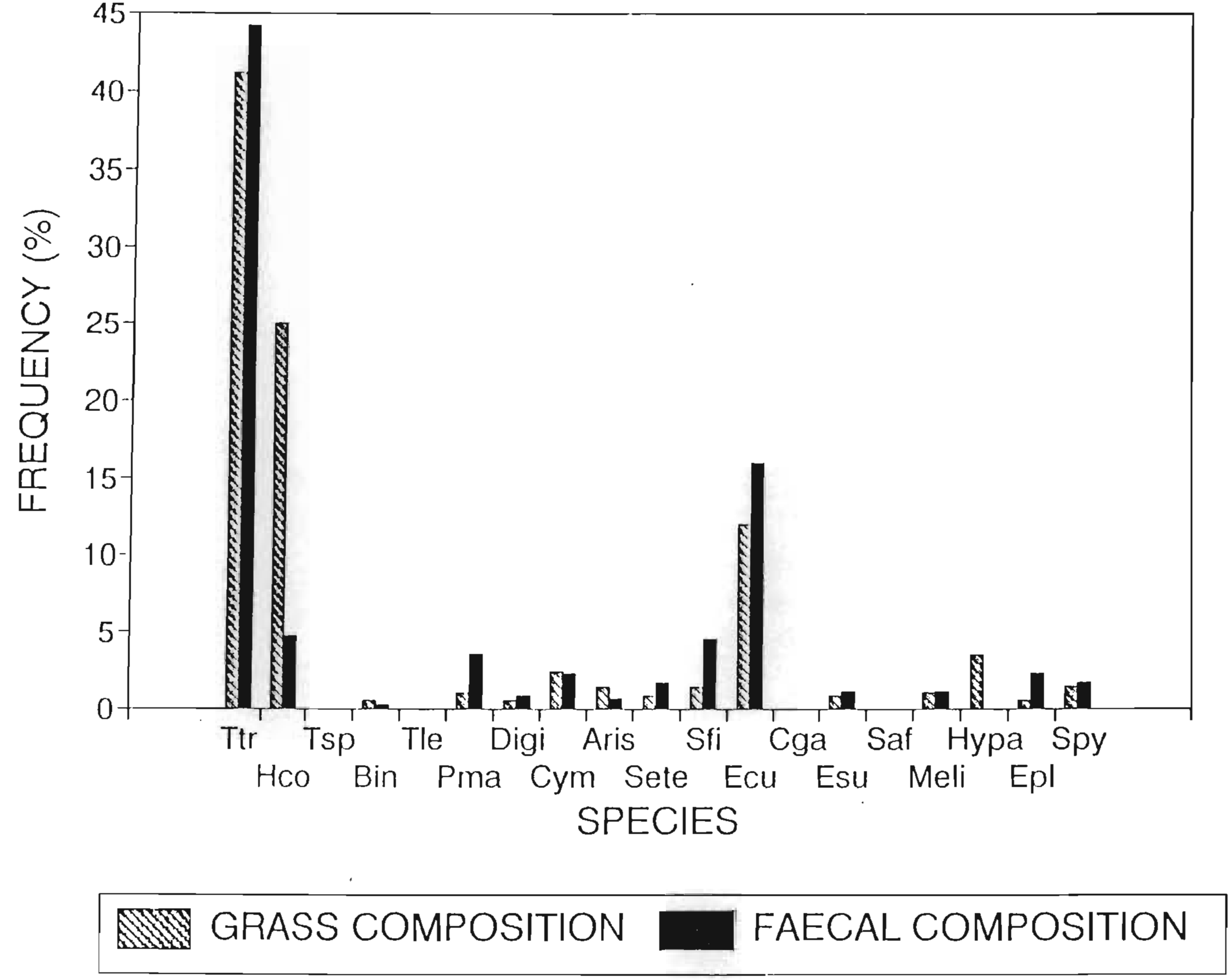

Figure 4.12 The percentages of grass species present in vegetation and faeces in E/Camp area for August.

area. The roan were not found to be utilising the recorded species in significantly different proportions to their occurrence ($p>0.05$).

A two-way analysis of variance was performed on the dry-weight data shown in Table 4.4 after arcsin transformation and the results are presented in Table 4.6.

Table 4.6 Analysis of variance of dry-weight vegetation data.

	DF	SS	MS	F
Species	18	9069.5	503.86	11.43**
Areas	9	347.0	38.56	0.53 NS
Error	126	5552.67	44.07	
Total	151	14689.2		

The highly significant F-value reflected the difference in the proportions of different grass species in the feeding areas ($p<0.01$). The variance ratio for areas suggested that the species were present in similar proportions in the feeding areas.

Table 4.7 shows the preference ratings of each grass species recorded in the faecal samples for each feeding area. Confidence limits of 95% were attached to the index of selection. A significant departure from unity reflected selection for or against a species ($p<0.05$)

Table 4.7 Species preference ratings according to McAllister (1967). Selection index = % of species in diet/ % of species available.

SPECIES	FEEDING AREA									
	Mfomfeni October	Mfomfeni December	KwaNyong February	Mpumulwan March	Matshe-Matshe March	Amanzamnya April	Nyandu May	Mbokazi June	Nyandu July	E/Camp August
Themeda triandra	1.24	1.15	1.69	0.78	17.4*	1.07	4.02	0.92	4.33	1.08
Heteropogon contortus	0.53	0.25	4.82*	1.89	5.14*	0.75	0.36	0.49	0.48	0.19
Trachypogon spicatus	i	i	i	i	i	i	0.45	i	i	i
Bothriochloa insculpta	i	0.15*	0.29*	0.33*	2.54*	0.16*	0.13*	0.01*	0.03*	0.4*
Tristachya leucothrix	i	i	i	0.4	i	i	0.08*	i	i	i
Panicum maximum	22*	27*	4	3	i	3.5	10*	20*	24*	3.6
Digitaria spp.	3.67	9.67*	2.25	3.1	2.33	2.1	8*	0.65	13.5*	1.6
Cymbopogon spp.	0.01*	i	0.34*	i	0.04*	0.13*	1.71*	0.5*	0.71	0.96
Aristida spp.	0.14*	0.05*	0.47*	1.08	0.26*	0.7*	0.05*	0.29*	0.01*	0.43*
Seteria spp.	0.21	1.21	0.34	0.75	0.52	1.41	8*	2	5.5*	2.13
Sporobolus fimbriatus	1.4	5.1*	2	3.5*	2	2.19*	0.77	0.9	0.66	3.29*
Eragrostis curvula	2.63*	1.88*	1.9*	1.3	2.6*	0.88	0.46	3.15*	1.02	1.33
Chloris gayana	i	i	0.3	i	i	i	0.35	i	i	i
Eragrostis superba	1.25	0.63	4*	i	1.67	0.25	1	0.78	1.86*	1.38
Sporobolus africanus	12*	i	i	0.43	3.3	0.17	3.67*	4*	4.33*	i
Melinis spp.	0.25	2.25	2.7	9.11*	1.27	2.8	1.51	7.9*	1.34	1.1
Hyparrhenia spp.	0.62*	0.6*	0.26*	1.11	0.26*	0.14*	0.9	i	i	i
Eragrostis plana	0.33	1.67	1.6	1.75	0.73	2	4.17*	5.14*	1.33	4.6*
Sporobolus pyrimidalis	0.08*	0.23*	0.85	1.56*	i	i	0.08*	0.67	0.19*	1.21

* represents a significant departure from unity.

i: denotes total selection against a species.

4.4 Discussion

Food plant selection is subject *inter alia* to the general composition of the vegetation and the availability of the various grass species. The validity of any conclusions on the feeding preference of any species must therefore take this into consideration (Joubert 1976). The availability and acceptability of different food plants is influenced by growth stage, structure and the influence of management actions such as burning and the provision of supplementary feeds.

The determination of the principal food species by faecal analysis without attempting to assess the degree to which an animal selects those species from its environment, does not provide sufficient information on which to base any management decisions pertaining to that animal. An index of preference which estimates the extent to which a food species is consumed in relation to its availability can be used to identify those species which are palatable or preferred (Riney 1982).

The most important grass species in the diet of the roan herd at WNR were *T. triandra* (45.9%), *Hyparrhenia spp* (6.06%), *H. contortus* (5.2%), *Melinis spp.* (4.3%) and *E. curvula* (4.0%). Dicotyledonous forbs were also important in the roan herd's diet. Preferred species throughout the study period (PR>1) were *T. triandra*, *H. contortus*, *Panicum maximum*, *Digitaria spp.*, *S. fimbriatus*, *E. curvula*, *Melinis spp.* and *Eragrostis plana*.

A seasonal breakdown of the results showed that *T. triandra* was the greatest contributor to the diet throughout the wet and dry seasons whereas *Hyparrhenia spp.* were only consumed in signficant proportions in the early wet season. Consumption of this species declined drastically in the dry season which is perhaps a reflection of the fact that these species did not make a significant contribution to the grass biomass in the dry season range of the roan herd. Significantly, however, even in the `old land' areas that are dominated by *Hyparrhenia spp., T. triandra* was selected over the former species. In the dry season range of the roan herd, increaser species such as *Melinis spp.* and *Eragrostis spp. were* consumed to a greater extent than in the wet season range. The consumption of *T. triandra* declined slightly in the dry season range.

Dicotyledonous forbs were consumed to a greater extent in the dry season than the wet season rising to 20.6% in June. The roan herd, particularly the cows, were observed on several occasions browsing on *Acacia* shrubs.

From the results of the faecal analysis, it can be seen that the roan antelope are selective feeders with only two or three species comprising the bulk of the diet. The herd generally appeared to be selecting those species that made up a large proportion of the grass biomass such as *T. triandra*. The number of grass species consumed increased in the dry season, including a greater proportion of increaser species, reflecting the poorer veld quality in these `sweeter' areas although the overall diet was similar throughout the year. In both the wet and dry season feeding areas, *T. triandra* was the dominant grass species in terms of biomass. It was also the most important dietary species as determined by faecal analysis.

Hirst (1975) in his study areas in the Northern Transvaal found that preferred species of roan kept in an enclosure included *H. contortus, Melinis repens, T. triandra* and *Hyparrhenia hirta*. The animals were found to be highly specific in their choice of grass species even under stress. Joubert (1976) showed that *T. triandra* was the most important species in the diet of roan antelope in the Kruger National Park in both wet and dry seasons. Availability was found to play an important role in food selection as the major species did not necessarily have high preference ratings. He found that browse did not make a significant contribution to the diet of roan (<5% of total intake). Wilson and Hirst (1977), however, believed that browsing played an important role during critical periods of the year.

The roan antelope at WNR appear to have wet season and dry season feeding areas and this is reflected in their diet. Feeding in the wet season occurred on the dolerite outcrops which are dominated by tall grassveld species such as *T. triandra* and *Hyparrhenia spp.*. This area is characterised by sparsely distributed tall *Acacia sieberana* trees with an understory of *Acacia karoo, Acacia tortilis* and *Acacia caffra*.In the dry season, the Nyandu and Mbokazi areas which have a different grass species composition from the Tall Grassveld areas, were utilised most frequently.

Increaser species such as *Sporobolus spp.*, *Eragrostis* spp, *H. contortus* and *Melinis spp.* increased in the diet. The dry season areas were characterised by *Acacia nilotica* and *A. karoo* shrubs and had a `sweeter' composition of increaser grass species. Shade grasses such as *Sporobolus fimbriatus* and *Panicum maximum* occur under the trees particularly in denser woodland and were increasingly utilised in the dry season.

