THE POPULATION STATUS, DIURNAL ACTIVITY PATTERNS, RANGE AND TERRITORY SIZE, AND HABITAT USE BY THE WHITE RHINOCEROS *(CERATOTHERIUM SIMUM)* IN KYLE RECREATIONAL PARK, ZIMBABWE.

NORMAN JOHN MONKS

A thesis submitted in partial fulfilment
of the requirements for the degree of
Master of Science in Conservation Biology

The Durrell Institute of Conservation and Ecology
University of Kent at Canterbury
September 1995

"But ask the animals,
and they will teach you,
or the birds of the air,
and they will tell you;
or speak to the earth,
and it will teach you;
or let the fish of the sea
inform you. . . . .
In His hand
is the life of every creature
and the breath of all mankind."

Job 12: 7-9, 10.

SUMMARY.

The white rhino in Kyle Recreational Park, Zimbabwe, originate from Umfolozi Game Reserve in South Africa.

When a study was carried out on the rhino in the study area in 1973, grassland and savanna comprised 66% of the area. Since this time the Park has become bush-encroached and grassland and savanna now occupies only 41% of the total area.

Annual white rhino population growth over the last 8 years has been -6,4%. The population numbers have oscillated since 1973 but the general trend has been towards a gradually declining population as the habitat has down-graded.

The rhino selected for savanna, termitaria grassland and lake-shore grassland for feeding, which in Kyle Recreational Park occupies the central portion which is also heavily utilized by other grazers such as wildebeest, warthog, and zebra. Impala in the study area graze for 80% of the time and compete heavily with other grazers. The lake-shore is also heavily utilized by grazers and the two megaherbivores, hippo and white rhino compete directly with one another for this resource.

The present range and territory sizes of the white rhino are different to that seen in the 1973 study and are related to the area in the Park still holding good grassland. Only one territory is held and this occupies the whole of the suitable white rhino habitat. The beta male has adopted subordinate status within this territory but has opportunities to mate with cows in the absence of the alpha male.

ACKNOWLEDGEMENTS.

It has been a special privilege to have been able to spend time following and observing the white rhino in the Park where I am stationed. My sincere thanks go to the many people who have, in one way or another, made this study possible.

For part funding to attend The University of Kent in Canterbury I am deeply grateful to the Director of Malilangwe Conservation Trust, Dr Jeremy Anderson, also to Dr Shuan Russell who assisted me with funds from the Darwin Initiative. An anonymous donor gave me sufficient funds for basic living expenses. Without this donation I would not have been able to attend the course. Whoever this person or organization is I want you to know that your help meant so much to me and I give very special thanks to you.

Special thanks also are due to Dr Peter Mundy who was Chief Ecologist in the Branch of Terrestrial Ecology of the Department of National Parks and Wild Life Management when I began this study. I thank him sincerely for his support of my intention to undertake the MSc degree in Conservation Biology, and for his continued support during this study. His confidence in me has made my nineteen years of service to the Department all the more worthwhile. I also thank Peter for agreeing to be my local supervisor and for his many useful suggestions.

I thank the Director of the Department of National Parks and Wild Life Management and other Government officials who supported my application for study leave. The friendliness and support of officials in the different Ministries is remembered with gratitude.

I am grateful to my colleagues in the Department who were always available to give advice, and who lent me their offices and computers at various times during the write-up period.

The Pascoe family kindly allowed me the use of their flat whilst I was in Harare finishing the write-up. This has been a blessing and I thank them most sincerely.

Sue Kageler from the Department of Statistics, at the University of Zimbabwe kindly checked the statistics used in this study and I am grateful to her for her time and support.

Don Barnett gave up much of his free time to assist me with the final layout of the text. This meant a lot to me and I thank him and his wife Penny for always making me feel welcome when I dropped by at the house for advice.

Dr Richard Griffiths from The University of Kent (Durrell Institute of Conservation and Ecology) was my overseas supervisor and I thank him for his prompt replies to my queries and for his encouragement.

I am grateful to my family and to my brothers and sisters in Christ in many countries who uplifted me in prayer throughout this study. Their joyfulness and faithful support helped me through many deep valleys.

Finally, I acknowledge my complete dependence on God in whose creation, those unspoiled places, I find so much peace and joy. May He receive all the glory.

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF PLATES

1. INTRODUCTION.

The present study looks at the demography, daily activity patterns, habitat use, range and territory size in the small white rhino (Ceratotherium simum simum) population in Kyle Recreational Park (KRP), Zimbabwe. These factors are looked at in the light of the vegetation changes that have taken place since the rhino were first introduced to the Park in the 1960's.

In order to understand more fully the effects that a large herbivore such as white rhino will have on the environment, a knowledge of their patterns of habitat occupancy is important. This study although fairly short, has been supplemented by four years of casual observation on the white rhino in Kyle Recreational Park whilst carrying out other duties.
Aspects of this study are compared to the work carried out in the study area by Condy (1973) when the vegetation was at the sub-climax grassland stage. Some management suggestions are given for Kyle Recreational Park which may have application in other small Parks in which rhino occur.

A number of studies have been carried out on the social ethology, behaviour patterns, range and territory sizes of the white rhino (Owen-Smith, 1971, 1972, 1973, 1974a, 1975; Condy, 1973; Pienaar, Bothma and Theron 1993; van Gyseghem, 1984).

The white rhino situation at KRP is unique in that comparisons can be made of their ranges, territory sizes and social behaviour in two periods separated by 22 years. In 1973 conditions in the Park were probably nearly ideal for white rhino; the land had recently come under the protection of National Parks, a number of herbivore species were introduced and the habitat could be described as "open rolling grassland" (Ferrar 1973). Twenty two years later the Park shows a decreased grassland biomass, and the rhino population numbers have oscillated over this time, finally reaching a temporary equilibrium at very reduced numbers.

Three hypotheses were proposed for the small rhino population at Kyle:

- With a reduced population size, spatial occupancy will be different to that seen in 1973.
- If there is compression in available range due to a reduced grassland biomass, intrinsic behaviour patterns will be affected.
- With only two adult males in the study area, territory sizes, which Owen-Smith (1971) describes as "space correlated dominance relationships" will be larger than seen in the 1973 study when there were 5 territorial males in a population of 33 white rhino.

The white rhino in KRP originate from Umfolozi Game Reserve, South Africa. By 1892 white rhino were considered extinct in Zimbabwe. Between 1962 and 1974, white rhino from Umfolozi, South Africa, were reintroduced into their former ranges in Zimbabwe. Twenty-three white rhino were introduced into KRP between 1962 and 1966 from this source.

The area now known as Kyle Recreational Park was given protection in 1961. Vegetation in the area had been reduced to a fire-maintained, sub-climax grassland by annual burning before protection was given. Seven naturally occurring large ungulates were present in moderate numbers, and upon closure of the area uncontrolled fires were halted and a further fourteen large herbivore species (including white rhino) were introduced. Two Lichtenstein's hartebeest were introduced into the Park but both died soon after being released.

Vegetation in the area shows the effects of a large grazer biomass, and more than a decade of erratic rainfall. Open grassland has been invaded by woody growth, and grass cover in many areas shows a patchy discontinuous pattern as the vegetation has downgraded.

Rhino world-wide are endangered due to increased poaching and a shrinking habitat. Small island ecosystems such as KRP play an important role in the overall conservation of this species. Small areas can be easily patrolled and monitored even with the monetary constraints that most parks face. However, careful management and monitoring is needed of both the rhino and the habitat and the wildlife manager needs to play an active role in this regard.

2. LITERATURE REVIEW.

2.1. The taxonomic status of the African rhinoceroses.

The rhinoceros are of the family Rhinocerotidae and are one of the three extant families of the order Perissodactyla, the other two being the Equidae and Tapiridae. In Africa two species of rhino are found: Ceratotherium simum (the white or square-lipped rhino. separated into two sub-species: the northern race C.s.cottoni and the southern race C.s.simum), and Diceros bicornis (the black rhino) separated into four sub-species; D.b.bicornis, D.b.longipes, D.b.michaeli and D.b.minor. The distinction between the northern and southern race of white rhino is based largely on a minor difference in the outline of the dorsal concavity of the skull; the northern race having a slightly flatter dorsal profile (Owen-Smith 1988). Other minor differences include the lack of body hair in the northern species which also appear to be higher legged than the southern race, and have smaller teeth. Fossil records show that the white rhino, (genus Ceratotherium) is the most recent of the five extant species of rhinoceros (Thenius and Hofer 1960), having diverged from the African Diceros lineage during the Pliocene. The earliest records of Ceratotherium simum date back 3 million years, whilst the black rhino lineage dates back 12 million years.

The white rhino is almost entirely a grazer having wide lips suited to grazing the shorter grasses, whilst the black rhino is a browser, with a specially adapted upper prehensile lip with which to grip and pluck leaves. Adult white rhino weigh in the region of 1600 - 2400 kg making it the second largest land animal after the elephants, whilst the black rhino is smaller with adults weighing up to 1400 kg.

2.2. The historical distribution of rhino in Africa.

The white rhino (Ceratotherium simum).

Historically, the white rhino had a restricted range and occurred as two discrete populations (Fig.6): The southern race Ceratotherium simum simum which was restricted to southern Africa, north of the Orange River, extending northwards to southern Zambia and south-east

Angola, westwards to Botswana and Namibia (excluding the arid Namib desert) and eastward into Mozambique; and the northern race C.s. cottoni which occurred in north-east Zaire, north-western Uganda, south-west Chad and the eastern portion of Central African Empire. The reason for this discontinuous distribution is not known.

The black rhino Diceros bicornis.

Black rhino had a wide range throughout the savanna areas of Africa, avoiding only the arid desert areas and the equatorial forest belt (Cumming et al. 1990). (Fig.6).

2.3. The distribution of white rhino in Zimbabwe pre 1900.

The distribution of white rhino in Zimbabwe before they became extinct in ca 1894, was fairly widespread wherever there was suitable habitat, although populations tended to be concentrated in the high watershed plateau (1000 - 1524 meters above sea level) where, with higher rainfall there was adequate surface water, and grazing was plentiful. The local practice of annual burning would have provided palatable grasses in what is normally "sourveld". Roth (1967) reports sightings of white rhino in the Lowveld (400-1000 metres above sea level) near the Mozambique border, and also below the Zambezi escarpment.

The range of the white rhino in Zimbabwe would have depended on adequate grazing and surface water supplies and wherever the topography was suitable. Pienaar et al. (1993) noted that in the Kruger National Park, white rhino tended to avoid very mountainous and broken terrain, and stony soils with abundant rocks on the surface. Areas of sparse poor quality grass, dense bush and areas without permanent water would not be utilized. It follows that if rhino could follow an unrestricted range they would have avoided these habitat types and their overall historical distribution in Zimbabwe would reflect this.

2.4. The decline of the rhino world-wide.

The rhinos world-wide are endangered species primarily due to the demand that Chinese and allied medical systems in Asia place on the horn, and the importance that men in North Yemen place on the horn as a dagger handle for the traditional dagger known as a *jambia*. (Cumming et al. 1990).

The two species of rhino in Asia, Rhinoceros sondaicus in Java and Dicerorhinus sumatrensis in Sumatra are facing extinction. The great one-horned rhino, Rhinoceros unicornis found in India and Nepal have a better population status but are still threatened. In Africa the northern white rhino Ceratotherium simum cottoni, confined to the Garamba National Park in Zaire, numbered twelve animals in 1983. This population has increased to 32 as a result of intensified protection and international interest. The southern white rhino C. s. simum and the black rhino, Diceros bicornis are likewise threatened due to increased poaching pressure, but are fairly well conserved in their present range in southern Africa.

Over-exploitation of rhino by increased poaching to supply a ready and affluent market is not the only threat that the species face. Loss of habitat due to an increasing human population has brought further pressure to bear on an already fragmented population. Where rhino are given protection, their range is restricted by the confines of the conservation area. In many cases, the rhino exist now in habitats that are marginal (exacerbated by the impact that this megaherbivore has on the environment when confined) and their future in these areas depends heavily on careful ecosystem management.

2.5. The extinction of white rhino in Zimbabwe.

Before 1900, white rhino were widespread in Zimbabwe wherever there was suitable habitat, although after 1880 with the increase in commercial hunting, the population began to decline rapidly. By 1892 the white rhino were virtually extinct in Zimbabwe (Coryndon 1894). Lang (1923) gave the last authentic record of white rhino in Zimbabwe as 1895. However, isolated sightings of white rhino were made right up until 1912 with Roth (1967), noting a report of a sighting of a bull and cow at a pan between Chipinda Pools and the Save River in 1929. This area is close to the Mozambique border and it can be assumed that these animals had come into the country from the small population still surviving at that time in western Mozambique.

2.6. The re-introduction of white rhino to Zimbabwe.

Whilst the white rhino had become extinct in Zimbabwe at the end of the 19th Century, the area in Natal, South Africa between the Black and White Umfolozi Rivers still had a remnant population of between 100 - 200 animals (Owen-Smith 1975). This area was proclaimed a game reserve in 1897 but only received protection in 1920. With this protection and an ideal habitat, the white rhino population increased rapidly and re-introductions of rhino to their former ranges were made from this breeding nucleus.

In 1962 "Operation Rhino" was mounted and eight animals were brought into Zimbabwe from the Umfolozi Game Reserve, four going to Matobo National Park and the other four to Kyle National Park.

Between 1962 and 1974 a total of 144 white rhino were reintroduced into Zimbabwe (Tomlinson 1977) of which 88 went into National Parks and 56 went onto privately owned ranches.

2.7. The present status of white rhino in Zimbabwe.

The status of white rhino in Zimbabwe at the end of 1993 shows both the results of poaching and a poor recruitment rate.

du Toit (1993) gives estimated figures for the Zimbabwe white rhino population as 116 animals (80 animals on State Land - National Parks and adjacent Communal Lands - and 36 animals on private land).

The Department of National Parks and Wildlife Management has initiated a de-horning exercise on all white and black rhino in the country. This measure appears to have had positive results in that poaching has decreased. The Department has also set up intensive protection zones and black rhino breeding areas where the remaining rhino are afforded concentrated protection.

The management of rhino in the smaller parks far from international borders, where there is less chance of unobserved poaching, is also an important aspect of rhino conservation.

2.8. White rhino in Kyle Recreational Park.

The background history of the white rhino population in KRP has been given by Condy (1973). Since this time no further studies have been carried out and regular demographic records have not been maintained, although total numbers are known for most years up to the present.

2.9. Previous studies on rhinoceroses.

Range size and behaviour studies have been carried out on white rhino in Kyle Recreational Park by Condy (1973), in Umfolozi by Owen-Smith (1973), in Kruger National Park by Pienaar et.al. (1993), in Queen Elizabeth National Park, Uganda, by van Gyseghem (1984), Rachlow in Matobo National Park Zimbabwe (1995 PHD thesis in.prep.) and by O'Connor (1986) working with captive animals. Similar studies on the black rhino have been carried out in Ngorongoro Crater by Goddard (1967) and Kiwia (1986 and 1989).

2.10. White rhino habitat utilization.

Pienaar et.al. (1993) studied the landscape preference of white rhino in Kruger National Park and found that the rhino selected certain habitat types e.g. areas with available surface water and good grasses, occurrence of pans for mud baths etc, and rejected others e.g. stoney ground, and sparse poor grasses and a shortage of permanant water etc. A knowledge of habitat/landscape preference has important management implications especially in the smaller parks where the rhino are restricted in their range. Dinnerstein (1991) looked at the demography and habitat use by <u>Rhinoceros</u> <u>unicornis</u> in Nepal in terms of future conservation.

3. THE STUDY AREA.

3.1. General.

Kyle Recreational Park is situated midway between the highveld and lowveld ecological complex in Zimbabwe at an altitude of 1 050 meters above sea level. (Fig.7) and is at the southern extremity of the miombo woodland complex that covers large areas of central Africa. Because of its unique location with both highveld and lowveld characteristics, the management initiatives applicable to the study area could be used, with modifications, for the smaller parks located in the highveld and lowveld.

The official area of the park is given as 16 900 ha which includes Lake Muturikwe and the servitude. The game park section is situated between the arms of the Shagashe and the Muturikwe Rivers (31°00'E and 20°10'S). The Beza Range of hills forms the northern boundary and the waters of the lake form the southern boundary. The surrounding land-use is mostly privately owned commercial cattle farmland in the north and south-west and communal land in the east. Great Zimbabwe Monument is situated south of the lake (Fig.8). The area of the game park depends upon the level of the lake; at full supply level the area is approximately 5 263 ha whilst at 20% full supply level, the area is approximately 6 170 ha (Mooring, 1993). The lake level during the study was approximately 8% and the area of the park was calculated to be 6975 ha.

The vegetation can be broadly described as predominantly miombo (Brachystegia/Julbernardia) woodland in the north and south-east. Acacia scrub savanna in the central portion and with seasonally fluctuating areas of lake-shore floodplain characterised by short to medium height grasses.

The park is located 32 kilometres due south-east of Masvingo Town and is fenced with a 2.4 meter 14 strand game fence in the west and north whilst the waters of the lake forms the eastern and southern barriers.

3.2. History of the study area.

The study area has had a long history of human habitation which is reflected in the modified seral vegetation which characterises parts of the park. The Great Zimbabwe complex which was the centre of a large population from the 13th - 15th century A.D. is located 12 kilometres due east of the park and it is likely that the study area was settled by people during the era of this kingdom as evidenced by the number of old dwelling sites in the Park. Basutu transport riders who came up with the pioneer column in 1890 settled in the present area further modifying the habitat by crop growing, tree cutting and annual burning. Later the area became state-owned public grazing land leading to overgrazing and further degradation of the land (Ferrar and Kerr 1971).

The dam wall was completed in 1961 and on the 4th August that year, the area between the arms of the lake was proclaimed a game reserve and fenced. In 1967 it was proclaimed a national park, the status changing to a recreational park in 1975 (under the Parks and Wildlife Act of 1975) due to the establishment of water sports on the newly created lake.

Seven naturally occurring large herbivores were present in the area at the time it was fenced in 1961 (Ferrar 1973). Soon after closure, a further 14 species were introduced (Table 1). Two Lichtenstein's hartebeest were introduced into the park but both died soon after arrival. There are no large predators in the Park apart from leopard, <u>Panthera pardus</u> which are reported to only kill impala. Both the side-striped jackal <u>Canis adustus</u> and black-backed jackal <u>Canis mesomelas</u> occur in the Park.

A total of 22 white rhino were introduced into Kyle from Umfolozi Game Reserve between 1962 and 1966. The present population originates from this introduction.

3.3. Physical features of the study area.

The central portion of the park is gently undulating, interspersed with a number of seasonal streams which drain into the lake. Most of this section lies approximately 1 050 meters above sea level. The northern border of the park is dominated by the Beza Range of hills which rise about 400 meters above the rest of the park to a height of 1 485 meters above sea level. The topography of the southern portion of the park is very broken and impressive, with granite "ruwaris" (bare granite whalebacks) dominating the area, interspersed with wooded grassland.

Areas along the lake which are inundated during the wet season from the rising lake are exposed in the dry winter months as water is drawn off to the south-east lowveld for the sugar-cane crop. Parts of the previously inundated areas along the lake have been colonised by grasses and present sweeping open grassland (Plate 1) which is utilized heavily by grazing species including the white rhino and hippopotamus.

An inland dam (Chenyati Dam) is situated in the central area of the park on sandveld and provides a source of permanent water for wildlife in the area. Other small dams have been built but all have been unsuccessful due to the unstable nature of the soils. Ferrar and Kerr (1971) note that no point in the park is further than five kilometres from the lake-shore although this distance will obviously vary depending on the level of the lake.

3.4. Geology and soils.

The geology of the study area is described by Wilson (1964) in the geological survey bulletin number 58. The Beza Range in the north-east is a formation of the phyllites and are capped by banded ironstone and quartzites. In the central area dominated by Combretum tree species, the sub-surface rock formations are exposed along a low ridge running east-west. Elsewhere in the central portion, the soils are red-clays derived from the basement complex of banded ironstone and gold-belt schist. These soils are fertile but prone to capping if exposed. In the west along the park boundary, the soils are sandy and less fertile derived from the underlying granite rock. Black clay soils are found along the drainage lines leading in to the lake.

In the south-east, granite outcrops dominate, interspersed with sandveld vegetation. The soils are shallow due to the underlying granite shield and are susceptible to waterlogging in some areas (vleis). Carver (1966) reports all soils in the study area as being critically short of phosphorus.

3.5. Climate.

The study area receives a single rainy season, with approximately 80% of the annual rain falling between the months of November to March. Mean annual rainfall is 828 mm but can be erratic with large fluctuations. For the years 1973/4 - 1994/95 mean annual rainfall has been 766 mm and has ranged between 161 mm (1991/92) to 1200 mm (1977/78). South-easterly winds can bring moist air in the form of "guti" (low cloud and drizzle) during the dry winter season and although no significant precipitation falls, it does have a modifying effect on the vegetation preventing rapid desiccation of grasses. Daily maximum and minimum temperatures are measured in the fish pond area of the research headquarters in the park which is sheltered. As a result, the measured temperatures do not accurately reflect minimum temperatures in the rest of the Park which will be lower. Mean minimum and maximum temperatures for the period 1974 - 1994 were: minimum 10.2°C and maximum 28.9°C. Ground frosts are experienced in June and July and can vary in severity. Occasionally "black frost" is experienced in the park killing back frost susceptible trees and bushes (Peltophorum africanum, Bauhinia thonningi, Ficus spp.) and causing rapid drying of grasses. The mean monthly rainfall and temperatures for the study area are shown in Fig. 1.

3.6. Management.

3.6.1. Wildlife population reduction.

A number of population reduction exercises have been carried out in the form of live translocation since 1978. Unfortunately records of these translocations are not complete.

In 1969 the kudu population was reduced to 60 by culling (Wilson 1970). In 1968 there was a population crash of reedbuck in the park (approximately 90% mortality) during unseasonably cold weather compounded by nutritional stress and heavy tick burdens (Ferrar and Kerr 1971).

During the drought of 1992 many wild life species in the Park died including white rhino. No translocations took place but an active supplementary feeding programme was initiated with food donated by the private sector. Feeding sites were dominated by wildebeest. Wild life losses were high. The Park, being a closed ecosystem requires active and adaptive management since wild life are unable to disperse during times of stress.

3.6.2. Controlled burning.

The Park is divided into a number of blocks using roads and firebreaks as boundaries (Fig.9) and a four year controlled burning programme is designed to burn all blocks at least once every four years. The purpose of the programme is to prevent woody encroachment (West 1958), and to clear moribund grasses. The burning also assists in controlling the excessive tick population (Minshull 1981) although there is some dispute as to the efficacy of fire as a tick control measure. The past decade of below average rainfall has interrupted the programme. In addition, woody encroachment to the exclusion of grasses has made burning in a number of blocks impossible due to the lack of litter.

3.6.3. Monitoring of the ecosystem.

Twenty-two permanent concrete beacons have been sited in the Park as fixed-point sites from which to photograph vegetation changes. Changes in the vegetation structure over the past twenty years has been dramatic.

Wildlife population estimates are carried out annually by total counts from the air or by road strip counts. Population trends can be seen from these counts. Metabolic biomass has been calculated for the study area using these figures.

3.6.4. Tick control.

Apart from the controlled burning programme, two Duncan Applicators (automatic tickicide dispensers) have been placed in the park. The efficacy of this method in reducing the tick burden on wild life has been proven in trials (Duncan and Monks 1992). In addition. 30 red-billed oxpeckers (Buphagus erythrohynchus) were introduced into the park on 11th November 1993, as a means of biologically controlling tick numbers (Monks 1994, Departmental report).

3.7. Visitor usage.

Kyle Recreational Park is a popular park well utilised by visitors. Masvingo Town, 33 kilometers away, is central to the larger centres being almost equidistant from Bulawayo, Harare, Mutare, and from the South African and Mocambique borders. Road access is good. An air service exists between Harare and Masvingo.

The Great Zimbabwe complex is located across the lake from the park, approximately 12 kilometres away. However, distance by road, because of the size of Lake Muturikwe, is approximately 60 kilometres. The drive to Great Zimbabwe passes through spectacular scenery. Many visitors take the opportunity to visit Great Zimbabwe and stay over in the park for game-viewing where viewing the white rhino is especially favoured. The park lodges are situated on an immense granite outcrop overlooking the lake. The lake offers opportunities for fishing and water sports. Visitor statistics for the years 1984-1994 are given in Table 8.

Organised school tours are made to the park and many of the children visitors have never seen a wild animal larger than a duiker. The park is situated in the largest and most densely populated regional district in Zimbabwe and has great potential for conservation education.

3.8. Vegetation.

The vegetation of the study area has been described by previous workers who have emphasised certain aspects for their field of study; (Wilson 1970; Ferrar and Kerr 1971; Minshull 1981; Minshull and Norval 1982; Condy 1973; Ferrar 1973; and Lightfoot, 1978). Ferrar described the vegetation in the Park as predominantly open rolling grassland with extensive miombo Brachystegia/Julbernardia woodland in the hilly north, whilst West (1966) stated, "The Park contains much open country, grassland and savanna in which trees are sparsely scattered in grassland". When the area was given protection in 1961, the vegetation had been reduced to a fire-maintained sub-climax grassland in most places. After the closure of the area as a park, indiscriminate burning was prevented and many grassland areas developed into regrowing successional woodland. This trend has continued and the study area is now characterised by woody invasion with a decrease in the grass component.

The controlled burning programme has not been adhered to for a number of reasons and this, together with erratic rainfall over the past decade and a large grazer biomass, has resulted in woody invasion in all areas of the Park apart from the area regularly inundated by the lake (up to about the 20% full supply level).

Ferrar (1973) placed the vegetation types in the study area in three major divisions: woodland, savanna and grassland. These divisions have been retained for the present study.

The habitat map (Fig. 10) produced for the present study looks at the vegetation in terms of suitability for white rhino and the major divisions were further sub-divided according to species composition and abundance. The terminology used for the vegetation types follows with adaptations, that of Pratt, Greenway and Gwnne (1966). The abundance of the woody or grass component was assessed subjectively by ranking as follows:

1 = 0 - 20% cover

2 = 20 - 40% "

3 = 40 - 60% "

4 = 60 - 80% "

5 = > 80 "

If the grass cover ranked 3 or less (less than 60%) with trees, the vegetation type was termed "grassed woodland". If the ranking for grass abundance was over 4 (greater than 60% but less than 80%) with trees, the vegetation type was termed "wooded grassland". If either the woody or grass component had an abundance rank of 5 (greater than 80%) the vegetation type was considered a pure representation of either the woody or grass component, e.g "woodland" or "grassland". Wooded grassland was placed in the "savanna" division and grassed woodland in the "woodland" division.

Descriptions of the 14 habitat types in the study area are given below, and are shown in the habitat map (Fig.10).

(a) **Acacia wooded grassland savanna.**

This vegetation type occupies approximately 1286 ha (18,4%) of the study area. It is characterised by successional Acacia karroo and A. rehmanniana scattered woodland in a strong sward of grassland, the predominant grasses being Hyparrhenia filipendula, Hyperthelia dissoluta and Heteropogon contortus, with some areas being reduced to short Panicum atrosanguineum (Plate 2). The area provides valuable but average grazing for the white rhino especially during the dry season.

(b) **Terminalia wooded grassland savanna.**

This occurs on the sandy soils and occupies approximately 281 ha (4,0%) and is characterised by Terminalia sericea scattered woodland in a strong sward of grassland consisting primarily of H.filipendula, Pogonarthria squarrosa and H. contortus. This vegetation type has the same grazing value as the previous type.

(c) **Grassland with termitaria communities.**

This vegetation type represents a pure grassland sward with scattered termitaria communities raised above the level of the surrounding grassland. It occupies approximately 581 ha (8,3%) of the total area. The predominant grass species is Hyparrhennia filipendula with Cynodon dactylon in the wetter areas and around termitaria. It is an important grazing area for the rhino especially during the dry season.

(d) **Miombo woodland.**

Brachystegia spiciformis and Julbernardia globiflora woodland with a bare understorey characterise this vegetation type found on the red soils. Miombo woodland occupies approximately 953 ha (13,7%) of the study area and is not utilized by the rhino. Brachystegia glaucescens is found on the Beza Range of hills, but since these areas are not used by the white rhino, they have been conveniently placed under the broader type "miombo woodland". Grass cover is insignificant.

(e) **Grassed mixed woodland.**

The woody component of this vegetation type is very varied with Peltophorum africanum, T. sericea, Combretum spp., Bauhinia thonningii, Acacia spp., Pterocarpus rotundifolius, Pseudolachnostylis maprouneifolia, Grewia monticola, Dombeya rotundifolia, Zizyphus mucronata being common. The grass component is fair, with a covering ranging between 20% - 60% and consisting of mixed grasses such as Aristida congesta, H.filipendula, P. squarrosa, H.contortus, Sporobolus pyramidalis, and Digitaria spp. It is found mainly on the red soils and occupies approximately 670 ha (9,6%) of the study area. During the period covered by this study, the rhino utilized this vegetation type for shelter during wet or cold weather. The area will probably serve as a food source later in the season.

(f) **Grassed Peltophorum africanum woodland.**

This vegetation type consists of almost pure stands of P.africanum woodland and is found on the red soils especially in capped areas. Grass component abundance ranges from 0 - 40% with grasses such as H. contortus, Themeda triandra, and A. congesta being found. The area occupied by this type is approximately 191 ha (2,7%). Rhino were found in this vegetation type only once during the study, grazing in a clear area and later resting in the shade of trees on a particularly hot day. As a food source this area is marginal.