It was found that `old land' areas which comprised mainly *Hypparhenia spp.* were not utilised to any great extent by the roan herd. These species were only utilised in the early wet season after burning had occurred the previous winter and were completely ignored as the wet season progressed and in the dry season. The palatability of the cauline *Hyparrhenia spp.* declines as the wet season progressed because of the increased lignification of these species. These species can reach heights of up to two metres reducing visibility for the roan and this might explain why summer areas feeding areas were abandoned as the wet season progressed. Heitkoning (1993) found that roan in the Northern Transvaal were deterred by high densities of stem in the grass sward. *Hyparrhenia spp.* were co-dominant with *T. triandra* on dolerite outcrops which were favoured by the roan herd in the wet season. By the end of the wet season the taller, late flowering *Hyparrhenia spp.* had surpassed *T. triandra* and other species in height thereby rendering the areas unattractive to the roan. *Hyparrhenia spp.* tend to spread where there is protection from burning, trampling and fire (Edwards 1967). The stocking rate of herbivores is low at WNR and this may unwittingly assist in the spread of these species. The effect of this is countered by the biennial burning policy that is implemented on the reserve.

It is commonly accepted that rare or endangered species have more specialised feeding habits than more abundant ones (Wilson and Hirst 1977). Confounding the issue of specificity of feeding preferences are other factors which play a role in habitat selection. Many areas exist which have suitable food sources for roan and yet the species has become locally extinct. This suggests that the past and present distribution of roan cannot be explained on the basis of food plants alone (Joubert 1976).

CHAPTER FIVE

SOCIAL STRUCTURE AND ACTIVITY PATTERNS

5.1 Introduction

The amount of time allocated to foraging and rumination by a large ruminant herbivore is dependent upon the quality and quantity of the food supply and its spatial distribution (Leuthold 1977). The need to rest and perform certain social functions further limits the amount of time available for the acquisition of sufficient food to meet its nutrient requirements. The relative amounts of time apportioned to each of these functions is influenced by the quality of food which tends to decline with the onset of the dry season (Heitkoning 1993). The daily feeding patterns of ruminants generally tend to be regular with the animals feeding actively in the early morning and in the late afternoon (Moen 1973).

The social organisation of a population is influenced by its response to its environment and as a result varies with changes in that environment (Leuthold 1977). The behavioural response of a population to its environment can be measured by assessing the density, physical condition, behaviour and social structure of its individuals. Cowan (1974) suggested that social constraints played an important role in determining patterns of range occupancy, density and distribution. Previous studies on the social organisation of roan antelope occurring at low densities indicated that the species was not strictly territorial, with the female herds being accompanied by a single bull which defended an exclusion zone of 200-500m around the cows (Joubert 1970, 1974).

Data on diurnal activity, herd size and composition were collected during the study period in order to assess herd stability and to augment and update information available to the reserve managers.

5.2 Methods

Herd size and composition were recorded whenever the roan herd was encountered during the study period. The activity that the majority of the herd members were engaged in, on each observation, specifically grazing, resting and other activities (*ie.* fighting, drinking, walking and other social interactions) was noted along with the time. Sex and age of each herd member was also recorded using the classification of Joubert (1976).

5.3 Results

5.3.1 Diurnal Activity Pattern

The overall diurnal activity patterns of the roan herd in the wet and dry seasons are presented in Figure 5.1. The roan herd grazed intensively between 0900 and 1200 with a second minor peak of activity between 1600 and 1700. Resting peaked between 1200 and

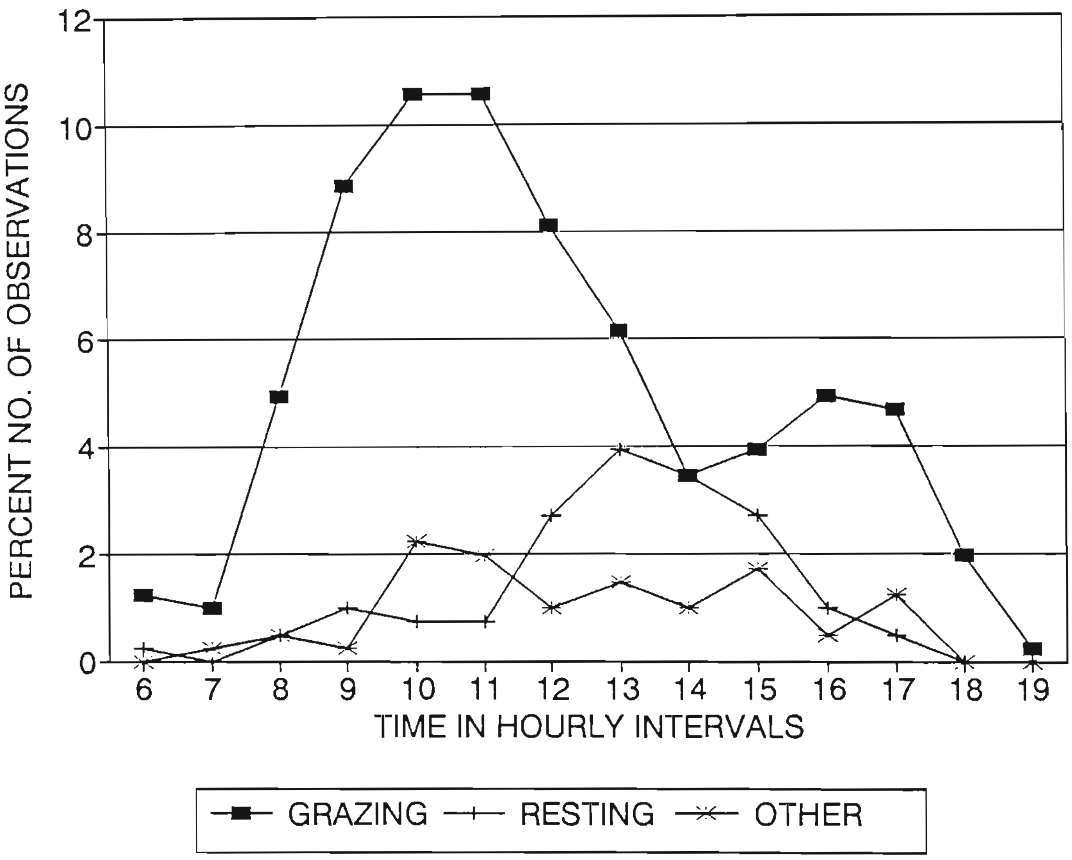

Figure 5.1 Diunal activity pattern for the roan herd at Weenen Nature Reserve (n=404).

1600 h. The roan herd was observed drinking in the late morning while other activities were generally evenly dispersed during the day. Similarly, grazing took place throughout the day but declines were observed very early and very late in the day. No attempt was made to record activity patterns at night due to various logistical constraints.

5.3.2 Herd Composition

The herd's sex and age structure is shown in Table 5.1. The roan nursery herd at WNR consisted of eleven (11) members. A herd bull, a subordinate male, six cows and three juveniles, whose ages ranged from approximately two months to sixteen months. One of the cows was visibly pregnant as determined from photographs taken of the herd. Five (5) other roan antelope occurred within the reserve comprising four bulls and an unsexed adult individual. The sex of the youngest juvenile was not determined. A total of sixteen roan antelope occurred at WNR in February 1995, having increased from the nine animals that were introduced in 1988, an increase of 77.8% over seven years. Of the seven animals that were born and survived at WNR, three were born during the study period of 16 months, suggesting improved reproductive success.

Table 5.1 Structure of the roan herd at Weenen Nature Reserve (as of January 1995).

Herd bull	Adult cow	Sub-adult bull	Heifer (12-16 mths)	Calf (7-10 mths)	Calf (5-8 wks)
1	6	1	1	1	1

5.4 Discussion

The roan herd at WNR was found to have two grazing peaks during the day, a major one in the morning and a lesser one in the mid-afternoon. A resting peak was observed in the middle of the day. These observations tally with those of Sekulic (1977) who found that a roan herd in his study area in Kenya grazed intensively between 1000 and 1100 with a resting peak occurring between 1400 and 1500. Joubert (1970) found that roan in his study area in Kruger National Park had a grazing peak just before sunset, although, unlike Estes (1991), he did not think that much grazing occurred after sunset. The resting peak observed in the present study appeared to coincide with the hottest part of the day. Grazing, however, was largely confined to cooler periods, although the roan were observed grazing throughout the day. Seasonal differences in foraging behaviour was not considered in the present study. It has, however, been shown that roan increase foraging time in the dry season although they appear to spend less time ruminating than other grazers during the day. This was due to the fact that the daily fibre intake of roan varied little between seasons (Heitkonig 1993).

The roan herd in the present study consisted, throughout their home range, of females and their young, accompanied at all times by the same bull. The herd composition remained the same in that none of the other solitary roan bulls in the reserve joined the nursery herd in either the wet or the dry seasons. The herd bull was observed on two occasions chasing a solitary bull when it approached the herd. Fighting ensued in both cases which only ceased when the interloper had withdrawn.

Roan antelope are regarded as semi-gregarious, generally sedentary and occurring in small herds numbering between six and 20 animals (Estes 1991). Males are tolerated by the herd bull until they reach the age of about three years when they are evicted. The sub-adult males join bachelor herds and remain part of these until they mature at about six years of age (Joubert 1970). Two males were observed together at WNR but it does not appear that bachelor herds occur in the study area due to the current low population density and the fact that the majority of the lone bulls are animals that were originally translocated to the reserve. Joubert (1970) believed that the social behaviour of roan was governed by a linear dominance hierarchy. The rank order based on age was maintained at all times by roan antelope that were kept in an enclosure at Kruger National Park. Joubert suggested that other animals would be not be permitted to join such a tightly structured social system.

Roan antelope are regarded as having a high reproductive potential under favourable conditions, with cows being capable of calving every ten months or so. The cows go into post-partum oestrus within six weeks of giving birth (Joubert 1970, Huntley 1971). Initially, the WNR herd did not show a satisfactory rate of increase. This situation appears to have improved during the study period with a third of the cows having a calf at heel and one being visibly pregnant. The initial slow rate of increase was probably related to an unstable sex ratio within the original nine translocated animals, and not to habitat conditions which were unlikely to have been very different to those which prevailed during the study period. The herd composition appears to have stabilized, thereby allowing reproductive capacity to improve. Joubert (1970) regarded the ideal sex ratio and age structure of a founder roan herd to comprise a mature bull, four adult cows, three heifers and a male calf which closely resembles the composition of the nursery herd at WNR.

CHAPTER SIX

THE EFFECT OF MANAGEMENT PRACTICES ON ROAN HABITAT USE

6.1 Introduction

Thorough knowledge of the ecological requirements of an endangered ungulate provides the basis for the formulation of an appropriate programme of management actions directed at that species. The identification of the minimum habitat requirements for a species is essential before specific management actions can be instituted. When sufficient knowledge is available, measures that can be implemented include, (i) manipulation of the habitat to make it as productive for the species as possible, (ii) the installation of dry season water points, (iii) the reduction of competitors for food and (iv) the control of predators (Riney 1982).

Weenen Nature Reserve is located within the Draycott Plain which is an ecotonal grassland which is distinguished by tall grassveld (Pentz 1938a, 1938b). The region is subjected to periodic fires and is regarded as a sub-climax maintained by fire (West 1951). Experiments by West (1951) have shown that controlled burning maintains the undisturbed veld while protection leads to changes in composition and structure, ultimately leading to the replacement of the grasses by forbs and woody shrubs. Extensive overgrazing in the past has led to the invasion of woody shrubs with consequent changes in the vegetation.

In the absence of sufficient grazing pressure and as a result of high rainfall, certain grass species tend to alter the structure of the grass layer resulting in a loss of palatability particularly for species that are sensitive to the amount of stem in the grass sward (Heitkoning 1993). Burning is used as a method to defoliate grassland periodically and maintain it in an optimum condition for roan antelope.

Competition from other ungulates may negatively affect highly selective species such as roan antelope, and is of particular significance in small reserves where numbers per unit area tend to rise more rapidly than in larger reserves (Wilson and Hirst 1977). The provision of water plays an important role in controlling temporal and spatial distribution of ungulates. The distribution of roan antelope is regarded as being dependent on the availability of open water (Smithers 1992). Competition among different ungulates can be controlled to some extent by avoiding an even distribution of water points.