(g) **Loudetia grassed Combretum woodland**

This vegetation type is found on the red soils and also in the central section of the study area where the soils are shallow with exposed rock. Combretum fragrans and C.molle are the main tree species. Grass abundance ranges from 10 - 40% with L.simplex being the predominant species interspersed with A.congesta. The rhino were never seen in the rocky section of this vegetation type but old (probably from the end of the last dry season) droppings were found on the patches of deeper red soils in the area. This vegetation type covers approximately 333 ha (4,8%).

(h) **Loudetia grassed mixed woodland.**

This vegetation type is found on the hard-capped red soils on the edges of miombo woodland. Tree species were stunted in size, and in the early stages of succession consisting of Acacia rehmanniana, A.karroo and P.africanum. Grass cover ranged from 20 - 40% and woody growth about 25%. No rhino were seen in these areas which occupied approximately 263 ha (3,8%) of the study area.

(i) **Bushed drainage-line grassland.**

This small area of H.filipendula vlei-line (seasonally wet grassland) is being invaded with A.karroo and A.rehmanniana scrub. Rhino were not seen in this area during the period covered by the study. The area covers approximately 57 ha of the study area (0,8.%). Grass cover is about 60%.

(j) **Grassed dense mixed successional woodland**

Situated on the deeper fertile red soils in the north-west of the study area, this vegetation type is characterised by the impenetrable nature of the successional woodland. Distance between tree trunks averages less than 50 cm. The trees are tall but with small trunk diameter, and the species composition is very diverse. It is well differentiated from type (e) by physiognomy. This area occupies approximately 583 ha (8,4%) of the study area, and is mainly unavailable to the rhino due to the thickness of the woody vegetation.

(k) **Un-grassed successional Acacia/Peltophorum scrub**

This vegetation type occupies the west central portion of the study area which was inundated by the lake at full supply level in the mid 1970's. The lake level has receded markedly since this time and Acacia spp. and P.africanum have colonised the bare capped red-clay soils (Plate 3). Grass cover is less than 20% consisting mainly of A. congesta which has no forage value. The white rhino utilised these areas for resting during the day. The area covered by this type is approximately 713 ha (10,2%) of the study area.

(l) **Lake-shore grassland**

This vegetation type has the most valuable grazing in the study area throughout the year. In the seep-zone areas near the lake shore and along the feeder streams, the grasses remain green throughout the year. The most common grasses are Cynodon dactylon, Panicum maximum, P.dregeanum, Urochloa mosambicensis and Erograstis spp. Further inland away from the wet area, H.filipendula, C.dactylon and H.contortus occur. This area, which occupies approximately 683 ha (9,8%) of the study area is heavily utilised by all grazers including the two megaherbivore species, white rhino and hippo. (Plate 4).

(m) **Grassed Albizia amara woodland.**

This vegetation type occupies a small area in the mid northern section of the study area on a low rocky ridge. A. amara is the predominant tree species with Digitaria spp., H. contortus, H. filipendula ranging from 20% - 60% in abundance. This area occupies approximately 39 ha (0,6%) and was not seen to be utilised by the rhino during the study period. Buffalo had reduced much of this fairly tall grassland type to a short cropped sward. No new white rhino droppings were found in this area.

(n) **Granite hill woodland**

This vegetation type is found in the extreme south of the study area in the granite hill complex mainly on the sandy soils. At the base of outcrops the woody vegetation is varied, and grass abundance varies from 0 - 60% consisting of Digitaria spp., A.congesta, H.filipendula, H.contortus, Eragrostis spp.and P.squarrosa. The rhino fed in these areas soon after rain when run-off from the granite shield (ruwari) keeps grasses greener than the surrounding areas. The approximate area occupied by this type is 342 ha (4,9%). This vegetation type is similar to (e) but is differentiated by the concentration of woody vegetation at the bases of ruwaris.

4. CHANGES IN THE VEGETATION STRUCTURE AND HERBIVORE BIOMASS 1968 - 1995

4.1. Methods.

4.1.1. Increase in woody invasion over time.

The latest aerial photography coverage for the area (reference Surveyor General, Masvingo Block 13th June, 1985) was used for producing the habitat map in this study. The 1968 and 1985 aerial photographs (which give a 17 year range) were used to obtain a measure of the increase in woody invasion over time. Points were marked on the 1985 aerial photos and the corresponding site marked on the 1968 set. So that future measurements can be taken of the same areas, the sites were selected: 6 from existing fixed point beacons and 6 from easily located sites with grid references given. An area of 1 cm X 1 cm was drawn on clear acetate (which equalled one quarter of the grid square of 1 km^2 at the photograph scale of 1:25 000) and 25 holes punched in it with a pin at intervals of 2 mm. The sheet was placed over the location point on each map and aligned to match. Using a stereoscope, the number of trees/bushes that the holes "hit" were counted first on the 1968 photographs and then on the 1985 photographs (Table 2).

The increase in woody growth over time was tested for significance using a paired t-test. This method gave an objective quantifiable way of indicating the increase in woody vegetation in the study area although its limitations are recognised.

4.1.2. Changes in herbivore biomass.

Ferrar (1973) gave wildlife estimates for the study area at that time. No figure is given for the numbers of hippo grazing in the park area. For the purposes of this study, the number is assumed to be similar to the present estimate. The total grazer metabolic biomass occurring at that time was calculated using the 1973 estimates. Wildlife population estimates have been carried out over a number of years since this time, the latest being carried out in November 1993 using the road strip count method and data analyzed using the Fourier Series Estimator for Density proposed by Burnham et al. (1980). These population estimates have been updated for this study by my personal knowledge of the wildlife in the area. The basal energy requirements of the wildlife is measured in calories or joules per day and will vary with the mass of the animal. The total grazer metabolic biomass ($Mass^{0.75}$) in the park including one third of the hippo population (which is the approximate number grazing the lake shore edges in the park) was calculated (Table 3).

4.2. Results.

4.2.1. Increase in woody invasion 1968-1985.

Woody invasion over the 17 year period 1968-1985 measuring changes on aerial photographs has been significant ($t=1.77$; $df=11$; $p<0,01$). Overall there has been approximately 49% increase in woody invasion in the 17 year period. The most common invading tree species on the red soils are Acacia rehmanniana, A.karroo and Peltophorum africanum. Terminalia sericea is the most common woody invader on the sandy soils. Photographs taken from fixed point beacons in the study area in 1968 and 1995 show this increase in woody vegetation (Plates 5 and 6). The study area shows seral stages of the savanna areas which are characterised by localized encroachment mainly by Acacia species. The percentage of total area occupied by the three major vegetation types (savanna, grassland and woodland) in 1973 and 1995 are given in Table 7.

4.2.2. Changes in grazer biomass.

The total herbivore metabolic biomass in the park is estimated to be 46 329.5 $kg^{0.75}$. The grazer biomass is calculated to be 35 140.5 $kg^{0.75}$ (approximately 75,8% of the total herbivore biomass). The white rhino population contributes 3 133 (8.9%) of the total grazer biomass and 6,8% of the total biomass. The four most abundant grazers in the park (wildebeest, zebra, impala and warthog) together contribute 57.6% of the total grazer biomass. Wildebeest alone contributes 17,9% of total grazer biomass in the park which exceeds the biomass contribution made by all other species including hippo (16,7%). The buffalo population contributes 11,9% total grazer biomass but range widely, not remaining in one area for any length of time.

In 1973 the grazer metabolic biomass was approximately 38 903 $kg^{0.75}$ which is 3 763 $kg^{0.75}$ more than at present. However grassland was calculated to occupy about 45% of the area at that time (Ferrar, 1973) whilst at present it is calculated to occupy only 19% of the total area. Grassland and savanna combined, occupied approximately 66% of the total area in 1973. The present study shows grassland and savanna comprising only 41% of the total area.

4.3. Discussion.

In 1973 the grassland in the study area was assessed as consisting of a high percentage of medium quality grazing (Ferrar,1973). It was felt that this grazing was durable and could withstand heavy grazing pressure. Poor rainfall, an increase in woody invasion and a large grazer biomass has changed the grassland structure. It can no longer be considered able to withstand heavy grazing pressure since most of the available grazing is only present in a fairly small area of the park (approximately 19% open grassland and 22% savanna).

Most of the northern, and parts of the southern area of the park are unsuitable or marginal for grazers. The areas occupied by savanna, grassland and woodland is different to that of 1973. Savanna (defined as trees in a strong grass sward where the grass component is the main feature) occupies approximately the same percentage, since some savanna areas have moved to woodland and grassland has become bush encroached moving to savanna. The grassland component has decreased markedly, whilst the woodland has increased. The area considered prime rhino habitat (Fig.11) is heavily grazed by other species such as wildebeest, zebra, and warthog. Impala utilize grazing in KRP about 80% of the time and also compete for grazing in these areas. Rhino occupancy in this area was confirmed by sightings and by carrying out dung counts, the location of each dung site being recorded on a 1:50 000 map (Fig.12). The area is approximately 21 km^2 in extent and comprises 30% of the total Park area.

During a road strip count census carried out in 1993 it was calculated that 63% of wildlife were found on the lake shore fringes, 6% in the west of the central section, 3% in the north of the central section and 28% in the mid central portion around Chenyati Dam

(Monks 1993, Departmental Report). Wildebeest, zebra, impala and warthog were the most abundant species found in these areas.

When the white rhino were introduced into the study area between 1962 and 1966, the vegetation had been reduced to a fire maintained sub-climax grassland. With the control of fire and the subsequent increase in grazer biomass through introductions, poor and erratic rainfall, together with the modifying effect that the rhino exert on the habitat, woody invasion has increased. This has resulted in a lowered grazer carrying capacity.
Large grazing herbivores including white rhino have transformed the grassland structure in many places from tall grassland to short decumbent grasses. This is seen particularly in Hyparrhenia grassland areas which have been reduced to a ground layer of Panicum atrosanguineum (Plate 2). Bare capped areas caused by over-utilization are seen frequently in grassland forming bare islands which are susceptible to erosion, (Plate 7). Large herbivores exert direct pressure on the habitat by trampling grasses, compacting the soil and removing the herb layer. With a large herbivore biomass concentrating in a fairly small area at high concentrations, the overall impact is considerable. Heavy utilization of the grass layer has reduced plant biomass and primary production. Poor rainfall years have exacerbated the situation leading to high levels of woody encroachment. The four year burning programme, if implemented is only effective in containing woody growth in areas where there is adequate litter, and many areas lack this. Grassland areas that are burned are heavily selected by grazers such as wildebeest, zebra, impala and white rhino (Ferrar 1973). Continuous cropping and consequent depletion of root reserves, leads eventually to bare, capped areas impervious to rainfall and open to erosion.

Conybeare (1991) measured vegetation changes around artificial water supplies in Hwange National Park caused by the impact of elephant, and found that there was a reduction in species richness and species diversity in the woody component. In the study area, although no measurements were made, it is fairly apparent that the grass component in areas of high occupancy is likewise suffering from a reduction in species richness and diversity as there is an increase in annual grasses such as Aristida congesta.

The situation in the park of a large grazer biomass, and a degraded grassland is similar to that experienced in Umfolozi. A reduction in grazer biomass including wildebeest was initiated in this reserve and after good rains there was a rapid recovery in the grass component (Owen-Smith, 1988).

5. IDENTIFICATION OF INDIVIDUALS, POPULATION STRUCTURE, SOCIAL CATEGORIES AND STABLE ASSOCIATIONS BETWEEN INDIVIDUALS

5.1. Methods.

5.1.1. Identification of individuals.

In 1993 the white rhino moved out of the study area into an area across the Muturikwe River beyond the park boundary. This was probably due to nutritional stress (pers.ob.). A capture operation was initiated by the Departments' veterinary surgeons to relocate the rhino and during this time the animals were de-horned, ear notched and the age class and sex recorded. Unfortunately, due to a very large group of spectators and enthusiastic participants, no horn profile photographs were taken of the rhino before de-horning, so that it is not possible to match ear notches to individuals that were known by their horn shape apart from two old individuals (5.1.2.). The history of the remainder of the white rhino apart from juveniles is not known. During the study, individuals were identified by the ear notch pattern. Two animals had the same pattern and were differentiated by body size and horn-stump shape (thickness and size).

The actual number of rhino in the study area were known from the de-horning exercise, so identification, sexing and ageing was an on-going project carried out whilst collecting other data until all individuals had been recorded. One sub-adult cow could not be accounted for during the present study. The bottom jaw of a sub-adult rhino was found imbedded in the dry mud of a seasonal stream when I was searching for the rhino and it is presumed that this is from the missing animal which probably died in 1993/4. The animal was judged to be about 7 years old using the ageing criteria based on tooth wear developed by Hillman-Smith, et al. (1986).

5.1.2. Population structure.

For ageing purposes only three age classes were used: juveniles, sub-adults and adults. The size of the rhino and its associations with other rhino was used to allocate individuals to an age class. Calves at foot were placed in the juvenile category. The sub-adult class included animals not dependent on the mother and obviously smaller than the full grown animal. At about 3-4 years of age when the mother calves again, the previous young is chased off and joins a companion group. At this stage it enters the sub-adult class. In the case of females, even if the animal appeared to be smaller than the full grown adult but had calved, it was placed in the adult class. Parturition can occur between 6-7 years (Owen-Smith 1988). The adult class included all animals that had either achieved full body size or whose behaviour indicated that they had assumed adult status e.g. solitary males. Two animals were identified as being from the original introductions from Umfolozi in the 1960's. Number 8, "Marufu" (which means, death), was introduced from Umfolozi in October 1966 aged about two years making him now about 31 years old. He was identified by a distinctive scar on his left rump.

Number 3, "Msasa" (named after an indigenous tree) had an almost horizontal anterior horn which was distinctly different from the other rhinos. During the dehorning exercise this feature was noted so that the ear-notch could be tied up to the animal. "Msasa" was introduced into the study area from Umfolozi in 1965. No age is recorded at introduction, but assuming that she was at least two, her present age will be about 32 years. This animal produced a male calf in June last year (1994). Owen-Smith (1988) gives white rhino longevity as being about 45 years. The white rhino population structure is compared to that occurring in 1973.(Fig 2).

5.1.3. Social category and stable associations.

Five social categories were recognised, based on behaviour, companion preference and use of space. The criteria used for assigning an individual to a category is based on that used by Owen-Smith (1973). The social categories existing in the present population are: alpha bull (territorial male), beta bull (subordinate adult male), cow-cow companions, cow-juvenile association and sub-adult bull companions. The alpha male held an exclusive territory whilst the beta male, although adult, adopted subordinate status and resided in the alpha male's territory.

5.2. Results.

5.2.1. Population structure.

The present population consists of 13 individuals (2 adult males, 5 adult females, 2 sub-adult males, 1 sub-adult female, 2 juvenile males and 1 juvenile female). The proportion of reproductively active adults in this small population is 54% which is what may be expected in an increasing megaherbivore population (Owen-Smith 1988). The overall sex ratio is 6 males : 7 females which does not differ from parity. The age and sex structure of the population does not differ greatly to that occurring in 1973. (Fig.3).

5.2.2. Social categories.

(a) **Alpha males.**

Only #8 ("Marufu") was recognised as being an alpha male having a territory. He was mostly solitary except when in temporary association with cows, and once with beta male #4.

(b) **Beta males.**

#4 is an obviously mature animal but younger and not as thick set as Marufu. No records exist for his age to be calculated, but he is judged to be between 10 and 12 years of age since he is mainly solitary, and bulls after the age of about 10 years tend to exhibit solitary behaviour. He was not seen to mark an area by scrapes, horn-beating or backward-kicking after defecation. He was seen in association with the cow-cow group, but the association never lasted for more than one day.

(c) **Sub-adult males.**

#10 and #11 fell in this category. They were noticeably smaller than both #4 and Marufu and moved as a pair during the period covered by this study. They were seen twice in the company of the cow-cow group but the association only lasted a couple of hours. No marking behaviour was seen although #10 on only one occasion was seen to kick backwards (one kick) after defecation. This action lacked purpose unlike the vigorous kicks (14 counted during one episode) made by the alpha male.

(d) **Cow-cow associations.**

At the beginning of this study there were 2 cow-cow groups. The one consisted of adult cow #5 and adult cow #2. The second group consisted of adult cow #9 and sub-adult cow #6. In June, #2 was seen alone with beta male #4. A search was made for her companion #5 who was eventually found with a newly-born calf (after calving, cows tend to chase off companions or older offspring). A day later #4 was seen alone and upon searching, #2 was found in association with #6 and #9. This association has continued during the remainder of the study period.

Cow #6 was possibly ovulating (cows come into oestrus at about 5 years of age) during the time of this study and it is possible that she had been covered by beta bull #4 which was seen in close association with her and her female companion #9. There appeared to be a discharge around the vaginal area and a sperm-like substance was seen on the ground where she had just urinated.

(e) **Cow-calf associations.**

Cow #3 ("Msasa"), had a male calf in June 1994 which was still at foot. Cow #1 calved in March 1995 (a female) and cow #5 calved in June 1995 (a male). #5 and her calf were seen once in association with the cow-cow group (#2, #6 and #9) but did not get closer than about 8 body lengths. The other cows with calves were never seen with other rhino.

5.3. Discussion.

Condy (1973) had sufficient demographic data on the white rhino in the study area to more precisely allocate individuals to 5 age classes. (Class I juvenile 0-3 years, class II sub-adult 3-6 years, class III adult 6-9 years, class IV adult 9-12 years, and class V adult over 12 years). In the present study, only the ages of two old individuals and the juveniles were known, and it was necessary to allocate individuals to the broader age classes used.

The composition of individuals in each age class in the 1995 population is: adults 54%, sub-adults 23% and juveniles 23%. In 1973 the composition was 58% adult, 15% sub-adult and 27% juvenile. Social categories within the two populations for the different years are similar, however Condy (1973) reports sub-adult cows associating with other cows of similar age. In the present small herd there was only one sub-adult cow and she was seen in association with an adult cow until that cow calved, and then very briefly with an adult male, finally associating for the rest of the study period with two adult cows. Although there were two sub-adult bulls of approximately the same age in the population, the sub-adult cow did not form a bond with them. Owen-Smith (1975) cites examples of sub-adults of both sexes forming bonds.

The pattern of social organisation within the small white rhino population in the study area is the same seen in other populations. Since there is no apparent population pressure in the study area, these patterns can be stated to be intrinsic. In herbivores, spatial dispersion between the social groups (age and sex class) is a feature of the cooperative and competitive interactions relating to survival and reproduction (de Boer and Prins, 1990). The white rhino have no natural predators and there is no advantage to them moving as a large herd for protection. Dominance is a feature of adult males (Owen-Smith 1988) which compete for reproductive opportunities. During the study, the largest gathering of individuals was seen during a resting period where 7 individuals rested in close proximity to one another. After the rest period the gathering split up into their cohesive groups and moved off in different directions.

6 POPULATION CHARACTERISTICS OF THE WHITE RHINO IN KRP.

6.1. Methods.

Data was collected and collated from warden, ranger and scout monthly reports at KRP, and population changes over the 29 year period, 1969 - 1995 illustrated graphically, (Fig. 3). The population structure in 1973 and 1995 are shown (Fig. 2). For the period 1980 to 1991 details on the age and sex structure of the rhino population are lacking so that only total population numbers are known. Data on translocations was collated from Station reports and updated using the figures presented by du Toit (1993). Calving and conception times were worked out using available information.

The last translocation of rhino from the study area was made in 1987. The annual population growth rate was calculated for the years 1988 - 1995 using the formula

$nt = no(1+r)^t$ rearranged as: $r = \sqrt[t]{(\frac{nt}{no}} - 1)$

where:

t = no. years

nt = present population number

no = original population number

r = growth rate

6.2. Results.

6.2.1. Natality

Details of natality are lacking: only 18 births in the 22 year period being recorded.

6.2.2. Mortality and translocation.

Of the 33 recorded mortalities, causes of death are given for 15 animals only (8 stuck in mud, 3 bulls died from wounds sustained after fighting, 1 died of nutritional stress, 1 bull was poached, 1 bull ingested wire and died and 1 bull died of old age). Fifteen (45%) of the recorded mortalities were in the combined adult/sub-adult age class whilst 11 (33%)

were in the juvenile class. The remainder were in unknown age classes, records merely stating "1 rhino died" etc. (Table 5). Information on the ratio of male to female mortalities is lacking.

No white rhino introductions were made into the study area after 1966 but twenty four removals by translocation are recorded (Table 4). The majority of these removals (16) took place between 1975 and 1980 (5 in 1975, 6 in 1978 and 5 in 1980), and were made as a result of heavy local population pressure in the favoured white rhino habitat, (Lightfoot 1978).

6.2.3. Population density.

Condy calculated the crude rhino population density (i.e. for the whole park regardless of habitat suitability) in the study area in 1973 to be 0,7 rhino per km^2 whilst ecological density (i.e. the area of suitable white rhino habitat) was calculated to be 0,8 rhino per km^2. From the habitat map of the study area produced for the present work, it was calculated that approximately 49,68 km^2 (71,2% of the total area) was available to the rhino, ranging from marginal to good habitat. Crude population density is calculated to be 0,19 rhino per km^2 (1 rhino to 5,4 km^2) and ecological carrying capacity to be 0,26 rhino per km^2 (1 rhino to 3,8 km^2). Although about 71% of the total area of the park is available to the white rhino, only about 30% was regularly used by them.

Comparisons of densities of white rhino in other areas are given in Table 6 (showing density, range and territory size.)

6.2.4. Seasonality of conception and calving.

Conception and calving times are shown in Fig.4 and follow similar trends to that seen in other W. rhino studies. Calving peaked between March and June with the majority of calves being born in April, although there were births in all months apart from November, January and February. Conception peaked between November and March with only one conception taking place between July and October. The peak conception time coincides with the wet season when grass quality and quantity is best. The calving peak is in April, at the tail end of the wet season after a gestation period of 16 months. At this time the female will be in peak condition and able to withstand the heavy physiological demands made by lactation.

6.2.5. Population growth and fluctuations.

Population fluctuations over the period 1966 - 1995 (Fig.3) show oscillations, with the trend being towards a steadily decreasing population. It is difficult to work out population growth for the years 1968 to 1987 as a number of translocations were made during this period. Population figures could not be found for the years 1980, 1981, 1983, 1985, 1986 and 1990. The annual growth rate in the 7 year period 1988 - 1995 was -6,4%.

6.3. Discussion.

The white rhino population numbers have oscillated over the 29 year period 1966 - 1995 as environmental changes affect population equilibrium. Population growth calculated for the last 7 years, 1988 - 1995 (where population numbers are known and no translocations took place) is -6.4% per annum. Using the data given by Condy (1973), population growth between 1967 (after introductions) and 1971 (before translocations) was 1.03% per annum. Owen-Smith (1988) gives overall population growth in Umfolozi as being 9% p.a. The density of the rhino in the study area are compared to that in other areas and is discussed in section 8.3.

A slightly artificial situation is seen by the de-stocking programmes, but the general demographic pattern has been that of a slowly declining population reaching short periods of equilibrium and then falling rapidly until equilibrium is again reached, each time at a reduced population level. Assuming that the translocations were a natural process of emigration, the rhino population fluctuations in the study area show similarities to the processes as discussed by Riney (1964 and 1982) relating to large herbivores expanding from low concentrations in favourable habitat and eventually exceeding the carrying capacity of the environment.

Riney shows four stages in this process as reported by Owen-Smith (1988):

Stage 1. A rapid population growth initially

Stage 2. A steady deterioration of the habitat as the population reaches and then exceeds carrying capacity. Animals lose condition, there are deaths and the population stabilises temporarily.

Stage 3. A rapid decline as the population adjusts to the lowered carrying capacity of the area.

Stage 4. The population stabilises at very much reduced numbers in the degraded habitat.

The population oscillations of white rhino in KRP show a number of cyclic patterns of the above processes leading to a greatly reduced population in an area of reduced carrying capacity.

Owen-Smith (1988) used a computer-based simulation model on population dynamics of large long-lived herbivores, and concluded that population fluctuations result mainly from the interaction between the herbivore and the vegetation, and that dispersion and predation dampens these population fluctuations. The wildlife in KRP are unable to disperse and there are no large predators apart from leopard which are known only to prey on impala.

Large grazer herbivores react to adverse nutritional conditions in a number of ways, e.g. an increased calving interval, late attainment of sexual maturity which retards population growth, and mortality. Owen-Smith (1988) suggests that ovarian activity in white rhino may be suppressed by low nutrition so that oestrus is delayed until more favourable conditions exist. These natural population regulating mechanisms are slow acting so that it is possible that habitat degradation and mortality will continue before equilibrium is reached. Goodman (1981) suggests that in large long-lived herbivores, annual survival rates rather than fecundity may affect population dynamics.

With the large grazer herbivore population existing in the park (Section 4) and the increasing degradation of the grasslands, it is doubtful whether the white rhino population will increase overall beyond the present level. Since the wildlife is unable to disperse, management should aim at reducing the grazer biomass to reduce population pressure, which will allow the grasslands in the study area to recover.

7. DAILY ACTIVITY PATTERNS.

7.1. Methods.

Data collection for daily activity patterns was recorded by the focal sampling method (Altmann 1974, Martin and Bateson 1986). Five minute intervals between observations was considered suitable for recording the various activities which were classed as follows:

- Feeding (feed stand and feed walk)
- Resting (lying or standing)
- Walking
- Comfort (wallow, scratch etc)
- Social (interaction between individuals)

Before data collection began the Park was traversed by road, and dung sites noted on a map (Fig.12). This gave an indication of the area most frequently occupied by the rhino.

The study area is conveniently divided into unevenly sized blocks by roads, rivers and firebreaks (Fig.9). Each block was systematically searched at the beginning of the study and checked for signs of rhino occupation (tracks and droppings). If no evidence was found for the presence of rhino in the block, the area was given a low priority when searching for the rhino later to obtain data for daily activity patterns. In order that the area was not totally excluded from the study resulting in unnatural biases, these blocks were checked at two-weekly intervals. If signs of rhino use were located, then the blocks were included in the daily search for rhino. Since all searches were made alone, on foot, and data collection was carried out alone, this method was considered the most practical.

Blocks in the study area were traversed on foot at first light and once a rhino was located, it was followed for as long as possible and activity recorded. Defecation and urination and all social interaction was recorded when noted. The observations were terminated only after an animal was lost and could not be found after careful searching, or when light failed. The daily location of animals was not made easy due to the thickness of bush and the height of the grass. Over the full study period, daily activity patterns covering the 12 hour period (0600hr-1800 hr) were obtained. A total of 115 observation hours were made on individual white rhino. Nocturnal observations were attempted at two periods of full moon (12th May and 12th July) but were terminated when the animals were lost. #8 (alpha male) was lost when he went into 2 meter tall Hyparrhenia grassland and #4 (beta male) was lost when he went into thick Acacia scrub. No night vision equipment or assistance was available during this study.

It was not practical to limit the daily search to a particular individual due to the difficulty and time involved in locating a rhino. It was therefore decided to begin observations on any rhino found rather than be selective and possibly forego observation time. All blocks in which there was evidence of rhino presence were searched equally with no preference being given to a particular area.

The total observation time spent on each social category within the rhino population did not differ greatly (Cows with calves at foot = 22 hours, adult cow companions = 28 hours, alpha male = 32 hours, beta male = 24 hours). Only 9 hours of observations were made on sub-adult male companions.

It was possible to follow the located group or individual at a distance of about 70 metres when they were walking. When the individual was stationary (feeding or resting) it was possible to approach to within about 30 meters depending on habitat type and wind conditions. A small bag of fine ash was used to give wind direction, and the animals kept up-wind from the observer. When there were two or more rhino together, observations were made on a selected animal only.

7.2. Results.

Fig. 5a shows the mean percentage time spent on the various activities by each social group throughout the 12 hour period.

Fig. 5b shows the mean percentage time spent active or inactive throughout the 12 hour period (0600 hr - 1800 hr), of each social group.

Fig. 5c gives the mean percentage time spent active or inactive throughout the 12 hour period taken from pooled data.

Figs. 5d-5h shows the mean percentage time spent in each activity (feeding, resting, walking, comfort, social) using pooled data.

The population is too small to carry out statistical analyses for differences in activity related to age and sex. Fig. 5a illustrates graphically these differences which are described below.

7.2.1. All activities using pooled data.

Resting reached a peak between 1100 hr - 1200 hr. No periods of rest were witnessed early in the morning or in the late afternoon. (Fig.5b). Social activities (interaction with other rhino) occurred throughout the 12 hour period but appeared to be more concentrated between 1500 hr - 1800 hr. (Fig.5e). Comfort activities (wallowing, scratching etc) occurred throughout the day with a peak between 0900 hr - 1000 hr. (Fig.5d.) Walking was seen throughout the day with low periods between 0600 hr - 0800 hr when the rhino were feeding intensively, and at the peak resting time. (Fig.5c).

Feeding activity peaked early in the morning and late in the afternoon, with the lowest feeding period being between 1100 hr - 1200 hr corresponding to the time when resting reached a peak. (Fig.5a).

7.2.2. Mean percentage time active and inactive.

The percentage time spent active for all social categories (pooled) peaked in the early morning and late afternoon and decreased to very low activity percentages between 1100 hr - 1200 hr. (Fig. 5c). In the active category i.e. excluding resting, feeding occupied 77% of the time the rhino spend on activity, walking occupied 15% whilst social activities occupied the least (2%).