Habitat diversity which promotes stability particularly in multi-species situations is influenced by different stages of successsion, time since burning and distance to water. All of these can be influenced and have important implications for management (Walker and Goodman 1983).

The influence of various management measures on habitat use was assessed to determine their suitability for the roan herd.

6.2 Methods

6.2.1 Roan distribution in relation to other ungulates

The location of the roan herd was noted on a map in relation to a 200x200m grid whenever it was encountered during the study period. All large herbivores within 200m of the roan herd were recorded. Their activity was also recorded and their presence was taken as indicative of potential feeding competition (Wilson and Hirst 1977). The data were analysed by comparing the relative number of observations of potential competitor species in the dry and wet seasons.

6.2.2 Roan distribution in relation to burning

The distributional plotting of the roan herd was related to the burning regime immediately prior to and during the study period. The data were analysed with the aid of Bonferroni confidence intervals. Three categories were used for the analysis namely, (i) six to twelve months, (ii) twelve to twenty-four months, and (iii) more than twenty-four months, post burning.

6.2.3 Grazing activity in relation to grass height

Grass height was recorded when the roan herd was encountered. The activity of individuals in the herd *e.g* grazing, resting, socializing or `other' activities (as defined previously) were noted. Grazing in the dry and wet seasons was related to grass height by using a contingency table. Three categories were used for grass height, (i) <50cm, (ii) >50cm and <100cm, and (iii) >100cm.

6.2.4 Roan distribution in relation to permanent water

Each observation of the roan herd was assigned to a category based on the distance to a permanent water source. The entire area of the reserve that was available to the herd was zoned according to the following categories; (i) <500m, (ii) >500m and <1000m, (iii) >1000 and <1500m, and (iv) >1500m. The Bonferroni-*z*-statistic (Neu *et al*. 1974) was used to determine which categories were selected *i.e* used more or less than expected.

6.3 Results

6.3.1 Roan distribution in relation to other ungulates

The results for five large herbivore species in relation to season are shown in Table 6.1. Zebra (*Equus burchelli)*, hartebeest (*Alcelaphus buselaphus*) and white rhino (*Ceratotherium simum*) most often associated with the roan herd in both the wet and dry seasons. Waterbuck (*Kobus ellipsiprymnus*) used the preferred dry season feeding areas of the roan but were not recorded in the wet season areas. Lone roan bulls were noted in close proximity to the herd on two occasions in the dry season feeding areas, but no encounters were observed in the wet season areas.

Table 6.1 Number of observations of potential competitor herbivores recorded within 200m of the roan herd (percentages in parentheses).

Species	Number of dry season observations	Number of wet season observations	Total number (dry and wet)
Zebra	54 (28.3)	53 (46)	107
Hartebeest	67 (35.1)	32 (27.8)	99
White rhino	46 (24.1)	24 (20.9)	70
Waterbuck	14 (7.3)	-	14
Eland	8 (4.2)	6 (5.2)	14
Roan (lone bull)	2 (1.0)	-	2
Total	191	115	

6.3.2 Roan distribution in relation to burning

The results of the effects of burning at three post-burn time intervals are shown in Table 6.2. The recently burnt areas (<12 months) were utilised less than expected ($p<0.05$) while areas burnt more than 12 months previously were utilised more than expected ($p<0.05$).

Table 6.2 Simultaneous confidence intervals using the Bonferroni-z-statistic to determine utilisation and preference of areas burnt within specified periods.

Time elapsed since last burn (months)	Expected proportion of usage (P_{io})	Observed proportion of usage (P_i)	Bonferroni Interval
>6,<12	0.525	0.058	0.029<p<0.0867 *
>12,<24	0.349	0.681	0.624<p<0.738 *
>24	0.126	0.261	0.207<p<0.315 *

Z=2.39; n=379

* indicates a difference at the 0.05 level of significance.

The Bonferroni intervals show that the categories are all significant at the 0.05 confidence level. The recently burnt category (<12 months) was utilised less than expected by chance while both other categories were utilised more than would be expected by chance alone.

6.3.3 Grazing in relation to grass height

Data presented in Table 6.3 demonstrate the relationship between the grazing activity of roan and grass height in the dry and wet seasons. A significant relationship (p<0.01) existed between the grass height of the feeding area where the roan herd grazed and the season in which the grazing occurred. In the dry season, the herd utilised short and medium height grasses whereas in the wet season, medium to tall grasslands were chosen.

Table 6.3 Contingency table of seasonal grazing and grass height. The figures are the number of observations made in each grass height category.

	Grass Height (cm)			
Grazing activity	<50	>50cm,<100	>100cm	Total
Dry season	97	44	0	141
Wet season	29	87	32	148
Total	126	131	32	

Chi-square=82.69; df=2; $p<0.01$

6.3.4 Roan distribution in relation to permanent water

The results of the Bonferroni-z-statistic analysis are presented in Table 6.4a and 6.4b. In both the wet and dry seasons the herd showed a positive selection for areas within 1000m of a permanent water point ($p<0.05$). Areas beyond 1500m were selected against ($p<0.05$).

Table 6.4a Simultaneous confidence intervals to determine the utilisation and preference of areas within specified distances of permanent water sources in the dry season.

Distance to water (m)	Expected proportion of usage (P_{io})	Observed proportion of usage (P_i)	Bonferroni Interval
500	0.194	0.138	0.076<p<0.200
1000	0.341	0.456	0.367<p<0.545 *
1500	0.274	0.328	0.244<p<0.412
>1500	0.191	0.077	0.029<p<0.125 *

Z=2.50; n=195
* indicates a difference at the 0.05 level of significance.

Table 6.4b Simultaneous confidence intervals to determine the utilisation and preference of areas within specified distances of permanent water sources in the wet season.

Distance to water (m)	Expected proportion of usage (P_{io})	Observed proportion of usage (P_i)	Bonferroni Interval
500	0.194	0.249	0.174<p<0.324
1000	0.341	0.665	0.583<p<0.747 *
1500	0.274	0.086	0.038<p<0.134 *
>1500	0.191	-	-

Z=2.50; n=209

* indicates a difference at the 0.05 level of significance.

6.4 Discussion

Seasonal habitat use by roan antelope is influenced by a number of factors, including local differences in soil nutrient status, grass sward physiognomy, and water availability (Heitkoning 1993). Management inputs geared at improving habitat for roan, particularly in the critical dry season, must therefore focus on maximizing the benefits to be derived from manipulating these factors.

The roan antelope selected areas that were burnt more than a year previously in both the dry and wet season ranges. This confirms the observations made by other investigators (Joubert 1976, Heitkoning 1993). The latter pointed out that roan have difficulty in obtaining an intake rate from regrowth on green flush that was equivalent to that on more mature stands of grass.

The tall *Themeda-Hyparrhenia* grassveld area of the roan herd's wet season range is a fire-induced subclimax which maintains its grass and shrub/tree composition as a direct result of regular burning. Without regular defoliation preferred species such as *Themeda triandra* and *Heteropogon contortus* disappear from the veld (West 1951, Edwards 1967 and Tainton 1981). The late summer and autumnal aspect grasses with robust stems and cauline leaves are favoured by the absence of burning and light or selective grazing. These grasses, for example *Hyparrhenia spp.* and *Cymbopogon spp.* tend to become unpalatable as they become mature. Burning in these areas is essential to remove moribund material and increases accessibility to grazers and improves the condition of the veld by enhancing the protein content of the available forage (Wilson and Hirst 1977).

The roan herd preferred short to intermediate grass when feeding in the dry season and the wet season. Tall grass was generally avoided where it occurred. The lower lying dry season feeding areas have a `sweeter' composition of grass species with the tall grasses found in the wet season range being largely absent. These areas along with the north-facing xerocline slopes have been most adversely affected by erosion which occurred in the past. Roan and other grazers are attracted to these warmer areas in the winter because of the presence of increaser grasses which have a relatively higher dry season nutrient content. There is a greater density of shrubs which can be exploited by the roan which have been noted to increase browse ingestion quite dramatically at the height of the dry season (Child and Wilson

1964). Heitkoning (1993) pointed out that roan tend to select food for minerals rather than energy content. Grass biomass in these areas is kept low resulting in an insufficient fuel quantity to burn on a regular basis. Severe grazing pressure could result in bush encroachment particularly if burning is not undertaken at regular intervals. The roan prefer grassy open woodland (Joubert 1976) suggesting that bush encroachment could negatively impact this species.

West (1951) recommends that veld burning should take place in the late winter or early spring after the first rains have fallen, and when the grasses are still dormant, in order to encourage the growth of *Themeda triandra*. This is the most important dietary species for the roan at Weenen Nature Reserve throughout the year. Staples (1930) found that summer burning discouraged *Themeda triandra*. Burning earlier, for example in autumn, in an area susceptible to erosion is not recommended on the grounds that the young grass is immediately grazed, leaving the area susceptible to wind and rainfall erosion. For a species that is not attracted by newly burnt green flush and that requires medium tall grass not only for grazing but also for hiding new-born calves such as roan, it is necessary to burn on a biennial basis. This burning strategy allows for half of the reserve to be burnt while maintaining the other half in an unburnt state.

The stocking rate of herbivores at WNR has been kept low given the past history of the landscape which was previously extensively eroded. Rehabilitation is an on going exercise particularly on the shale flats in the western part of the reserve. As a result of this low grazing pressure, patch grazing is a common phenomenon, but this can be remedied by burning in the late winter or early spring (West 1951).

The roan herd tended to select feeding areas that were less than a kilometre from the nearest permanent water source in both the wet and dry seasons. The fact that roan were always in reach of a water source and in many cases two, could also indicate that water points were evenly distributed in their range. The availability of water at WNR does not appear to be a limiting factor for the roan. Roan are regarded as water dependent with their water intake being comparable to that of cattle (Hofmann 1973). Joubert (1970) pointed out that roan are dependent on a regular water supply particularly in the dry season, when they visit waterholes at least once or even twice a day. In the wet season temporary water was observed in seasonal streams and depressions and the roan were observed drinking from these sources. The roan herd was rarely observed drinking at the permanent water points in the wet season, a reflection of the fact that water was readily available. In the dry season the roan were observed on a number of occasions at water holes, an indication of their importance at this time.

Competition for grazing with other herbivore species does not appear to be a limiting factor for roan antelope at WNR owing to the policy of maintaining low stocking rates by Natal Parks Board on reserves under its jurisdiction. The maintenance of a broad spectrum of grazers and browsers is regarded as one of the basic tenets of management of African natural areas (Wilson and Hirst 1977). It is therefore not in the long term interest of the roan to attempt to isolate and protect them from natural levels of competition.

The roan herd in the study area were most frequently associated with zebra, hartebeest and white rhino. Although similar numbers of observations of these species were made in both the wet and dry season feeding areas of the roan, it must be borne in mind that the dry season range of the roan was considerably smaller than that of the wet season. This suggests that there is a greater concentration of herbivores and therefore potential competitors, in the most critical areas for the roan. Waterbuck, a potential competitor species of roan because they tend to select similar grass species (Kiley 1966, Spinage 1982), were also observed making use of the Nyandu valley area which forms part of the roan's dry season range.

Zebra form the greatest potential threat to roan because they are close-to-ground grazers that readily utilise medium to tall grasslands (Joubert 1976). Heavy concentrations of zebra trample longer grass and initiate a process of grazing succession by grazing the grass short. Species that prefer short grass, such as white rhino (Owen-Smith 1988) and hartebeest follow the zebra and effectively keep the grass short.