With all activities (including resting), feeding occupied 48% of all activities, walking 10%, and resting 37% of the time. Social and comfort activities occupied the remaining 5% of time. The rhino were generally inactive between 1000 hr - 1400 hr with a peak period of inactivity between 1100 hr - 1200 hr. On cool days, more time was spent feeding and less time on resting. On very cold, wet days, the white rhino tended to inhabit the thick bush where they were sheltered from the weather. There feeding occurred sporadically throughout the day.

7.2.3. Activity patterns for each social category.

Activity patterns (feeding, walking, comfort, resting, social) are illustrated in Fig. 5a.

(a) **Feeding.**

Alpha and beta males spent a similar percentage time feeding, (46% alpha male and 45% beta male) whilst cows with calves spent more time feeding than all other social categories (48%), and cows without calves spent the least time feeding (33%).

(b) **Walking.**

All social categories spent a similar percentage of the time walking although the alpha male spent the most time in this activity (13%) whilst cows with calves spent the least time doing so (9%).

(c) **Comfort.**

The alpha male spent more time in comfort activities (8%) than all the other categories who spent similar low periods in this activity (ca.2%). Rubbing on selected rubbing rocks (Plate 8) and scratching against bushes was included in comfort activities.

(d) **Resting.**

Cows without calves appeared to spend more time resting (54%) than all the other categories with the alpha male spending the least time in this activity (32%). Cows with calves spent 12% less time resting than cows without calves.

(e) **Percentage time active and inactive.**

The percentage time that the rhino were active or inactive are illustrated in Fig. 5b. The alpha male spent the greatest percentage time (68%) active and the least time resting (32%). Cows with calves showed a similar percentage time in activities as the beta male (58% and 61%) with similar rest percentages. Cows without calves were the least active, spending more time (54%) resting than all the other social categories.

7.3. Discussion.

White rhino diurnal activity was observed between 21st April and 17th July, a period of just under three months with one hundred and fifteen hours of observation time. Despite the short period spent on observation, the results of this study show strong similarities to other activity studies carried out on the two species of white rhino as well as on the black rhino.

Condy (1973) found that feeding occupied approximately 40% of all activities and resting 38% of the time. The present study shows feeding occurring 48% of the time and resting 37% of the time. Owen-Smith (1973) found that white rhino in Umfolozi had activity peaks in the early morning and late afternoon which extended into the evening. He was able to show monthly variations in the daily foraging time and found that in August less time was spent foraging whilst a peak was reached in November and December. van Gyseghem (1984), studying the northern white rhino found that feeding reached a peak at about 1600 hr which lasted late into the evening whilst resting peaked between 1200 hr - 1400 hr. Goddard (1967) and Kiwia (1986) studied the daily activity patterns of black rhino (D.b.michaeli) in the Ngorongoro Crater, Tanzania, and found that feeding peaked between 0600 hr - 0700 hr, declining between 1000 hr - 1500 hr and then reaching a peak again at 1800 hr. The percentage time black rhino spent active and inactive follows the same pattern as the present study on white rhino. The white rhino exhibited the typical bimodal activity patterns seen in most herbivore species in Africa (Napier-Bax and Sheldrick 1963; Guy 1974, Barnes 1983a; Conybeare 1993), with periods of rest occurring during the hot hours and with feeding peaks early in the morning and late afternoon.

Unfortunately no nocturnal activity studies could be made during the study but there is no reason to suppose that activity patterns would differ greatly from that seen in other white rhino populations, with feeding carrying on into the evening, periods of rest occurring in the early morning followed by feeding again at about 0600 hr.

During this short study, two cows had calves under the age of two months making the observations on activity biased to the early period after parturition. It is interesting to note that cows with calves spent more time feeding than all other social categories. Presumably this is due to the high nutritional demands made on the mother during lactation. The alpha male spent more time walking than any of the other social categories, due to the territory marking behaviour which necessitates regular patrols of territory boundaries.

Cows with calves spent the least time walking and this is probably due to the fact that the calves are limited in the distances they can travel. "Msasa" with her year old calf had a larger range (4,7 km^2) than #1 with a 2 month old calf (3,2 km^2). Presumably once the calf is stronger and older, the percentage time spent walking will be similar to other social groups.

Cows without calves spent more time resting than other social categories. This social group would not have heavy nutritional demands made on it (as seen in lactating cows) and may not need to feed as much as cows with calves. The white rhino build up subcutaneous fat reserves during the wet season when grass quantity and quality is best, and this sustains them during the dry season.

Comfort activities were seen more often in the alpha male than in other social categories. During one period of observation the alpha male wallowed, rolling over first on one side than the other so that all but the spine was covered with mud. After wallowing, the animal rubbed its head on an Acacia rehmanniana tree on which there was old mud and then walked over to some rocks on which it rubbed its belly. The animal then smelled the rock and licked the mud off, repeating the rubbing and licking twice. The same behaviour was seen in the beta male. Presumably there are minerals in the mud favoured by the rhino. No rhino or other wildlife species were seen licking termitaria (which will have a higher mineral content than surrounding areas), although this is a common practice in other wildlife areas in the country.

When a rhino had wallowed and had walked to a tree or rock on which to rub, it often smelled the place attentively first before rubbing. It is possible that olfactory clues are left by previous animals in the rubbed off mud.

Social behaviour was seen more frequently in the beta male and the cow-cow group (Fig. 5b). Other white rhino studies show more social behaviour associated with the alpha male than by other social categories. Since the study area has only one alpha male with a large territory to demarcate it is possible that this animal is having to spend more time marking territory than in social activity. According to the conception and calving times (Fig. 4), very few cows would be in oestrus during the time covered by this study and it is possible that this would account in part, for the fact that the alpha male was seen so infrequently with cows. In periods of the alpha male's absence within his territory it is possible that the beta male has the opportunity to mate with in-oestrus cows.

8. TERRITORY AND RANGE SIZE.

8.1. Methods.

Each time a rhino was seen, its location was marked on separate 1:50 000 maps using six figure references giving a location accuracy of approximately 100 meters. Animals under observation for daily activity patterns were followed and their routes marked on the map. White rhino territorial males exhibit defined behaviour patterns when marking territory. The territorial adult male frequently carries out a boundary patrol, horn-beating and spray urinating on bushes or grass tufts, and defecating preceded by scraping and followed by backward kicking to break up the dung bolus. This leaves a distinct basin-shaped midden and scrape marks can be clearly seen (Plate 9). New scrapes (Plate 10) and all marking behaviour was noted and the site given a number and the location fixed on a 1:50 000 map (Fig.13). During general rhino searches, any territorial marking sites were recorded and later confirmed to be in the area or on the boundary of the alpha male.

Individual location points were collected throughout the study and part of the write-up period and at termination the range and territory size worked out using the minimum convex polygon method (Dalke. 1942; Mohr, 1947) by connecting the peripheral location points and measuring the enclosed area with a planimeter. Range overlap is shown on one map by drawing in the ranges of each individual or group (Fig.18). Areas of heavy rhino occupancy were confirmed by dung counts made from the road (Fig.12).

8.2. Results.

Figs.14 - 17 show ranging patterns of individuals or cohesive groups during the study period. Fig.18 shows the range overlap between individuals and groups. The range overlap of all social groups is interesting in that the ranges are centred within the area of prime rhino habitat, and all social groups are found within the territorial male's territory. Fig.14 shows the territory of the one alpha male in the present white rhino population.

White rhino alpha males defend a mutually exclusive area which is demarcated by middens and scrapes. The alpha male will allow subordinate males and females within the territory but all rhino will be challenged when encountered. Rival alpha males are not tolerated.

The territorial male "Marufu" occupied an area of 7.8 km^2, the beta male had a range of 4.3 km^2, cow/cow companions had a range of between 4,3 - 6.6 km^2, cow/calf groups between 3,2 - 4.7 km^2 and the sub-adult bulls had a range of 7,7 km^2.

Crude population density, territory and range size is compared to those worked out for other white rhino populations (Condy, 1973; Owen-Smith, 1971; Pienaar, Bothma and Theron, 1993; Conway and Goodman, 1989; van Gyseghem, 1984). (Table 6).

8.3. Discussion.

Although the term "home range" is used by a number of ecologists, there is disagreement in its meaning as well as disagreement as to how it should be measured. Burt (1943) defined "home range" as the area in which an animal moves during its normal activities of feeding and reproduction. Jewell (1966) defined home range as the area traversed during routine activities whilst Walther (1972a) defines it as the area familiar to the animal within which it establishes some space-time pattern of movement. Anderson (1982) states that all methods have associated problems and concluded that the minimum convex polygon method was appropriate for obtaining a reasonable approximation of range estimate. To allow comparisons to be made with other white rhino range sizes, the ranges of rhino in the study area were calculated using the minimum convex polygon method. The term "range" is used in this study rather than "home range" since the observation period was too short to positively define a home range.

The territory of an alpha male remains in a fixed area which may change slightly over time so that although the study was short, the territory boundary and size can be conclusively stated.

Owen-Smith (1973) and Condy (1973) found that beta males confined to an alpha male's territory exhibited subordinate status and that cows ranged extensively through a territory. This was confirmed in the present study. It appears that the one alpha (territorial) male has occupied the area of prime rhino habitat and that the only other adult bull has assumed a subordinate position within this area.

One encounter between the alpha and beta male was witnessed: The beta male was in the confirmed territory of "Marufu" and this alpha male who was nearby, when recognising the beta male, walked quickly over to it to investigate. The beta male roared and backed away with flattened ears at which stage the alpha male halted his advance. After some time the beta male made hesitant advances towards the alpha male ending in nasonasal contact. The animals faced each other and then the alpha male began to push the beta male back using horn to horn contact. The beta male gave way steadily at which stage the alpha male lost interest and moved off to drink. The beta male stood for some time as the alpha male drank and later moved off to graze by the lake shore. After about fifteen minutes the beta male followed and began to graze about 10 body lengths away. The two animals showed no further interest in each other. This behaviour follows closely the description of encounters between alpha and beta males described by Owen-Smith (1975).

The alpha male occupies non-overlapping mutually discrete areas and does not normally tolerate other alpha bulls within that area. The fact that the only other adult bull in the population was never seen to mark when defecating (although he did spray bushes on a number of occasions) and that his range overlapped that of the alpha male confirms that he is subordinate and does not hold a territory. Normally alpha bulls will occupy all available areas which will be divided up into discrete territories. This was not seen in the study area even though there were other areas available in less suitable habitat to the other adult male. At the beginning of this study it was assumed that there would be at least two alpha males in the population, but this was disproved by later observation. No such situation has been found in literature on white rhino territories.

It is possible that in the degraded habitat in KRP the prime area occupied by the alpha male does of necessity, have to be utilized by the other adult male, and in order to have this area available, he has adopted subordinate status. In time he may challenge "Marufu" who will, if ousted, remain in the area (or move out on to less suitable habitat) but assuming subordinate status. Usually a territory, when established, is taken over in its entirety by the bull which ousts the present territory holder. The low (0.2/km^2) crude density of white rhino in the study area is similar to that of C.s.cottoni in Queen Elizabeth National Park Uganda (van Gyseghem, 1984). Alpha male range size is similar in all areas whilst the cow range measured in this study is fairly small (4-7 kms) as compared to the 1973 population (3-20 kms) and that of other areas (Kruger 7 - 45 kms, Ndumu 5-23 kms, Umfolozi 9-21 kms). Females range extensively and move within the boundaries of territorial males with no restriction.

The small range size measured during this study is probably due to the fact that seasonal ranges were not measured. However, as the area most suitable for the rhino is fairly small, it is doubtful that overall range will be as great as that seen in the study carried out by Condy (1973) when grassland and savanna occupied approximately 66% of the study area as opposed to 41% at present.

9. HABITAT USE.

9.1. Methods.

During data collection for daily activity patterns, the habitat type (as defined in 3.8) and the activity taking place by the individual in that type was recorded.

Habitat use for the major activities of the white rhino (feeding and resting) was worked out for the two major vegetation types most occupied by the rhino during the study period, viz: lake-shore grassland and wooded grassland (savanna). Data from individual observations were clumped into three categories: cows with calves at foot, adult males, and cow-cow companions.

For the purpose of analysis, habitat use in termitaria grassland was combined with savanna. The major activities carried out by the rhino are feeding and resting. A chi-square test was applied to the data using the null hypothesis that there is no habitat preference between social groups for feeding or resting sites. Indices for habitat selection for feeding by each social group and for the population as a whole was calculated using Hulbert's (1978) niche breadth index:

$B^1 = X^2/[A \sum(x_i^2/a_i)]$

where a_1 = relative abundance of habitat type.

A = the sum of the habitat types

x_1 = % number of sightings in the habitat type

X = total number of rhino sightings.

Niche breadth measures quantitatively, the use animals or plants make in a set of resource states (Krebs, 1989). Core areas were identified from the range maps by counting the number of sightings made in each 1 km^2. Areas showing a high percentage occupancy are taken to be core areas within the range.

9.2. Results.

9.2.1. Niche breadth (feeding).

The alpha and beta male showed fairly narrow niche breadth indices (0,213 and 0,212) with the alpha male selecting savanna and the beta male lake-shore grassland habitat.

Cow/cow groups had the widest index (0.2901) and were found feeding in four distinct habitat types, although they tended to select for the lake-shore.

Cow/calf groups had the narrowest niche breadth index (0,1974) selecting for the thicker savanna vegetation and rejecting the more open lake shore habitat.

The overall feeding niche breadth index for the population was 0.279 which is fairly narrow as the white rhino select for short grasses which are found around trees and termataria in savanna and along the lake shore.

9.2.2. Social category habitat selection.

There was a significant difference in habitat selection between social groups for feeding ($Chi^2 = 3.37$; 2 d.f.: $p<0,05$) and resting ($Chi^2 = 27.22$: 4 d.f: $p<0.001$).

Cows with calves spent 96% of the time feeding in Acacia savanna and only 4% of time on the open lake-shore.

Cow-cow companions spent 51% of feeding time on the lake-shore. 30% of time in Acacia savanna, 13% in granite hill grassed woodland and 6% in grassed P.africanum.

"Marufu" the alpha bull spent 92% of the time feeding in Acacia savanna and the remaining time feeding on the lake-shore.

The beta bull on the other hand spent 66% of the time feeding on the lake-shore, 22% in savanna and 12% of time in P.africanum woodland.

The data set on sub-adult bulls is small but shows 80% of feeding time spent on the lake-shore and the remainder in Acacia savanna. Resting was seen only once on the Lake shore. The most favoured wallow sites were in streams (58%), whilst Chenyati Dam was favoured for 28% of the time and the lake edge for 14% of the time.

When feeding, the rhino population as a whole selected for Acacia wooded grassland savanna 63% of the time and lake-shore grassland 32% of the time whilst the remainder of time was spent in grassed P. africanum woodland and granite hill woodland.