Although no attempt was made in the present study to determine which grass species form the bulk of the diet of zebra, being bulk grazers it is reasonable to assume that *Themeda triandra* and *Hyparrhenia spp.* which contribute most to the grass biomass at WNR, probably play an important role in their diet. *T. triandra* was found to be a favoured food of zebra in studies carried out elsewhere (Stewart and Stewart 1971, Grunow 1980, Grobler 1983). The fact that roan and zebra utilise the same food source does not necessarily imply that there is inter-specific competition between the two species. It is however conceivable that if one species, in this instance roan, is dependent upon the top parts of their favoured food plants and do not normally graze below 80mm (Joubert 1976), then close grazers such as zebra would deny them this source of nutrition if the grass was kept closely cropped. Zebra show a preference for well grassed, open woodland areas (Smuts 1975). These areas are also favoured by roan which creates greater opportunity for competition between the two species. Zebra were observed to be using most of the vegetation communities at WNR throughout the study period. The fact that utilisation was dispersed throughout the reserve and not concentrated in the dry season feeding areas of the roan appeared to reduce the possibility of inter-specific competition.

Significantly, the habitat preferred by roan in the dry season had short grass, probably as a result of the activity of other herbivores such as zebra, white rhino and hartebeest. An increase in the number of these species could potentially result in progressive denudation of these areas, resulting in their deterioration and accelerated plant succession leading to further bush encroachment.

Buffalo (*Syncerus caffer*) favour medium to tall rank stands of grass utilised by roan but because of their nomadic behaviour were never noted for long periods in open habitats preferred by roan. Buffalo are partial to more densely wooded areas not favoured by roan further reducing them as a direct source of competition. Pienaar (1969) noted that buffalo complement the grazing requirements of species which avoid tall mature stands of grass by opening up these areas. It is possible that roan could be negatively and indirectly impacted on by large numbers of buffalo.

The distribution of water points determines to a large degree the spatial utilisation of the available resources. An even distribution of water points tends to encourage spatial homogeneity by allowing numerous species access to areas utilised by rarer species resulting in a loss of habitat for the latter. It is therefore advisable to limit the number of permanent water points particularly in the dry season range of the roan to avoid concentrations of other more numerous water dependent species which could be detrimental to the roan. Specialist feeders such as roan are at a disadvantage in small protected areas and as such they must be protected from excessive competition if viable populations are to be maintained (Wilson and Hirst 1977). The results of other investigations and the present study demonstrate the need to develop a management policy for roan based on sound ecological principles.

CHAPTER SEVEN

HOME RANGE AND ACTIVITY AREAS

7.1 Introduction

Jewell (1966) defined home range as `...the area over which an animal travels in pursuit of its routine activities.' Morrison (1988) qualified this by adding that the size of this area is influenced by a number of factors and these include *inter alia*, the time period over which the area is measured, population density, and the age and sex of the individuals under study. Social organisation and body size also play a role in determining the size of an animal's home range, with more gregarious, larger species tending to have bigger ranges than solitary, smaller ones (Jarman 1974, Howard 1983).

The extent of an animal's home range is a function of the manner in which it is able to satisfy its habitat requirements and conduct its social functions (Leuthold 1977). Knowledge of the home range of a species within a particular area is essential for management purposes. The level of localisation, the pattern of occupancy and the spacing of individuals or groups of individuals in territories or home ranges has a bearing on conservation management, particularly when the area available for use is limited as is the case in small reserves.

Numerous techniques are available to determine home range size.

These range from physically relocating marked or known animals to techniques involving radio-telemetry and other remote sensing methods (Clarke 1986, Harris *et al.* 1990). Regardless of the method used, the objective is to obtain a number of relocations of specific individuals along a time base most suitable for addressing the research questions at hand.

Several analytical methods are used to calculate home range size. The appropriate technique to be applied is dependent on the type of method used to collect the location data and vary in level of complexity. The minimum convex polygon method (Mohr 1947) among others, was used for the present study to enable direct comparison with other studies conducted elsewhere.

7.2 Methods

The technique used to determine the home range area of the roan herd at WNR involved relocating the herd during intensive searches several times a month for a period of 16 months. The location of the herd was identified on a 200x200m grid superimposed on a 1:10 000 map of the reserve. Additional sightings made by personnel working at WNR were included. Group size and the composition were also noted.

The data collected during the study was analysed by Program Home Range (Ackerman *et al.* 1990). Several methods are used to analyse home range data. These include among others, the minimum convex polygon method (Mohr 1947) and the harmonic mean method

(Dixon and Chapman 1980).

The minimum convex polygon method entails connecting the peripheral locations in such a manner that the internal angles of the polygon so generated do not exceed 180°. The shortcomings of the method lie in the fact that large areas which are never visited by the animal are included. Furthermore, the method is biased by small sample sizes. Little information is provided by the method with regard to the intensity of use of the various areas within the home range.

The harmonic mean method is a non-parametric method which is based on the volume under a fitted three-dimensional utilisation distribution. A grid system which is spread throughout the home range of the animal or animals under study, is used to calculate the harmonic mean values based on areal moments. Centres of activity and contours of utilisation distribution can be calculated as a means of calculating home range (Dixon and Chapman 1980, Harris *et al.* 1990).

Areas which are used more frequently than others because they contain more dependable food sources and shelter from the elments are delineated by the harmonic mean method. These core areas are defined as portions of an animal's home range that exceed an equal use pattern based on harmonic mean values (Samuel *et al.* 1985). Areas of this nature are commonly used exclusively by individuals or groups of individuals, necessitating their delineation if the relationship between animal and habitat is to be understood (Samuel *et al.* 1985).

Several assumptions have to be adhered to if the the methods included in the program are to be valid. The locational data must be independent as this can influence the calculation of the extent of the home range and the core areas. The probability of locating an animal must be proportional to the amount of time spent in an area. Sampling must also be made throughout the seasons of interest. The minimum convex polygon and harmonic mean methods are both affected by outliers which are excursions beyond the normal home range. The former method is influenced to a greater extent than the latter by such locations.

7.3 Results

The total annual ranges for the roan herd as calculated by the minimum convex polygon and harmonic mean methods are shown in Table 7.1. The estimated home range size was derived from 404 locations. Figure 7.1 shows the seasonal home range of the roan herd. Figure 7.2 presents the 75%, 95% and 100% minimum convex polygons. The 55% (core areas), 75%, 95% harmonic mean contour plots are shown in Figure 7.3. Figure 7.4 presents the spatial utilisation of the annual home range by the roan herd.

Table 7.1 The estimated home range size of the roan herd at Weenen Nature Reserve. Two models have been used to calculate the home range and core areas.

Minimum convex polygon	Area in hectares
100%	1326
95%	1226
75%	906
Harmonic mean contours	
95%	1853
75%	1199
55% (core areas)	752.7
Core areas as percentage of total area and utilisation volume	
Area	35.9
Utilisation volume	55.3
Number of outliers	2

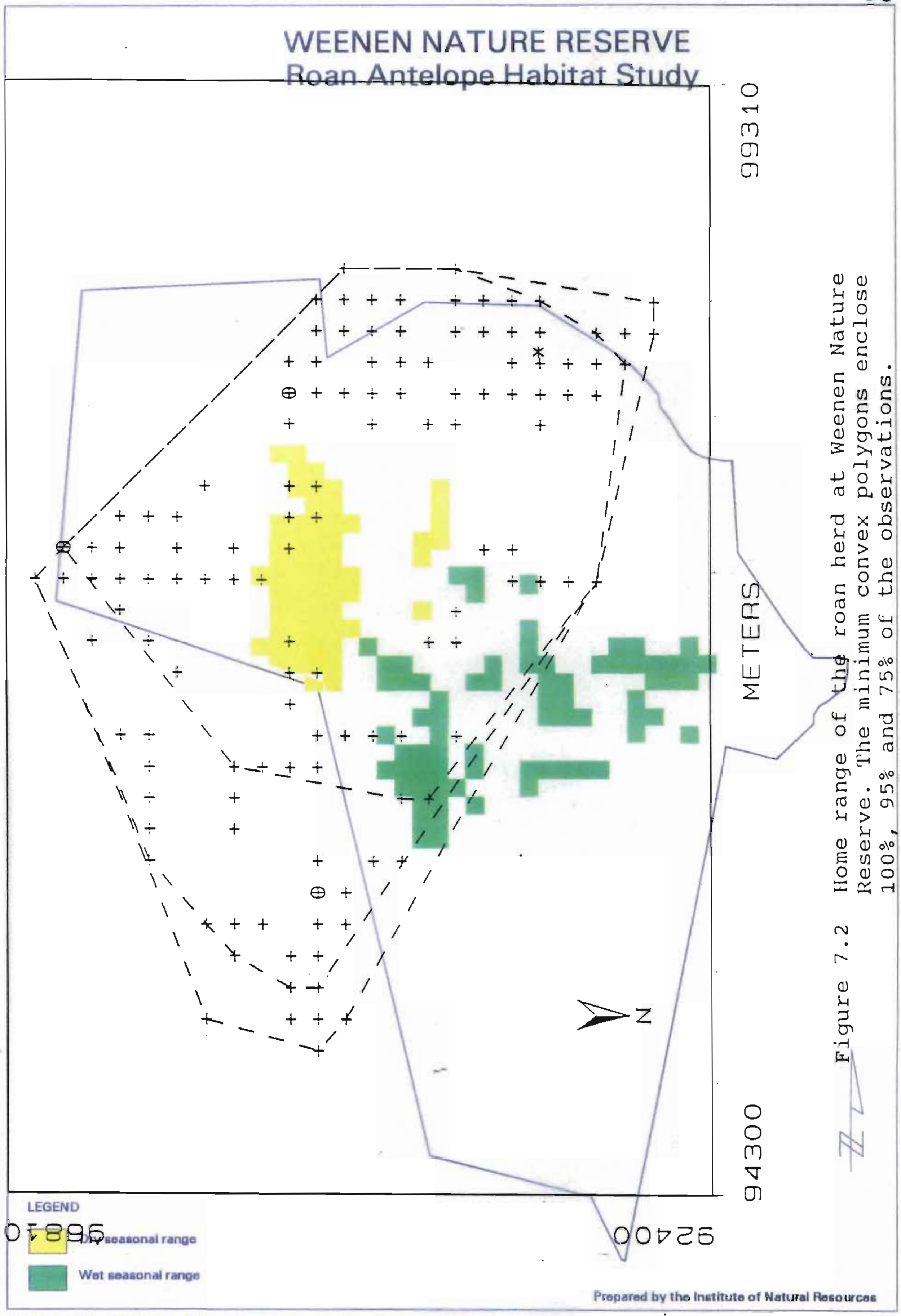

Figure 7.1 : Weenen Roan herd dry and wet season home range

Figure 7.2 Home range of the roan herd at Weenen Nature Reserve. The minimum convex polygons enclose 100%, 95% and 75% of the observations.