Resting occurred most frequently (45% of time) in the un-grassed successional Acacia/Peltophorum woodland located at the high water level mark and situated on a raised area sloping to the lake and drainage lines. (Plate 3). Grassed P.africanum woodland was favoured for resting 34% of the time, open lake-shore 14% of the time and Acacia savanna 7% of the time. Core areas are shown on the range maps (Figs. 13 - 17).

9.3. Discussion.

The two major habitats utilized by the rhino in the study area are Acacia wooded grassland (savanna) and lake-shore grassland. Short green grasses form the most important food source in the wet season and later the medium-tall grassland becomes heavily utilized. The wetter areas around the lake produce grasses of high forage value (Cynodon dactylon and Panicum spp.). Lake levels fluctuate considerably as water is drawn off to the lowveld sugar farms (lowering the lake by as much as one meter each time). Colonisation by grasses on the narrow bared areas produces green grass throughout the year which is utilized by the rhino, hippo and other grazers (Plate 4).

During the early part of this study, which began soon after some late heavy rains, the rhino were found more often in Acacia savanna where the dominant grass is Hyparrhenia filipendula. Prominent game paths were followed by the rhino in this tall grassland and on either side of the path the tall grass sward was cropped by swinging the head sideways, and pushing the taller grass to one side to expose the green leaves near the base which were then cropped. Areas within the tall grassland areas were being transformed into islands of short grasses. (Plate 2).

During the study, utilization of the medium-tall grasslands and lake-shore appeared to be cyclic probably corresponding to the condition of the lake-shore grassland. After measurable precipitation brought by "guti" rhino were found grazing at the base of granite hills where run-off had stimulated green growth. Cows with small calves were most often seen in the savanna areas in the central portion of the study area. Open areas such as the lake shore were shunned until the calf was stronger. Only "Msasa" was frequently seen on the lake shore with her year old calf, but when the calf was younger, they were more often found in the savanna area (pers.ob). Chenyati dam is situated in the savanna area and cows with calves were able to water there without the necessity to use the lake.

Wildlife use space disproportionately within the boundaries of their home range (Samuel et.al. 1985). These areas which are most frequently used are termed "core areas" and are shown on the range maps. Since these areas are heavily utilized, the impact on the environment will be greatest within the core area and identifying them is necessary before management recommendations can be made.

Under heavy nutritional stress the rhino have been known to move north away from the central portion of the park. This was seen in 1993 when the rhino were able to ford the Popoteke and Muturikwe Rivers in the north-east and move on to the Shamatera portion of the park and then on to private land. A capture and translocation operation was mounted and the animals brought back in to the park. Dispersion from the favoured rhino habitat was also seen in 1978 when, due to local population pressure, animals were breaking through the fence out of the study area. A de-stocking exercise was mounted and once pressure on available resources was relieved, there were no further problems.

Overall habitat selection shows a concentration of use in a fairly small area (21 km^2). This area is also heavily used by other grazers since it is the only area of good grassland.

10. FINAL DISCUSSION.

Spatial occupancy in the study area appears to be different to that found in 1973 when the rhino population was larger. Condy (1973) found that all available space in the study area was utilized as territories, which agrees with the findings of Owen-Smith (1971). The present study shows that even with a reduced population and only two potential alpha males, only one territory is maintained, and that the beta male does not yet defend a territory even though there is little chance of conflict if he did so. Owen-Smith (1971) suggests that territoriality in white rhino serves to regulate reproductive competition among males lowering the frequency of conflict. In the study area, since the females range only in the prime rhino habitat which is also the alpha male's territory, it would be wasted energy for the beta male to establish a territory outside of this area, where the chances of meeting with females is low. The alpha male cannot be present everywhere in the large territory he defends and there are reproductive opportunities for the beta male even though he has subordinate status. It was noted during this study that the beta male had probably mated with cow #6 in the absence of the alpha male [Section 5.2.2.(b)].

The white rhino in the study area showed behaviour patterns similar to that seen in other populations including those at higher population densities. All individuals apart from the alpha male were found with conspecifics and these groups appeared to be stable, although the cow/cow groups show some fluidity, (cows after parturition chase off conspecifics). The sub-adult bull association has remained stable since early 1994 (pers.ob.). Owen-Smith (1975) suggests that white rhino sub-adult associations may be the result of a high population density. This was not found in the present study. Even if the prime rhino habitat is regarded as being all of the available area, density is still only 1.6 rhino per km^2, compared to 3 per km^2 in Umfolozi.

It was assumed that the social categories and associations found in white rhino were the result of a high population density (Owen-Smith 1971). van Gyseghem (1984) disputed this and Owen-Smith (1988) revised his former assumptions. He found that each territory is occupied by a territorial bull and from 0-3 beta males. He suggests that the class of beta male is a typical feature of white rhino social organization and is not related to a high population density. The present study supports this assumption since the population density in the study area is only 0,19 rhino per km^2. Owen-Smith (1988) suggests that when densities are low as with Javan. Sumatran and black rhino there is little chance of encounters between rivals and there is therefore no need to assert spatial dominance. The present study shows that the alpha male maintains his territory even at a low population density.

Pienaar et.al. (1993) suggests that population density in an area will determine the territory size: in low density areas the territory will be larger. Condy (1973) suggests that territory size is related to the abundance of grassland in the area concerned. The present study suggests that both these factors will affect territory size but that in the absence of competition from rivals, territory size will be large even in prime habitat.

Habitat occupancy by the rhino shows strong selection for the lake-shore grassland and the savanna areas in the central area. As grazing pressure in this central area increases during the dry season. some rhino may begin to forage outside of their normal ranges. moving north into the dense successional woodland on the fertile soils in the north. Old dung from the last dry season were found in these areas but at very low densities.

The white rhino in K.R.P. are an important tourism and national asset. Even at the low population number now present in the park. tourists have ample opportunity to view the rhino due to the good network of roads in the central area. This study has shown that with the present large grazer biomass. the rhino are possibly at maximum stocking rate. Poor rainfall and drought has been a feature of KRP for the last decade or more. If the area experiences a further drought there is a danger of rhino losses as seen in 1992 when approximately half the white rhino population succumbed despite efforts to supplementary feed. There is need to de-stock other grazers such as wildebeest. impala, zebra and warthog and allow the grassland in KRP to recover. Supplementary feeding programs have failed in the past as wildebeest remain in the feeding area and monopolise the feed. Even with an increase and improvement in the grass component, it would be unwise to allow the white rhino population to increase to more than 15 animals. The tendency of the rhino to graze at soil level reducing grass cover and creating bare areas, causing capping and eventual bush encroachment, means that the vegetation will continue to be adversely modified.

Large grazer herbivores have a direct impact on the grassland by feeding, trampling and breaking of the plants. When the grassland areas are over-utilized, primary production is reduced and bare, capped areas begin to form with resultant bush encroachment. Water infiltration is reduced in these capped areas. (Immediately after 54 mm of rain fell in the study area in 1994 I measured water infiltration on capped red soils in K.R.P. to be to an average depth of 15 mm only). On the edges of many of the bare areas in the study area, harvester termites (Hodotermes mossambicus) are abundant and further reduce the grass layer causing large islands of bare ground. The dramatic vegetation changes in K.R.P. are very clearly seen by comparing photographic panoramas of areas over time (Plates 5 and 6). The stocking rates of the grazers in the Park have to be reviewed in the light of these changes.

11. MANAGEMENT RECOMMENDATIONS.

11.1. Vegetation.

The study area is fortunate in having a good time-span record (1965 - 1995) of vegetation photopanoramas taken from fixed point beacons located throughout the park. In 1961 the area was sub-climax grassland, and since this time browsers such as eland and giraffe were introduced into the park. Management should aim at getting the vegetation back into a more balanced state allowing sufficient woody growth to satisfy the needs of the browsers but also opening up grassland that show obvious signs of woody encroachment. The main encroaching species are Acacia rehmanniana, A. karroo and Peltophorum africanum. Bush clearing can be done by selectively thinning the woody component vertically and horizontally. Stumping of Acacia species has not proved to be successful and even chemical treatment of the stumps shows no marked effect on reducing growth. The park has a heavy demand on firewood both for the tourists and for the staff and the thinning process can be harvestable and continuous. At present large Brachystegia spiciformis and Julbernardia globiflora trees are being used for firewood. The thinning process should be used in conjunction with regular adherence to the four-year burning cycle, but this will not be effective until the herbivore biomass has been reduced.

11.2. Herbivore biomass.

Kyle Recreational Park is an island ecosystem, fairly small in size thus requiring progressive and active management. The overall herbivore biomass should be kept to within the ecological carrying capacity of the area and stocking rate should be calculated for a drought situation rather than for normal years. This will mean a reduced stocking rate. At the present time the area is over stocked with wildebeest, impala and warthog. Zebra are possibly reaching maximum carrying capacity. De-stocking of these species should be a priority. Tourist game viewing will not be affected by a reduction in population numbers since wildebeest, impala and warthog are most often found in the open grassland areas. It is ecologically important to ensure that there is an equilibrium between herbivore and plant biomass and when this is within a closed system it can only be achieved by active management. The white rhino population should be kept to a maximum of 15 animals and even this number should be approached with caution.

11.3. The white rhino.

Conservationists world-wide have focused their attention on critically endangered wildlife species such as the rhino. K.R.P. is fortunate in having a small white rhino population and every effort should be made to ensure that the population is well managed. The numbers of white rhino in the park should be kept low. As suggested above, with the vegetation as it is, the maximum number is 15. A small population such as this is better able to cope with poor rainfall years and the resultant nutritional stresses as they will be able to forage outside of their core area to obtain maintenance grazing to get them through the critical period. The sex and age structure of the population should be taken into account. No more than two alpha males would be suitable for the area.

Given that the white rhino population in the study area is a small isolated population, they are vulnerable to demographic extinction, disease epidemics, genetic drift and inbreeding (Ashley et al. 1990). Management should aim at drawing up a genealogy chart for the rhino population at K.R.P. and keeping this up by regular monitoring. During regular de-horning exercises. (Pienaar, Hall-Martin and Hitchins, 1991, note that the anterior horn grows at the rate of about 50.5 mm per annum). Young rhino can be ear-tagged so that they are identifiable when they leave the mother.

Genetic material should be exchanged with other areas holding white rhino. This should be done at national level where the genealogy of each rhino is known and genetic material can be exchanged in a controlled way. It is doubtful whether bringing in new bulls will be immediately successful in enhancing the genetic diversity of the population since the new bull will have to hold and defend a territory before he has breeding opportunities and this may take time. Exchanging cows between populations would be more practical in a small park such as K.R.P. Alternatively all progeny can be removed and translocated to other areas so that the bull does not cover his offspring. In the larger parks where there is room for a number of territories the importation of new bulls may be successful in the long-term.

The removal of the territorial bull from K.R.P. and replacing it with one of similar status from another area is also a viable possibility.

Deaths due to rhino getting stuck in the heavy cotton soils along streams in the dry season are common. Wallow sites in dry streams with more stable soils such as the upper and lower Mukonda Stream can be kept wet by leading water to it from the existing water pipe which leads from the development area to the entrance gate.

11.4. Ecological monitoring.

Ecological monitoring of the wildlife and the habitat is an essential component of the overall management of the white rhino.

The photopanoramas should be maintained yearly and some vegetation transects put down in individual habitat types to monitor vegetation changes. Walker (1976) gives methods for recording vegetation composition and utilization by putting in transects in various vegetation types. Herbivore biomass should be monitored by carrying out annual block counts from the air, or alternatively, by carrying out road strip counts which will show population trends. All staff should be encouraged to record natality and mortality and these records should be centralised, and when the data is compiled, fed back to the recorders for their information. After annual burns the burned blocks should be monitored for grass and woody growth and the numbers and species of wildlife utilizing the areas noted. The collated information should likewise be fed back to the staff.

11.5. Supplementary feeding.

If the park is stocked at the correct stocking rate and the vegetation is allowed to recover from the past years of abuse, there should be no need to supplementary feed the wildlife. Mineral blocks are required however, since the soils are deficient in phosphorus. A one to one mixture of monocalcium phosphate and coarse salt can be made to supply phosphorus to wildlife. All species utilize the supplement including the rhino. The distribution of these mineral blocks should be changed regularly so that there is no damage to the vegetation by continuous hoof pressure. The mixture can be dug into the ground or a termitaria but this can cause bare areas to form as the wildlife utilize the area and export soil by ingesting the soil together with the mineral.

LITERATURE CITED.

Altmann, J. 1974. Observational study on behaviour: Sampling methods. *Behaviour, 49, 227 - 267.*

Anderson, D.J. 1982. The Home Range : A New Nonparametric Estimation Technique. *Ecology 63(1) 103 - 112*

Ashley, M. V., Melnick, D. J. and Western, D. 1990. Conservation Genetics of the Black Rhinoceros (Diceros bicornis), 1:Evidence from the Mitochondrial DNA of Three Populations. *Conservation Biology Volume 4, No.1*

Barnes, R. F. W. 1983. Elephant behaviour in a semi-arid environment. *Afr. J. Ecology 21:185 - 196*

Burt, W. H. 1943. Territoriality and home range concepts as applied to mammals. *J.Mammal. 24: 346 - 352.*

Burnham, K. P., Anderson, D. H. and Laake, J. L. 1980. Estimation of density from line transect sampling of biological populations. *Wildlife Monograph 72:1 - 202*

Carver, A. J. 1966. Soil analysis Kyle Game Park. *Station report.*

Condy, P.R. 1973. The Population Status, Social Behaviour, and Daily Activity Pattern of the White Rhino (Ceratotherium simum simum) in Kyle National Park, Rhodesia. *M.Sc. Thesis, Univ. of Rhodesia.*

Conway, A. J. and Goodman, P. S. 1989. Population Characteristics and Management of Black Rhinoceros Diceros bicornis minor and White Rhinoceros Ceratotherium simum simum in Ndumu Game Reserve, South Africa. *Biological Conservation 47:109 - 122.*

Conybeare, A. M. 1991. Elephant occupancy and vegetation changes in relation to artificial water points in a Kalahari Sand area of Hwange National Park. *Unpublished D.Phil thesis, University of Zimbabwe.*

Coryndon, R.T. 1894. On the occurrence of white or Burchell's rhinoceros in Mashonaland. *Proc. Zool. Soc., London: 320 - 334.*

Cumming, D. H. M., du Toit, R. F. & Stuart, S. N. 1990. African Elephants and Rhinos: Status Survey and Conservation Action Plan. *IUCN, Gland.*

Dalke, P. D. 1942. The cottontail rabbits of Connecticut. *Bull. Conn. St. geol. nat. Hist. Surv. No. 65: 1 - 87* de Boer. W. F. and Prins. H.H.T. 1990. Large herbivores that strive mightily but eat and drink as friends. *Oecologia 82: 264 - 274.*

Duncan. I. M. & Monks. N. J. 1992. Tick control on eland Taurotragus oryx and buffalo Syncerus caffer with Flumethrin 1% Pour-on through a Duncan applicator. *Jl S .Afr.vet.Ass 63(1): 7 - 10.*

du Toit. R. 1993. Rhino Conservation In Zimbabwe. *Multispecies animal production systems. Project paper (in press). WWF. Harare.*

Ferrar, A. A. 1973. Niche Quantification: An approach to the analyses of habitat relationships in large herbivore communities. *M.Sc Thesis, Division of Biological Sciences, University of Rhodesia, Salisbury.*

Ferrar. A. A. & Kerr, M. A. 1971. A population crash of the reedbuck Redunca arundinum (Boddaert) in Kyle National Park. Rhodesia. *Arnoldia (Rhodesia), 5(16): 1 - 19*

Goddard, J. 1967 . Home range, behaviour, and recruitment rates of two black rhinoceros populations. *East African Wildlife Journal 5: 133-150.*

Goodman, D. 1981. Life history analysis of large mammals. In Dynamics of large mammal populations, ed. C.W. Fowler & T. D. Smith, pp. 415 - 436. New York: Wiley.