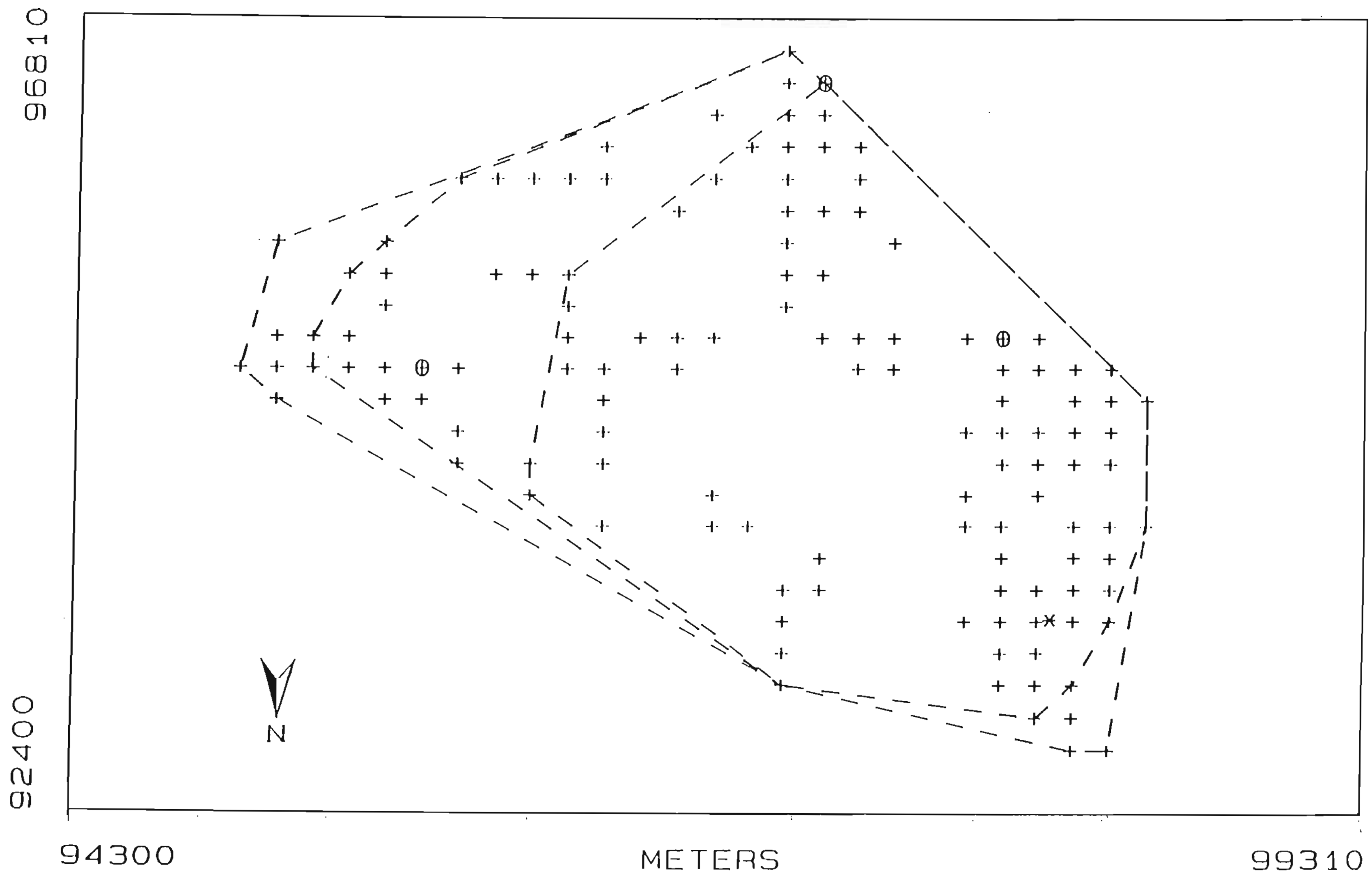

Figure 7.2 Home range of the roan herd at Weenen Nature Reserve. The minimum convex polygons enclose 100%, 95% and 75% of the observations.

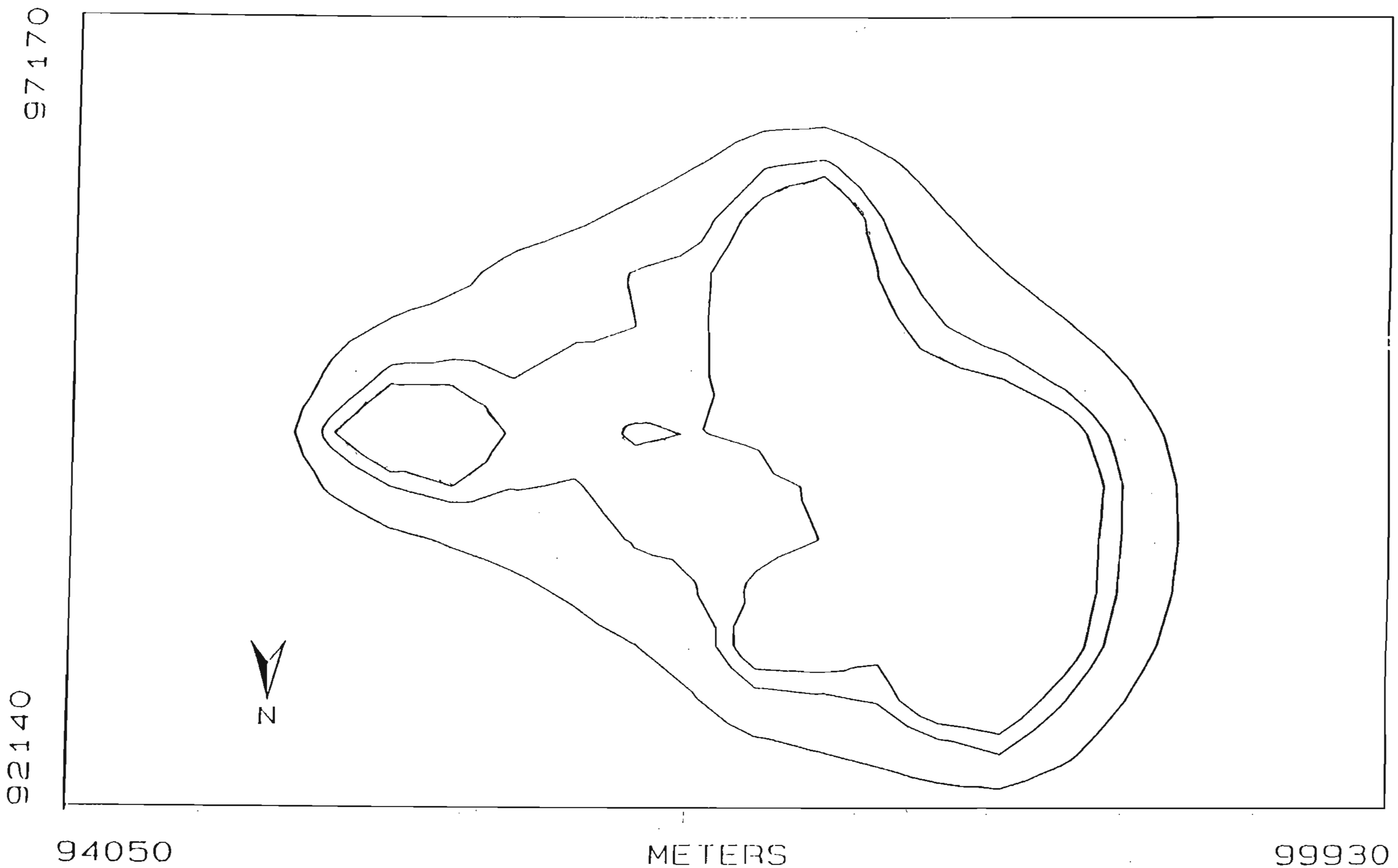

Figure 7.3 Home range of the roan herd at Weenen Nature Reserve. The harmonic mean contours enclose the core areas, 75% and 95% of the utlisation distribution.

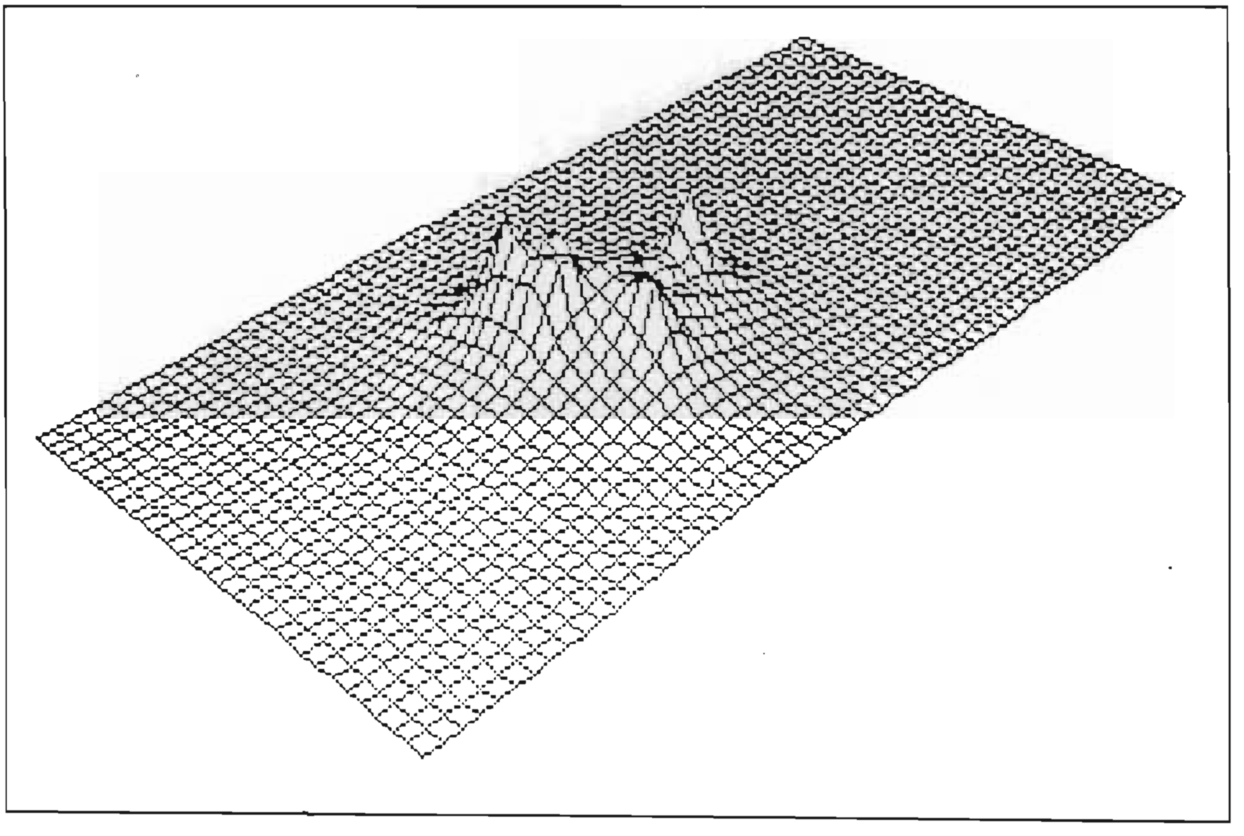

Figure 7.4 Spatial utilisation of the roan herd at Weenen Nature Reserve

7.4 Discussion

The harmonic mean method identified five core areas which were combined in the plot into two major areas and a smaller one located centrally. These areas represented the activity zones of the roan nursery herd. Outliers were excluded from the calculation of these areas to avoid the inclusion of transitional locations between seasonal home ranges.

The roan herd at WNR appeared to have distinct wet and dry season ranges which differed to some extent in grass species composition and topography (Chapter 3) and these differences were reflected in the seasonal diet (Chapter 4). Funston *et al.* (1994) found that habitat selection by buffalo was influenced by the presence of acceptable forage, cover available to predators,the proximity of water and the mobility of the herd. The roan herd's seasonal movements at WNR were influenced primarily by the need to obtain adequately acceptable forage. The proximity to water became an important factor in the dry season with the herd's range contracting when compared with the range in the wet season.

The herd's wet season range comprised the dolerite outcrops to the south and south-east of the reserve which supported taller, more nutritious grass species while the dry season range encompassed the lower lying, warmer valley bushveld areas with higher proportions of increaser grasses. The herd ranged widely in the wet season when the availability of water was not a limiting factor and the herd was able to exploit areas less utilised by other herbivores.

The annual home range size observed at WNR is comparable to that observed by Wilson and Hirst (1977) at the Percy Fyfe Nature Reserve in the Northern Transvaal. Joubert (1976) estimated that the activity zones of roan herds in his study area ranged between 60 and 100 km^2 which is six to ten times that observed for the WNR herd. Estes (1974, 1991) suggested that for sable (*Hippotragus niger*) in Zimbabwe, the large ranges observed may have been due to disturbance from hunting and low population density. He surmised that a similar breakdown in the normal territorial network and home range may account for the atypical behaviour of a single herd bull accompanying the nursery herd. Territoriality was not observed at WNR, with the same bull accompanying the herd for the duration of the study period. The herd bull was observed on two occasions chasing a solitary bull which attempted to approach the herd corroborating the assertion by Joubert (1970) that the dominant bull only protected an exclusion zone of about 500m around the herd as it moved through its activity zone.