Guy, P. R. 1974. Feeding behaviour of the African elephant in the Sengwa Research Area of Rhodesia. *MSc Thesis, University of Rhodesia, Salisbury.*

Hillman-Smith, A. K. K.. Owen-Smith, N., Anderson. J. L.. Hall- Martin. A. J. Selaladi. 1986. Age estimation of the White rhinoceros (Ceratotherium simum). *J. Zool., Lond. A) 210: 355 - 379*

Hulbert. S. H. 1978. The measurements of niche overlap and some relatives. *Ecology, 63, 252 - 253.*

Jewell. P. A. 1966. The concept of home range in mammals. *Symp. Zool. Soc. London. 18:85 - 109*

Kiwia, H. Y. D. 1986. Diurnal activity pattern of the black rhinoceros (Diceros bicornis) (L.) in Ngorongoro Crater, Tanzania. *Afr. J. Ecol. 1986, Volume 24, Pages 89-96.*

Krebs. C. 1989. Ecological methodology. *Donnelley and Sons pages 371- 407.*

Lang, H. 1923. Recent and historical notes on the square-lipped rhinoceros Ceratotherium simum simum. *J. Mammal., 4: 155 - 163*

Lightfoot, C. J. 1978. The feeding ecology of giraffe Giraffe camelopardalis L. in the Rhodesian Middleveld as a basis for the determination of carrying capacity. *M.Sc. Thesis University of Rhodesia.*

Martin, P. and Bateson, P. 1986. Measuring Behaviour. *Cambridge University Press.*

Minshull, J. I. 1981. Seasonal occurrence, habitat distribution and host range of four ixodid tick species at Kyle Recreational Park in south Eastern Zimbabwe. *S. Afr. J. Wildl. Res. 12, 118-123.*

Minshull, J. J. & Norval, R. A. I. 1982. Factors influencing the spatial distribution of Rhipicephalus appendiculatus in Kyle Recreational Park. Zimbabwe. *S. Afr. J.Wildl. Res. 12:118 - 123.*

Mohr, C. O. 1947. Table of equivalent populations of North American small mammals. *Am. Midl. Nat. 37: 223 - 249*

Mooring, M. S. 1993. Grooming behaviour of impala (Aepyceros melampus). *PHD thesis University of California. Davis.*

Napier-Bax, P, and Sheldrick, D. L. W. 1963. Some preliminary observations on the food of the elephant in the Tsavo Royal National Park (East) of Kenya. *E. Afr. Wildl.J. 7:40 - 53.*

O'Connor, S. M. 1986. Activity cycles of the Southern white rhinoceros Ceratotherium simum simum in captivity: implications for management. *Int. Zoo. Yb. 24/25:297-303.*

Owen-Smith. R. N. 1971a. Territoriality in the white rhinoceros. *Nature, 231, 294 - 6.*

_______________ 1972. Territoriality: the example of the white rhinoceros. *Zoologica Africana, 7, 273 - 280.*

_______________ 1973. The behavioural ecology of the white rhinoceros. *PHD thesis, University of Wisconsin.*

_______________ 1974a. The social system of the white rhinoceros. In *The Behaviour of Ungulates and its Relation to Management*, ed. V. Geist and Walther. pp. 341 - 51. *IUCN public., New series no. 24. Morges: IUCN.*

_______________ 1975. The Social Ethology of the White Rhinoceros Ceratotherium simum (Burchell 1817). *Z.Tierpsychol., 38, 337 - 384.*

_______________ 1988. Megaherbivores - the influence of very large body size on ecology. *Cambridge University Press.*

Pienaar. D. J., Hall-Martin. A. J. and Hitchins. P. M. 1991. Horn growth rates of free-ranging white and black rhinoceros. *Koedoe 34/2*

Pienaar. D. J., Bothma, J. Du P., Theron, G. K. 1993. Landscape preference of the white rhinoceros in the central and northern Kruger National Park. *Koedoe 36/1: 79 - 85.*

Pienaar. D.J., Bothma, J. Du P., Theron. G. K. 1993. White rhinoceros range size in the south-western Kruger National Park. *J. Zool., Lond. 229:641 - 649*

Pratt, D. J., Greenway, P. J. and Gwynne. M. D. 1966. East-African range classification. *J. Appl. Ecol. 3:369 - 382*

Riney, T. 1964. The impact of introductions of large herbivores on the tropical environment. *IUCN public, new series no.4:261 - 273*

________1982. Study and management of large mammals. *John Wiley and Sons Ltd. pp.371 - 375*

Roth, H. H. 1967. White and black rhinoceros in Rhodesia. *Oryx, 9(3): 217 - 231.*

Samuel, M. D., Pierce, D. J. and Garton, E. O. 1985. Identifying areas of concentrated use within the home range. *Journal of African Ecology. 54:711 - 719*

Smithers, R. H. N. 1971. Mammals of Botswana, *Museum Memoirs No.4 Trustees Nat. Mus. Rhodesia. Salisbury*

Thenius. E.and Hofer. H. 1960. Stammegesichte Saugetiere. *Sprenger Verlog., Berlin 322 pp. Rhinoceratoidea pp. 198 - 202.*

Tomlinson, D. N. S. 1977. White Rhinos Return To Rhodesia. *Oryx. Vol 14: 145 - 150.*

van Gyseghem. R. 1984. Observations on the ecology and behaviour of the Northern White Rhinoceros (Ceratotherium simum cottoni). *Z. Saugetierkunde 49 (1984) 348-358.*

Walker, B. H. 1976. An approach to the monitoring of changes in the composition and utilization of woodland and savanna vegetation. *S. Afr. J.Wild. Res. 6(1):1 - 32.*

Walther. F. R. 1972a. Territorial behaviour in certain horned ungulates with special reference to the examples of Thomson's and Grant's gazelles. *Zoologica Africana, 7:303 - 308*

West. O. 1958. Bush Encroachment, Veld Burning and Grazing Management. *Extract from Bulletin No. 1965 R.A.J. Vol 55 No. 4 407 -425.*

West, O. 1966. Preliminary report on the grazing in the Lake Kyle Game Park. *Departmental Report.*

Wilson, J. E. 1964. The Geology of the Country around Fort Victoria. *Geological Survey Bulletin 58. Govt. Printer, Salisbury.*

Wilson, V. J. 1970. Data from the culling of kudu Tragelaphus strepsiceros (Pallas) in the Kyle Recreational Park. Rhodesia. *Arnoldia (Rhodesia) (36). 1 - 26*

TABLE 1.

Naturally occurring and introduced Herbivore Species in Kyle Recreational Park and their population estimates as at the end of July 1995. Nomenclature follows Smithers (1971)

Common Name	Systematic Name	Population Estimate	
		1972	1995
Naturally occurring in the area:			
Bushpig	Potamochoerus porcus Linn.	100	60
Duiker	Sylvicapra grimma Linn.	250	200
Steenbok	Raphicerus campestris Thunberg	100	50
Klipspringer	Oreotragus oreotragus Zimmerman	25	30
Reedbuck	Redunca arundinum Boddaert	150	40
Bushbuck	Tragelaphus scriptus Pallas	80	60
Kudu	Tragelephus strepsiceros Pallas	200	60
Hippo	Hippopotamus amphibius Linn.	*	90
Introduced after area established as a Park:			
White rhino	Ceratotherium simum Burchell	33	13
Zebra	Equus burchelli Gray	80	100
Warthog	Phacochoerus aethiopicus Pallas	20	200
Giraffe	Giraffa camelopardalis Linn.	12	35
Oribi	Ourebia ourebi Zimmerman	10	0
Waterbuck	Kobus ellipsiprymnus Ogilby	5	1
Impala	Aepyceros melampus Lichtenstein	400	350
Sable	Hippotragus niger Harris	35	0
Tsessebe	Damaliscus lunatus Burchell	20	9
Wildebeest	Connochaetes taurinus Burchell	80	175
Nyala	Tragelaphus angasi Gray	15	0
Eland	Taurotragus oryx Pallas	30	30
Buffalo	Syncerus caffer Sparrman	80	44

* Hippo occur naturally in the rivers draining into the lake, but no estimates of numbers are available pre - 1961.

TABLE 2.

Comparison of woody cover in the study area measured from aerial photographs 1968 and 1985. (Number of bushes/saplings in each measured square).

Location (Beacon or reference point from 1:50 000 map).	1968	1985
Beacon 1	3	11
Beacon 2	5	12
Beacon 3	14	22
Beacon 4	9	18
Beacon 20	6	21
Beacon 22	14	21
935676	8	22
936693	2	14
952693	9	14
910682	10	22
925711	12	22
931646	12	15

TABLE 3.

Metabolic biomass of large herbivores in Kyle Recreational Park 1973 and 1994. Metabolic biomass of each species ($Kg^{0.75}$) in brackets [ ].

Species		1995 $Kg^{0.75}$		1973 $Kg^{0.75}$	
		Grazers	Browsers	Grazers	Browsers
Grazers					
Buffalo	[97,7]	4298.8		7816,0	
Hippo	[177,8]	5867,4		5867,4	
Reedbuck	[15.9]	636.0		2385.0	
Tsessebe	[29.2]	262.8		584.0	
Waterbuck	[45.0]	45.0		225,0	
Warthog	[17.4]	3480.0		348.0	
Wildebeest	[36,9]	6457,5		2952.0	
W. Rhino	[241.0]	3133,0		8194.0	
Zebra	[53,2]	5320,0		4256.0	
Mixed Feeders					
Eland	[79,2]	1188,0	1188,0	1188.0	1188.0
Impala	[15,9]	4452,0	1113,0	5088,0	1272.0
Browsers					
Bushbuck	[12.8]		768,0		1024.0
Giraffe	[143,3]		5732,0		1719,6
Kudu	[39,8]		2388,0		7960.0
Grazers ($Kg^{0.75}$)		35140.5		38903.4	
Browsers ($Kg^{0.75}$)			11189.0		13163,6
TOTAL $Kg^{0.75}$		46329,5		52067.0	

TABLE 4.

White rhino translocations from Kyle Recreational Park 1974 - 1995. (Adapted from du Toit, 1993)

Year	Destination	M	F	Total
1972	R. McLlwaine Recreational Park	1	1	2
1975	Matetsi. Kazuma Pan	1	4	5
1978	Mushandike Sanctuary	4	0	4
1978	Hwange National Park	2	0	2
1980	Hwange National Park	3	2	5
1984	Lone Star Ranch	0	1	1
1984	Matetsi	1	5	6
1987	Cecil Kop Nature Reserve	1	0	1
	TOTAL	12	12	24

TABLE 5.

White rhino mortalities Kyle Recreational Park, 1974 - 1995.
(Information compiled from records available. Year omitted if no recorded deaths).

Year	Sex and age class *						Sex and age unkown	Total	Cause of death
	Adult			Juvenile					
	M	F	?	M	F	?			
1974		1							Stuck in mud
				1	2	1			Unknown
								5	
1976		1							Unknown
								1	
1982	1								Killed in fight
	1								Senility
	1								Wire in gut
						1			Unknown
								4	
1985	1								Killed in fight
								1	
1987		1							Stuck in mud
						2			Unknown
								3	
1988	1								Poached
								1	
1990			2						Stuck in mud
						2			Uknown
								4	
1991				1					Stuck in mud
							1		Unknown
								2	
1992	1								Killed in fight
		2							Stuck in mud
		1							Poverty
						1			Stuck in mud
							6		Unknown
								11	
1994/95		1							Unknown
								1	
TOTALS	6	7	2	2	2	7	7	33	

? = Age class only, no sex recorded

* = Adult and sub-adult class combined

TABLE 6.

Population density, range and territory sizes of white rhino in five areas:
(Kyle 1973 = Condy, Kyle 1995 = Monks, Kruger = Pienaar et.al., Ndumu = Conway and Goodman, Uganda = van Gyseghem). (Figures rounded off to whole numbers if >1).

Area	Density km^2	aM	bM	FF	Fc	sM/sM
Kyle 1973	0,7	5 - 11	-	3 - 20	-	-
Kyle 1995	0.2	7 - 8	4	4 - 7	3 - 5	7
Kruger	0,5 - 1	6 - 14	-	7 - 45	-	-
Ndumu	0,6 - 2	3 - 14	-	5 - 23	-	-
Umfolozi	3 - 6	0,8 - 3	-	9 - 21	-	-
Uganda	0,1	-	-	-	-	-

aM=alpha male, bM=beta male, FF=female companions, Fc=female with calf. sM/sM=sub-adult male companions.

TABLE 7.

The total percentage area occupied by the three major habitat types in the study area in 1973 and 1995.