The tendency of the roan herd at WNR to utilise an area intensively before abruptly moving to another part of the range and settling down for a short period was also recorded by Joubert (1970) and Wilson and Hirst (1977). The latter referred to these patches as activity areas which did not vary significantly in terms of vegetation composition and physiognomy.

Joubert (1970) regarded the activity zones of roan at KNP as exclusive but as has already been pointed out, KNP is an area that supports very low densities of roan. Although no attempt was made to ascertain the patterns of habitat utilisation by the solitary bulls at WNR, from personal observations and communication with WNR personnel, they appeared to use areas peripheral to the home range of the nursery herd. It is not clear how the presence of additional roan herds would affect range use by the present herd. Wilson and Hirst (1977) believed that mortalities from trauma sustained during fighting among roan could be a significant factor if the animals were confined to a small reserve which did not have sufficient space to permit the expansion of their population.

Wilson and Hirst (1977) suggested that the number of roan should not exceed 4 animals/km^2 even in areas that did not exhibit the nutrient deficiencies found in their study area in the Northern Transvaal. The annual home range of roan at Percy Fyfe Nature Reserve compared favourably with that of the herd at WNR, a similarly sized reserve if the areas west of the main road and south of the Bushman's river are excluded from WNR. Wilson and Hirst (1977) proposed that roan numbers in the Percy Fyfe Nature Reserve should not exceed 50 animals. It is not clear to what extent the two reserves are comparable in terms of habitat quality, but given the low stocking rate at WNR and the fact that more areas could become available for utilisation, it is likely that the reserve can sustain a greater roan population than the sixteen animals present during the study.

CHAPTER EIGHT

Conclusions and management recommendations

The aim of the project was to determine the habitat use and feeding ecology of the roan antelope at Weenen Nature Reserve (WNR) with the intention of formulating a management policy for the conservation of this rare antelope species. Specific management questions that had to be addressed included determining the key habitat characteristics that influenced habitat use by the antelope. Areas that were not being utilised by the roan had to be assessed to ascertain their suitability for use by future additions to the roan population.

The results of the study showed that the roan nursery herd ranged over 44% of the area of the reserve that was available for utilisation. The herd utilised higher lying *Acacia sieberana* tall grassveld, on shale and dolerite derived soils in the wet season. In the dry season the herd preferred the `sweeter' north facing slopes and valley bushveld at lower altitude. The roan selected gently undulating terrain and avoided steep slopes. Thicket and dense closed woodland were avoided in preference for medium open woodland. Sparsely wooded grasslands (old lands) were not utilised to a great extent but this appeared to be the result of the grass field layer which comprised mainly cauline species such as *Hyparrhenia spp.*. Palatability of these species declined, becoming increasingly stemmy and fibrous as the wet season progressed.

The roan herd was found to be selective for *Themeda triandra* although several increaser grasses such as *Eragrostis curvula* became more important in the dry season. The roan did not immediately utilise burnt areas but only did so after several months. The length of this period would depend on the amount of rainfall that fell during the early wet season. Competition with other ungulates did not appear to be a limiting factor at the current low herbivore densities at WNR. The dry season range of the roan herd was utilised by several other species including white rhino, red hartebeest, waterbuck and zebra. This area is regarded as sensitive due to the numerous erosion sites (Weenen Management Plan 1985).

Recommendations

The dry season range of the roan herd contained most of the erosion sites that occurred prior to the proclamation of the reserve. The efforts to rehabilitate these areas will only be successful if herbivores including the roan, are not allowed to concentrate to a point where trampling and overgrazing cause further damage to this fragile area. The present low stocking rate must be maintained. Herbivores that tend to keep grass cover short for example, white rhino, red hartebeest and zebra, must be carefully monitored to ensure that these do not affect the roan which prefer medium to tall grass for grazing and calving. To this end the policy of excluding species such as impala and wildebeest must be maintained.

The burning regime must take cognisance of the fact that roan have a preference for areas with a medium to tall grass cover. Only part of the wet season range must be burnt at any one time allowing the roan access to preferred habitat. The actual size of the area that is burnt will be dictated by the size of the home range and pattern of habitat utilisation by roan at WNR. The current biennial burn can be maintained for the wet season areas although this may not be suitable for the dry season area. The latter areas have little grass cover in places and appear to be well utilised in the winter probably removing the need to burn biennially although this will be subject to the level of fuel load accumulation in these areas. Bush encroachment which results from injudicious use of burning and overgrazing must be avoided as this would adversely affect the roan which have a preference for open woodland.

Any additions to the roan population at WNR must be released in areas that allow them access to both wet and dry season range. Any further introductions must consist of cows and juveniles to avoid unduly upsetting the pattern of utilisation that has been developed by the present roan herd. The new herd must be closely monitored to determine how it interacts with the present herd particularly in the dry season. The roan population must be monitored to establish an appropriate carrying capacity for the reserve to avoid mortality and injuries due to fighting that has been known to occur in other areas. Excess animals particularly 2-3 year old males must be removed to avoid such a situation arising.

The present distribution of water points appears to be adequate and the availability of water is not a limiting factor for the roan herd. The development of water points in the western part of the reserve must be carefully controlled to prevent undue concentration of herbivores in this susceptible area.

There are areas within the reserve that could be utilised, however, these are currently inaccessible to the roan. These are the area west of the Estcourt road and the portion of the reserve south of the Bushman's river. The former comprises valley bushveld and resembles the dry season range of the herd while the latter is an extension of the *Acacia sieberana* tall grassveld. The requirement for large ranges and the fact that these areas fulfill only part of the seasonal requirements of the roan appears to exclude the possibility of the establishment of what would essentially be separate populations.

The habitat at WNR is probably marginal for roan antelope and this, along with the unstable structure of the founder herd, may account for the slow population growth of this species in the reserve. Having said that, the present herd appears to have established itself within the reserve as is evidenced by the improved calving rate during the study period. The prognosis for future population growth under the present management practices is fair and the goal of establishing a viable population appears to have been achieved.

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APPENDIX 1

DIAGNOSTIC KEY FOR THE IDENTIFICATION OF GRASS SPECIES

1 Costal silica bodies nodular,dumb-bell or cross shaped....2
Costal silica bodies saddle,cubic or kidney shaped.......13

2 Papillae present on all or some long cells................3
Papillae absent...7

3 Two or more globlose papillae in each long cell...*Themeda triandra*
Only one globlose or oblique papilla in each or some long cell...4

4 Thickened globlose or oblique papilla in each or some long cells only.......*Heteropogon contortus*
Papillae on some interstomatal cells only.................5

5 Dumb-bell silica bodies only present and papillae small..........*Trachypogon spicatus*
Dumb-bell and cross shaped (nodular) silica bodies present and papillae medium to large.................................6

6 Papillae thin-walled often partly overlying the stomata..........*Bothriochloa insculpta*
Papillae large and thickened on each interstomatal cell..............*Hyparrhenia spp.*

7 Micro-hairs rare to prominent..............................8

Macro-hairs absent.......................................10

8 No nodular shaped silica bodies occur in costal

zones...........*Tristachya leucothrix*

Nodular or dumb-bell shaped silica bodies occur in costal

zones...9

9 Prickle hairs in rows of silica bodies alternating with silica

silica bodies.........*Melinis repens*

Prickle hairs occurring mainly in intercostal

zones.............*Panicum maximum*

10 Cross shaped silica bodies in costal zones......*Digitaria spp.*

Cross shaped silica bodies few or absent...................11

11 Crescentic silica bodies absent in intercostal

zones........*Cymbopogon spp.*

Crescentic silica bodies absent in intercostal

zones........12

12 Silica cells absent in intercostal zone.......*Aristida spp*

Few irregular or cross shaped bodies at margin of intercostal

zone.........*Seteria spp.*

13 Silica bodies occasionally shortly dumb-bell shaped with wide

centres and macro-hairs.......*Sporobolus fimbriatus*

Dumb-bell shaped silica bodies and macro-hairs absent..14

14 Papillae abundant,thickened,oblique mostly on ends of long cells...........*Eragrostis curvula*

Papillae rounded,conspicuous or absent.......................15

15 Papillae conspicuous rounded to oblique most in the interstomatal cells.........*Chloris virgata*

Papillae absent.......................................16

16 Micro hairs absent............*Eragrostis superba*

Micro hairs present...................................17

17 Prickle hairs abundant on leaf margins,micra hairs occasional........*Eragrostis plana*

Prickle hairs absent,micro hairs frequent,unicellular.........
Sporobolus fimbriatus,Sporobolus africanus

APPENDIX 2

FAECAL ANALYSIS DATA

Table 1 Faecal analysis data for Mfomfeni feeding area (October).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	107	65	64	89	48	373	74.6	100
Heteropogon contortus	7	14	5	9	10	45	9	100
Trachypogon spicatus								
Bothriochloa insculpta								
Tristachya leucothrix								
Panicum maximum	9	3	2	1	1	16	1.4	100
Digitaria spp	3	1	1	1	2	8	1.6	100
Cymbopogon spp				1		1	0.2	20
Aristida spp	3	2	1			6	1.2	60
Seteria spp				2	2	4	0.8	40
Sporobolus fimbriatus	1			2	7	10	2	60
Eragrostis curvula	1		2	5	7	15	3	80
Chloris gayana								
Eragrostis superba	1		3	1	2	7	1.4	80
Sporobolus africanus	4		2		3	9	1.8	60
Melinis spp	1					1	0.2	20
Hyparrhenia spp	14	19	13	17	13	76	15.2	100
Eragrostis plana			1			1	0.2	20
Sporobolus pyrimidalis					1	1	0.2	20
Dicots	8	8	6	6	8	36	7.2	100
Unidentified	26	31	24	19	16	116	23.2	100

Table 2 Faecal analysis data for Mfomfeni feeding area (December).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	38	58	61	66	56	279	55.8	100
Heteropogon contortus	5	6	4		2	17	3.4	80
Trachypogon spicatus								
Bothriochloa insculpta	1				2	3	0.6	40
Tristachya leucothrix								
Panicum maximum	2	4	3	6	1	16	3.2	100
Digitaria spp	9	5	3			17	3.4	60
Cymbopogon spp								
Aristida spp			1	1		2	0.4	40
Seteria spp	1	11	2	5	1	20	4	100
Sporobolus fimbriatus	12	11	2	1	4	30	6	100
Eragrostis curvula	1	3	2		3	9	1.8	80
Chloris gayana								
Eragrostis superba		1	1	1		3	0.6	60
Sporobolus africanus								
Melinis spp	2		2		1	5	1	60
Hyparrhenia spp	14	9	7	20	9	59	11.8	100
Eragrostis plana		3				3	0.6	20
Sporobolus pyrimidalis		1			1	2	0.4	40
Dicots	7	7	4	5	6	29	5.8	100
Unidentified	21	25	20	15	12	93	18.6	100

Table 3 Faecal analysis data for KwaNyongo feeding area (February).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	62	82	63	71	69	347	69.4	100
Heteropogon contortus	9	20	16	9	7	61	12.2	100
Trachypogon spicatus								
Bothriochloa insculpta		3	6	10	1	20	4	80
Tristachya leucothrix								
Panicum maximum	1	1		1		3	0.6	60
Digitaria spp		5	2			7	1.4	40
Cymbopogon spp	4	4	6		1	15	3	80
Aristida spp	1	1	1	1	2	6	1.2	100
Seteria spp	4		6		1	11	2.2	60
Sporobolus fimbriatus		1	1		1	3	0.6	60
Eragrostis curvula	5	1	6	2		14	2.8	80
Chloris gayana		2				2	0.4	20
Eragrostis superba		5	6	5	5	21	4.2	80
Sporobolus africanus								
Melinis spp	5	3	2	5	11	26	5.2	100
Hyparrhenia spp	16	10	15	16	9	66	13.2	100
Eragrostis plana	2	1	6	3		12	2.4	80
Sporobolus pyrimidalis	2		3	2	1	8	1.6	80
Dicots	4	9	4	8	9	34	6.8	100
Unidentified	13	24	15	24	9	85	17	100

Table 4 Faecal analysis data for Mpumulwana feeding area (March).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	54	53	44	56	61	268	53.6	100
Heteropogon contortus	6	5	7	4	8	30	6	100
Trachypogon spicatus								
Bothriochloa insculpta	2	3				5	1	40
Tristachya leucothrix		1				1	0.2	20
Panicum maximum		1	2	1	3	7	1.4	80
Digitaria spp		1	7	5	5	18	3.6	80
Cymbopogon spp								
Aristida spp	2	3	2		1	8	1.6	80
Seteria spp	1	5		2	8	16	3.2	80
Sporobolus fimbriatus	2			2		4	0.8	40
Eragrostis curvula		1	2	5	7	15	3	80
Chloris gayana								
Eragrostis superba								
Sporobolus africanus		1	1			2	0.4	40
Melinis spp	8	11	13	9	7	48	9.6	100
Hyparrhenia spp	9	11	8	8	17	53	10.6	100
Eragrostis plana	1	1		1	1	4	0.8	80
Sporobolus pyrimidalis	3	1	1	2	1	8	1.6	100
Dicots	5	6	11	6	6	34	6.8	100
Unidentified	21	13	13	8	10	65	13	100

Table 5 Faecal analysis data for Matshe-Matshe feeding area (March).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	58	58	65	63	92	336	67.2	100
Heteropogon contortus	6	6	4		7	23	4.6	80
Trachypogon spicatus								
Bothriochloa insculpta	6	4		1	10	21	4.2	80
Tristachya leucothrix								
Panicum maximum								
Digitaria spp		1			4	5	1	40
Cymbopogon spp		1			3	4	0.8	40
Aristida spp	3			1		4	0.8	40
Seteria spp	1	1	2	1	3	8	1.6	100
Sporobolus fimbriatus				1		1	0.2	20
Eragrostis curvula	10	3	2	1	1	17	3.4	100
Chloris gayana								
Eragrostis superba					3	3	0.6	20
Sporobolus africanus								
Melinis spp	8	4	3	3	3	21	4.2	100
Hyparrhenia spp	20	18	18	13	23	92	18.4	100
Eragrostis plana		1	3	1		5	1	60
Sporobolus pyrimidalis								
Dicots	7	9	7	10	9	42	8.4	100
Unidentified	17	12	11	8	14	62	12.4	100

Table 6 Faecal analysis data for Amanzamnyama feeding area (April).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	63	62	65	51	63	304	60.8	100
Heteropogon contortus	2	2	1	4	1	10	2	100
Trachypogon spicatus								
Bothriochloa insculpta				2	1	3	0.6	40
Tristachya leucothrix								
Panicum maximum		7	4	3	2	16	3.2	80
Digitaria spp	1	4	3	1	3	12	2.4	100
Cymbopogon spp				1		1	0.2	20
Aristida spp	3	3	1	1		8	1.6	80
Seteria spp	4	4	5	4	6	23	4.6	100
Sporobolus fimbriatus	4	7	3	4	2	20	4	100
Eragrostis curvula		1	3	2	2	8	1.6	80
Chloris gayana								
Eragrostis superba		1	1			2	0.4	40
Sporobolus africanus						2	0.4	40
Melinis spp	7	8	11	6	6	38	7.6	100
Hyparrhenia spp	4	3	2	2	2	13	2.6	100
Eragrostis plana	2	2		2	2	8	1.6	80
Sporobolus pyrimidalis								
Dicots	9	3	7	6	7	32	6.4	100
Unidentified	12	11	12	16	15	66	13.2	100

Table 7 Faecal analysis data for Nyandu feeding area (May).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	52	44	38	33	41	208	41.6	100
Heteropogon contortus	15	5	3	2	5	30	6	100
Trachypogon spicatus	3					3	0.6	20
Bothriochloa insculpta	4	1	10	2		17	3.4	80
Tristachya leucothrix		1				1	0.2	20
Panicum maximum	1	3	3	7	3	17	3.4	100
Digitaria spp	2	3	4			9	1.8	60
Cymbopogon spp	4	1		2		7	1.4	60
Aristida spp	1		2		2	5	1	60
Seteria spp		1	3	5		9	1.8	60
Sporobolus fimbriatus	4	11	6	7	10	38	7.6	100
Eragrostis curvula	2	2	6	1	4	15	3	100
Chloris gayana				4	1	5	1	40
Eragrostis superba	1	1	1	1		4	0.8	80
Sporobolus africanus	2	1		3		6	1.2	60
Melinis spp	6	8	11	5	10	40	8	100
Hyparrhenia spp		2	3			5	1	40
Eragrostis plana	3	5	6	9	5	28	5.6	100
Sporobolus pyrimidalis				1		1	0.2	20
Dicots	14	7	11	12	10	54	10.8	100
Unidentified	9	15	10	10	16	60	12	100

Table 8 Faecal analysis data for Mbokazi feeding area (June).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	40	38	41	36	36	191	38.2	100
Heteropogon contortus	12	10	6	3	2	33	6.6	100
Trachypogon spicatus								
Bothriochloa insculpta				1		1	0.2	20
Tristachya leucothrix								
Panicum maximum	3	4	4	4	6	21	4.2	100
Digitaria spp	1	2		1	3	7	1.4	80
Cymbopogon spp		1	2	1	1	5	1	80
Aristida spp	2	2	1	2	1	8	1.6	100
Seteria spp			1			1	0.2	20
Sporobolus fimbriatus	8	4	6	6	5	29	5.8	100
Eragrostis curvula	6	5	4	8	10	33	6.6	100
Chloris gayana								
Eragrostis superba	3	3	3	1	1	11	2.2	100
Sporobolus africanus	1	2		1		4	0.8	60
Melinis spp	7	8	7	9	10	41	8.2	100
Hyparrhenia spp								
Eragrostis plana	1	3	5	5	5	19	3.8	100
Sporobolus pyrimidalis	1	2		1	1	5	1	80
Dicots	10	10	15	14	15	64	12.8	100
Unidentified	10	11	8	12	8	49	9.8	100

Table 9 Faecal analysis data for Nyandu feeding area (July).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	51	43	44	42	40	220	44	100
Heteropogon contortus	13	7	6	6	8	40	8	20
Trachypogon spicatus								
Bothriochloa insculpta	1	1		1	1	4	0.8	80
Tristachya leucothrix								
Panicum maximum	6	7	13	6	8	40	8	100
Digitaria spp	1	4	6	3	1	15	3	100
Cymbopogon spp		1			2	3	0.6	40
Aristida spp					1	1	0.2	20
Seteria spp	1	2		1	2	6	1.2	80
Sporobolus fimbriatus	2	7	7	9	7	32	6.4	100
Eragrostis curvula	7	2	5	12	7	33	6.6	100
Chloris gayana								
Eragrostis superba	1		2	3	1	7	1.4	80
Sporobolus africanus	3	1		1	2	7	1.4	80
Melinis spp	3	9	7	8	8	35	7	100
Hyparrhenia spp								
Eragrostis plana		2	2	1	4	9	1.8	80
Sporobolus pyrimidalis	3	1				4	0.8	40
Dicots	14	10	8	10	8	50	10	100
Unidentified	7	13	10	8	9	47	9.4	100

Table 10 Faecal analysis data for E/Camp feeding area (August).

Species	Sample number 1	2	3	4	5	Total	Mean No. Fragments	%F
Themeda triandra	49	43	49	46	45	232	46.4	100
Heteropogon contortus	1	8	2	8	6	25	5	100
Trachypogon spicatus								
Bothriochloa insculpta	1					1	0.2	20
Tristachya leucothrix								
Panicum maximum		2	4	7	6	19	3.8	80
Digitaria spp	1	2		1		4	0.8	60
Cymbopogon spp	5	1	4	1	1	12	2.4	100
Aristida spp			2		1	3	0.6	40
Seteria spp		3	3	2	1	9	1.8	80
Sporobolus fimbriatus	6	3	3	7	5	24	4.8	100
Eragrostis curvula	15	16	19	13	21	84	16.8	100
Chloris gayana								
Eragrostis superba		3	1	2		6	1.2	60
Sporobolus africanus								
Melinis spp	2	1	2	1		6	1.2	80
Hyparrhenia spp								
Eragrostis plana	2	4	3		3	12	2.4	80
Sporobolus pyrimidalis	5	1	1	1	1	9	1.8	100
Dicots	6	9	4	4	6	29	5.8	100
Unidentified	11	12	9	9	9	50	10	100

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Roan Antelope Habitat Study

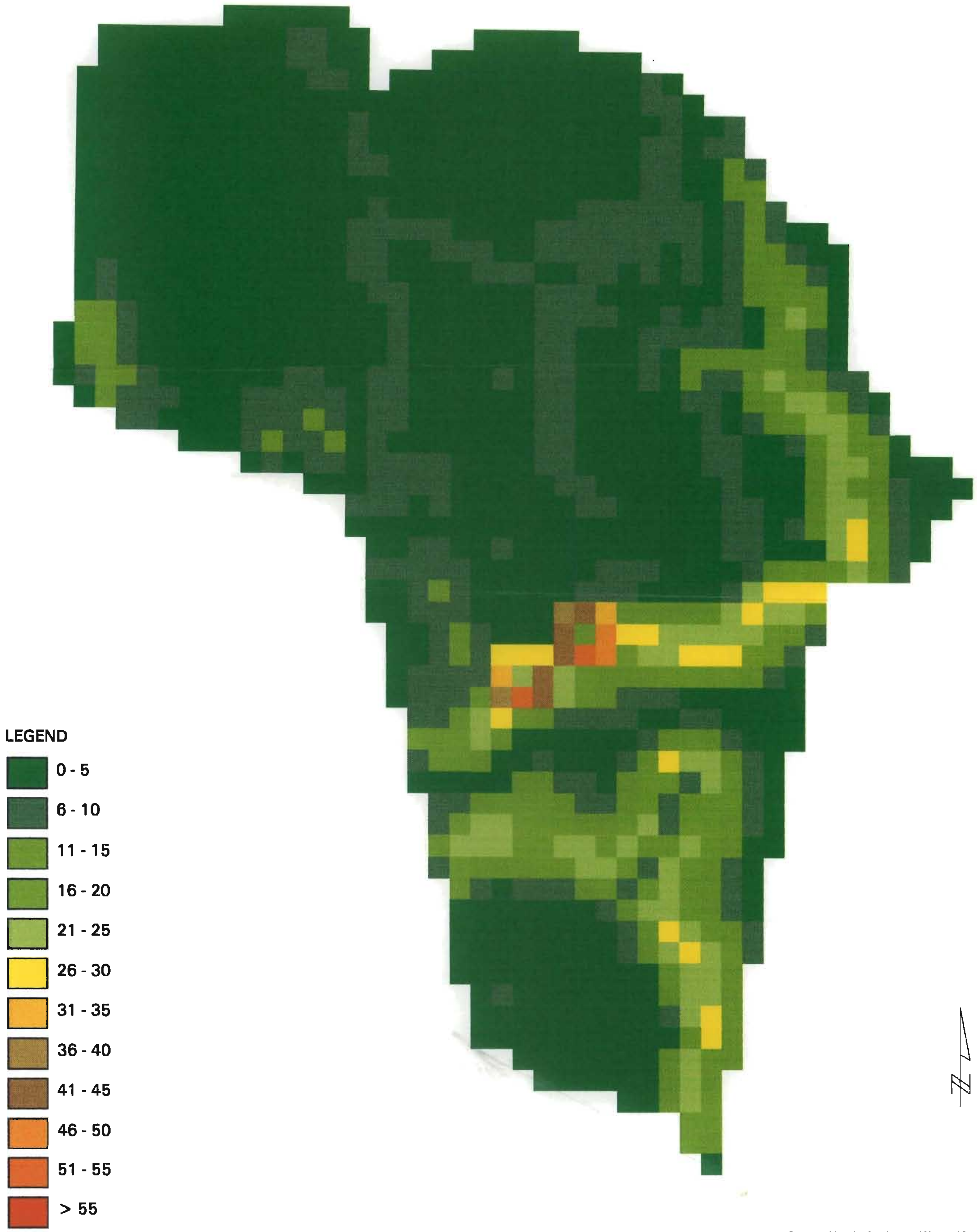

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Figure 1 : Slope map

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Roan Antelope Habitat Study

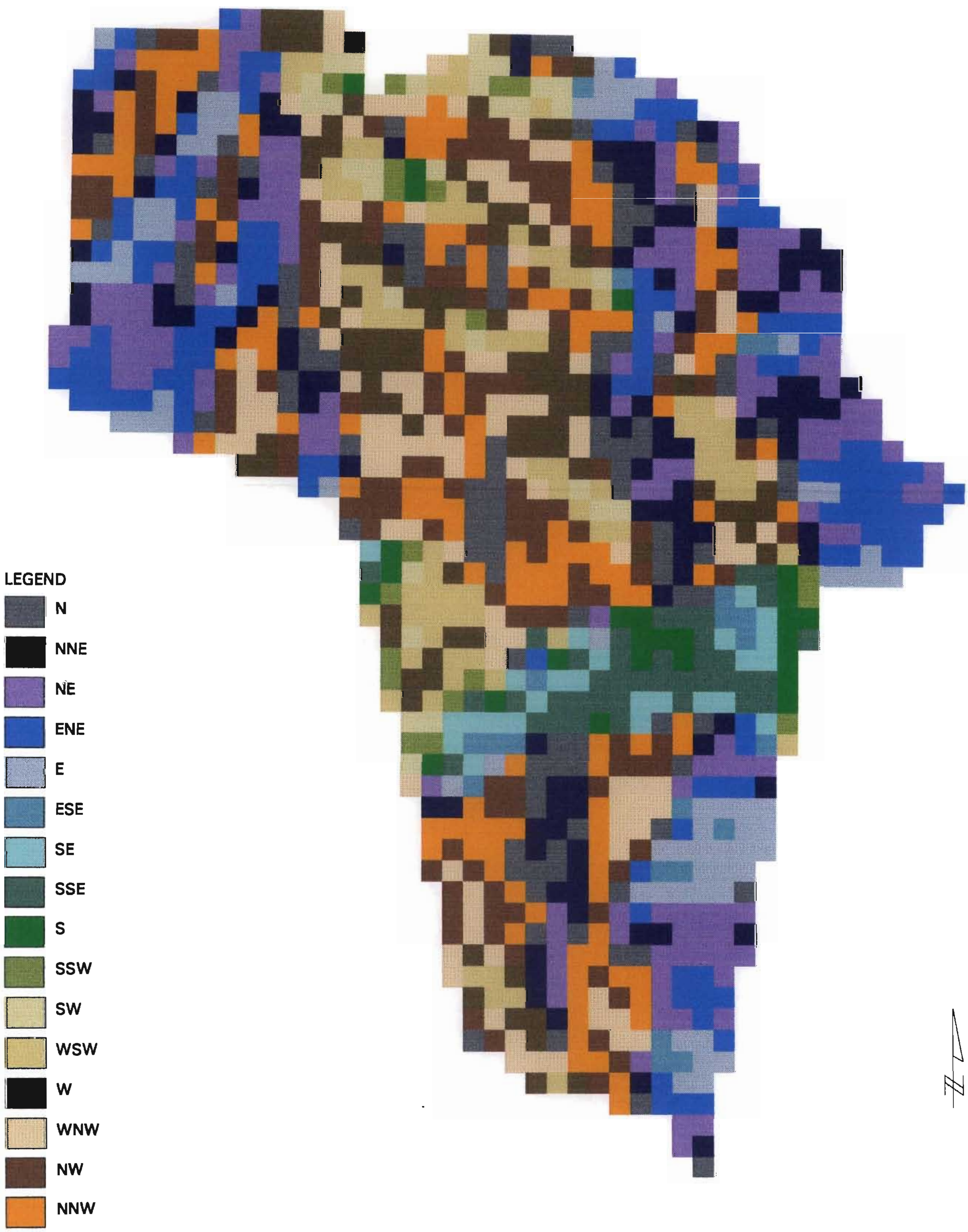

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Figure 2 : Aspect map

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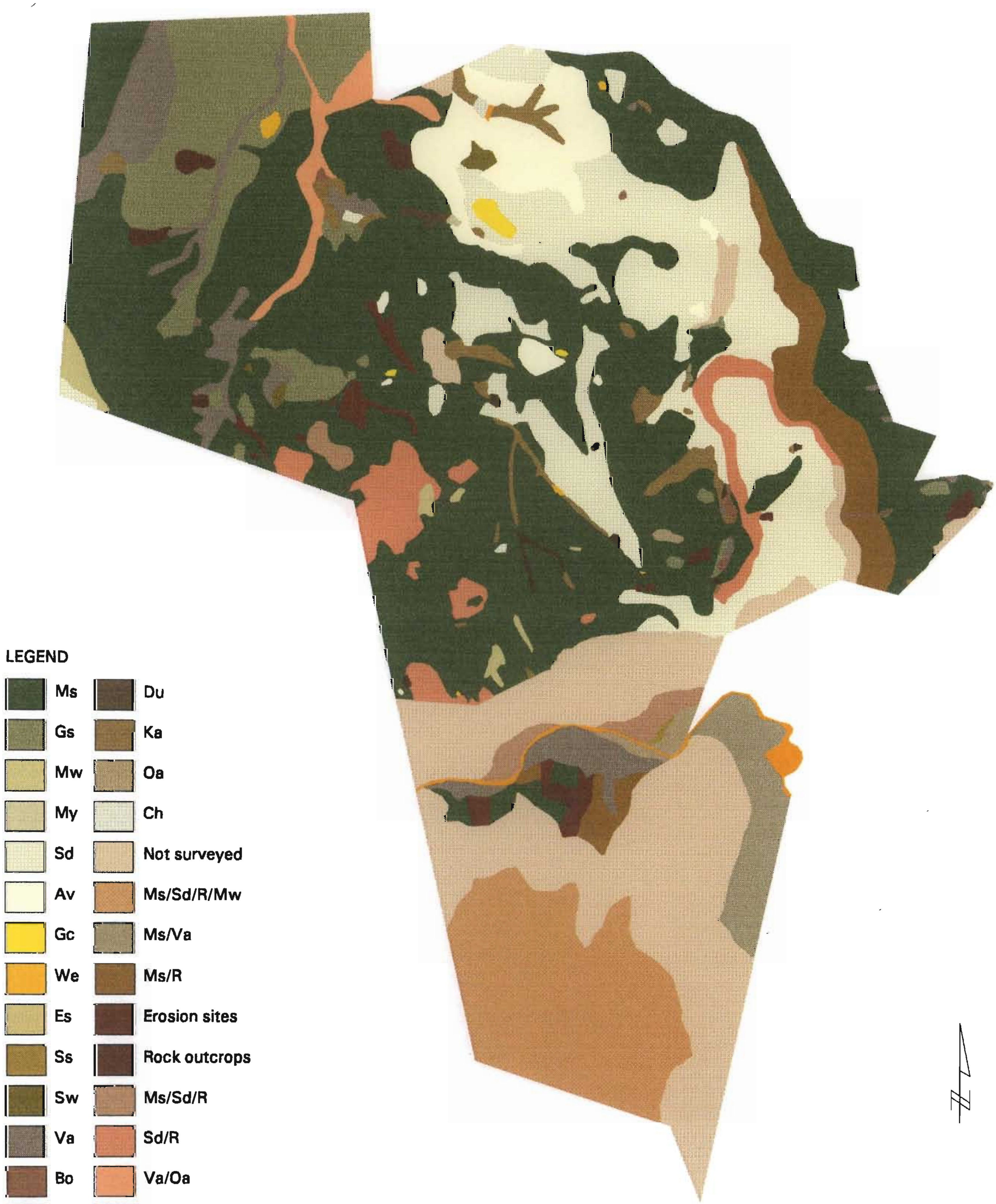

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Figure 3 : Soils map

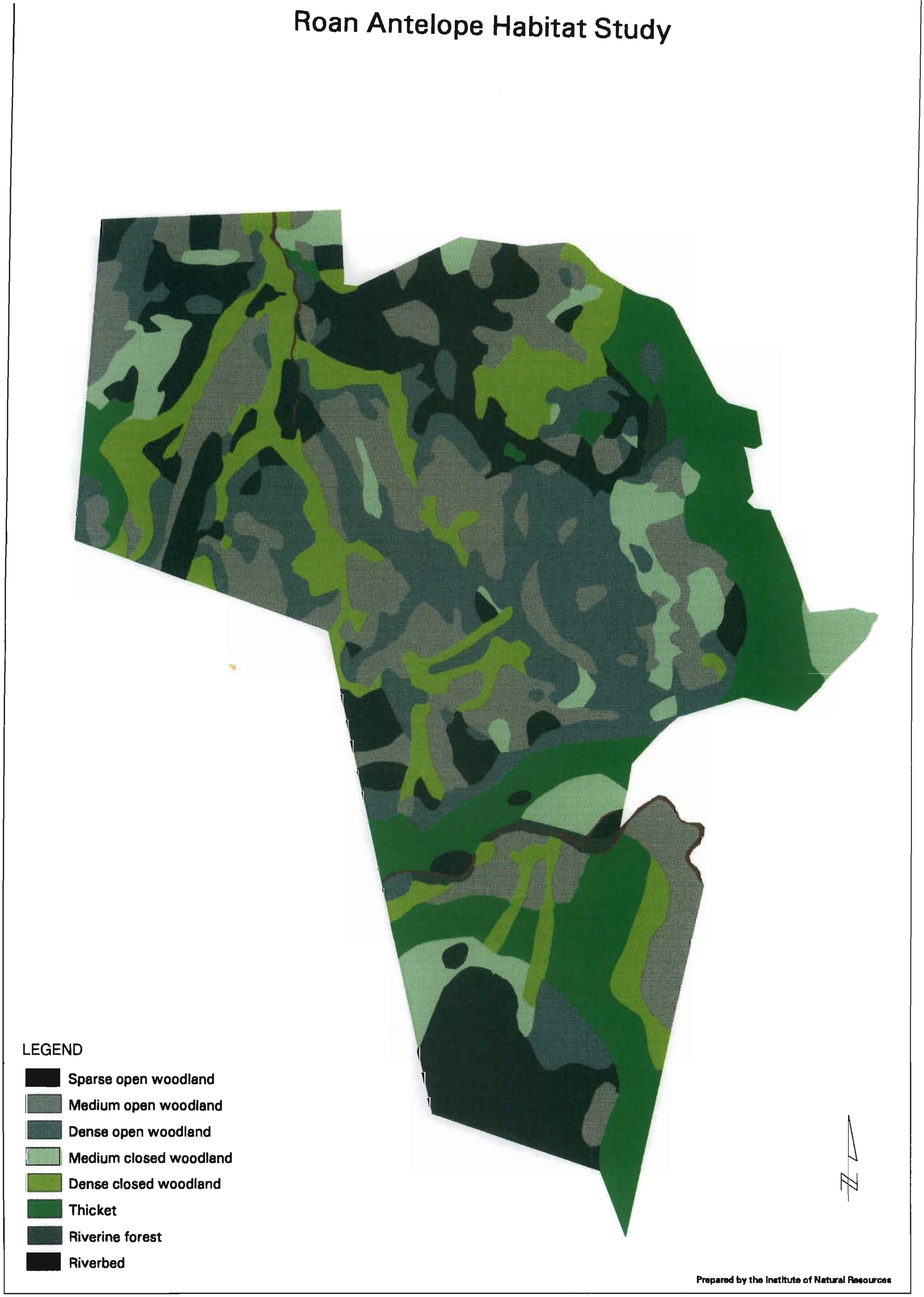

Figure 4 : Vegetation map