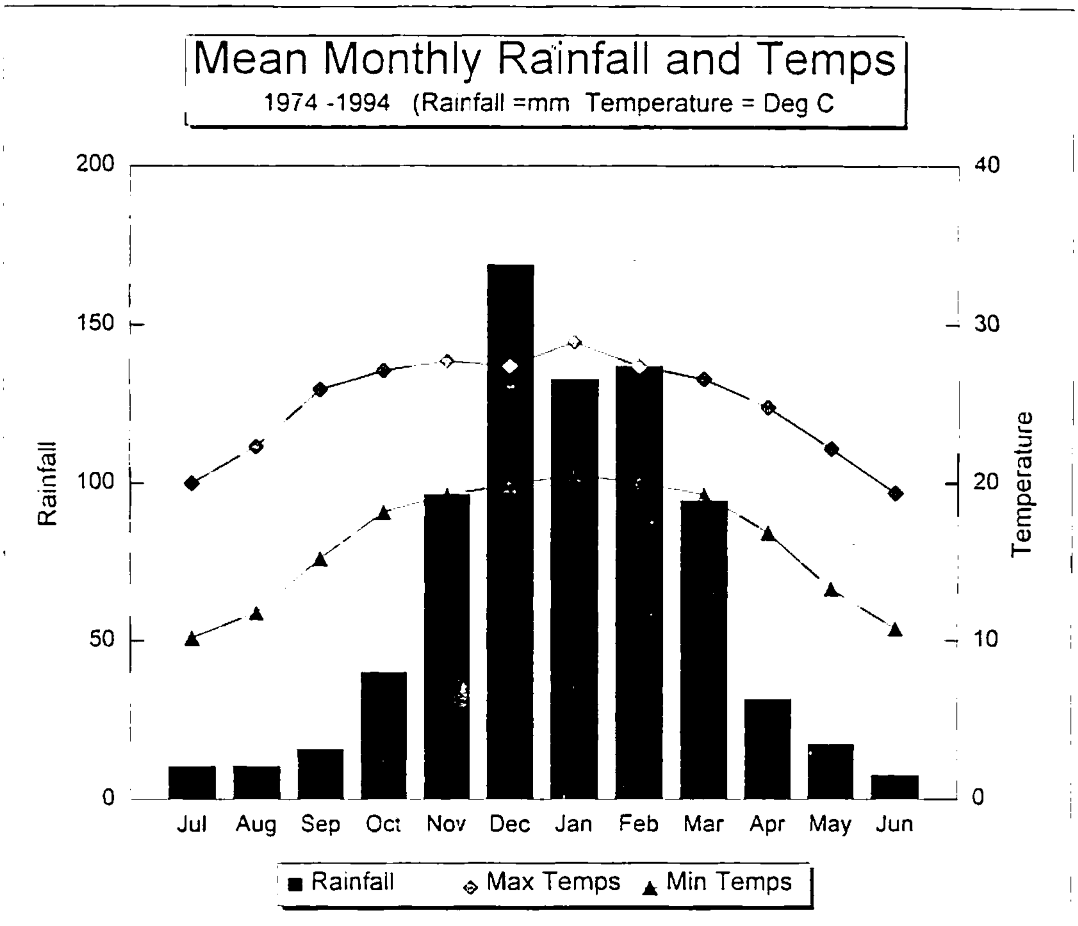
Major habitat type	1973	1995
Savanna	21%	22.5%
Grassland	45%	18,9%
Woodland	34%	58,6%

TABLE 8.

Visitor statistics, Kyle Recreational Park 1984-1994.
Compiled from figures supplied by Warden Tourism.
(Day = day visitors)

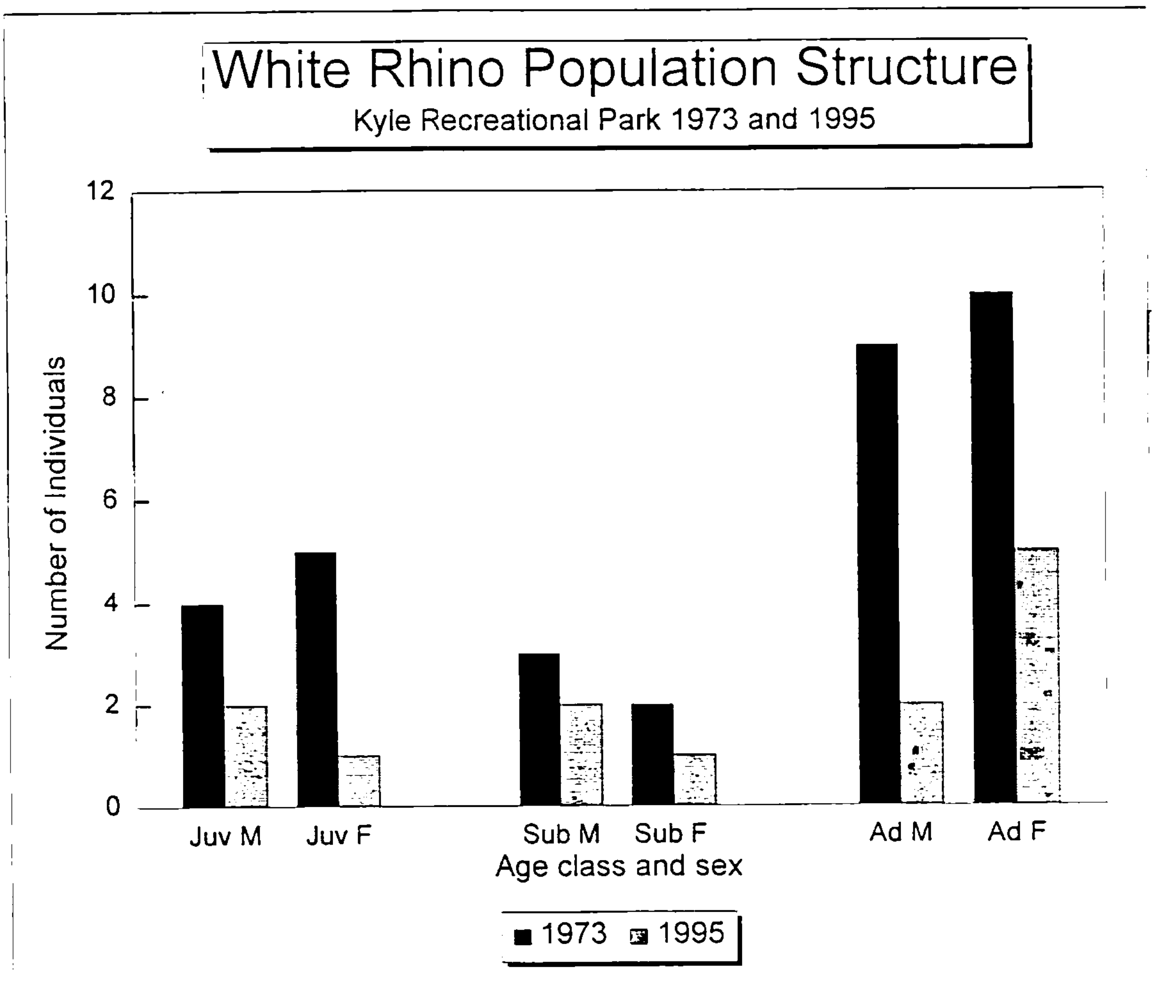
Year	Day	Overnight	Campers	TOTAL	% Foreign
1984	8188	3266	2161	13635	*
1985	7161	3905	1370	12436	*
1986	12605	4324	2156	19085	*
1987	7775	4438	3414	15627	*
1988	7571	3957	1433	12961	*
1989	8597	4968	2498	16063	*
1990	8336	5016	2624	15976	71%
1991	6646	4851	2823	14320	74%
1992	5118	4215	1843	11176	71%
1993	6335	4838	2407	13580	67%
1994	6252	4426	2803	13481	*

* Figures not available



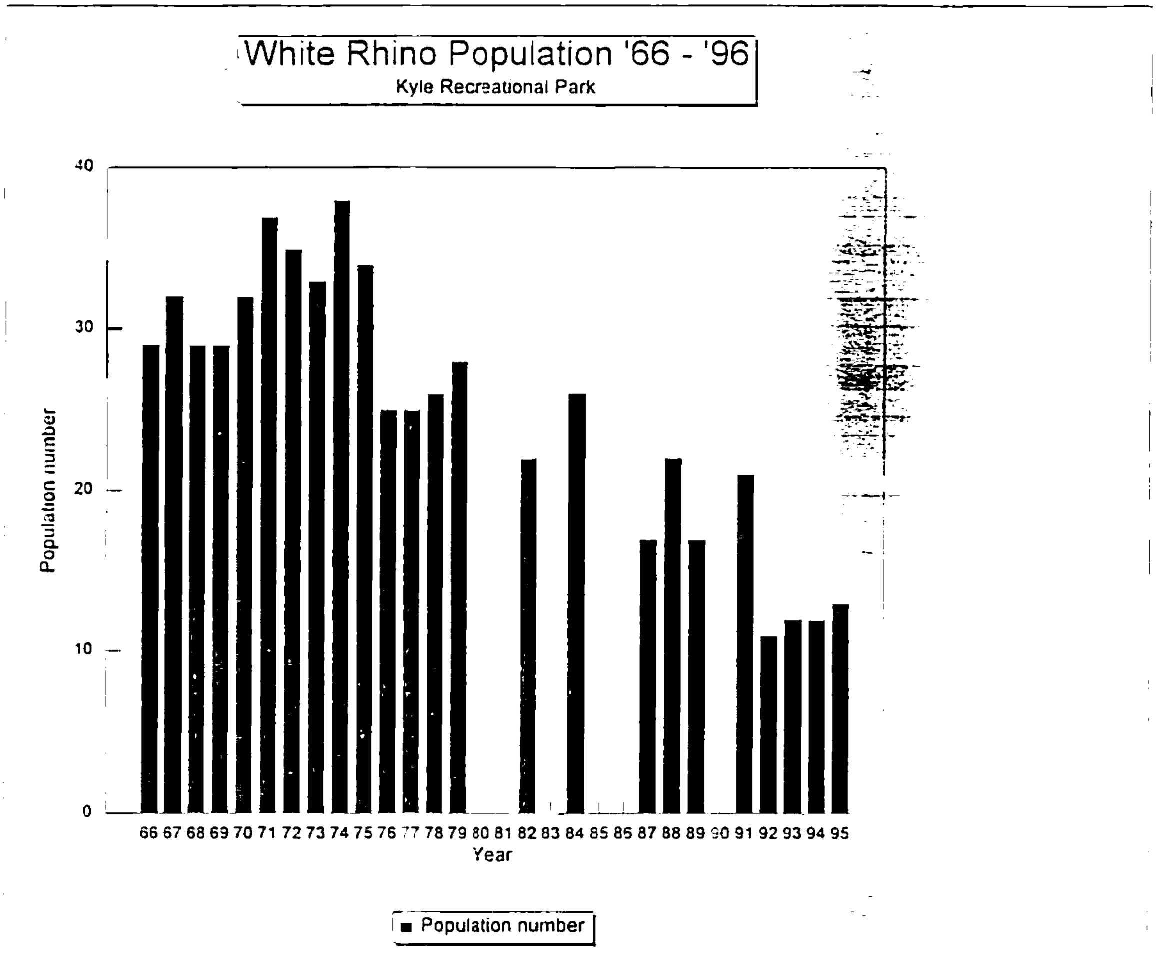
Mean Monthly Rainfall and Temps
1974 -1994 (Rainfall =mm Temperature = Deg C
Rainfall
Temperature
200
150
100
50
0
40
30
20
10
0
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Rainfall
Max Temps
Min Temps

Fig 1.



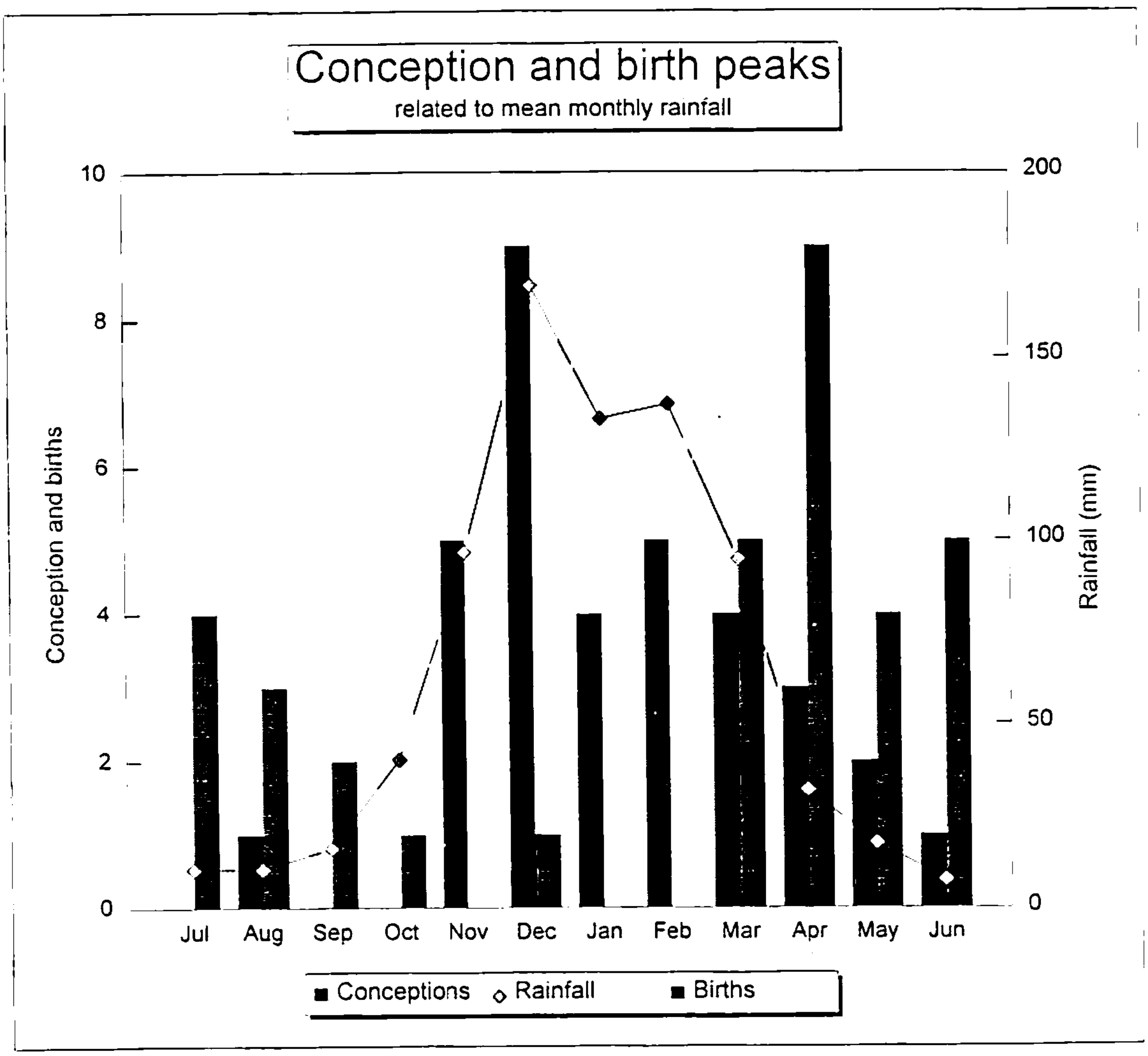
White Rhino Population Structure
Kyle Recreational Park 1973 and 1995
Number of Individuals
0
2
4
6
8
10
12
Juv M
Juv F
Sub M
Sub F
Ad M
Ad F
Age class and sex
1973
1995

Fig 2



White Rhino Population '66 - '96
Kyle Recreational Park
40
30
20
10
0
Population number
66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81 82 83 84 85 86 87 88 89 90 91 92 93 94 95
Year
Population number

Fig 3



Conception and birth peaks
related to mean monthly rainfall
Conception and births
Rainfall (mm)
10
8
6
4
2
0
200
150
100
50
0
Jul
Aug
Sep
Oct
Nov
Dec
Jan
Feb
Mar
Apr
May
Jun
Conceptions
Rainfall
Births

Fig 4

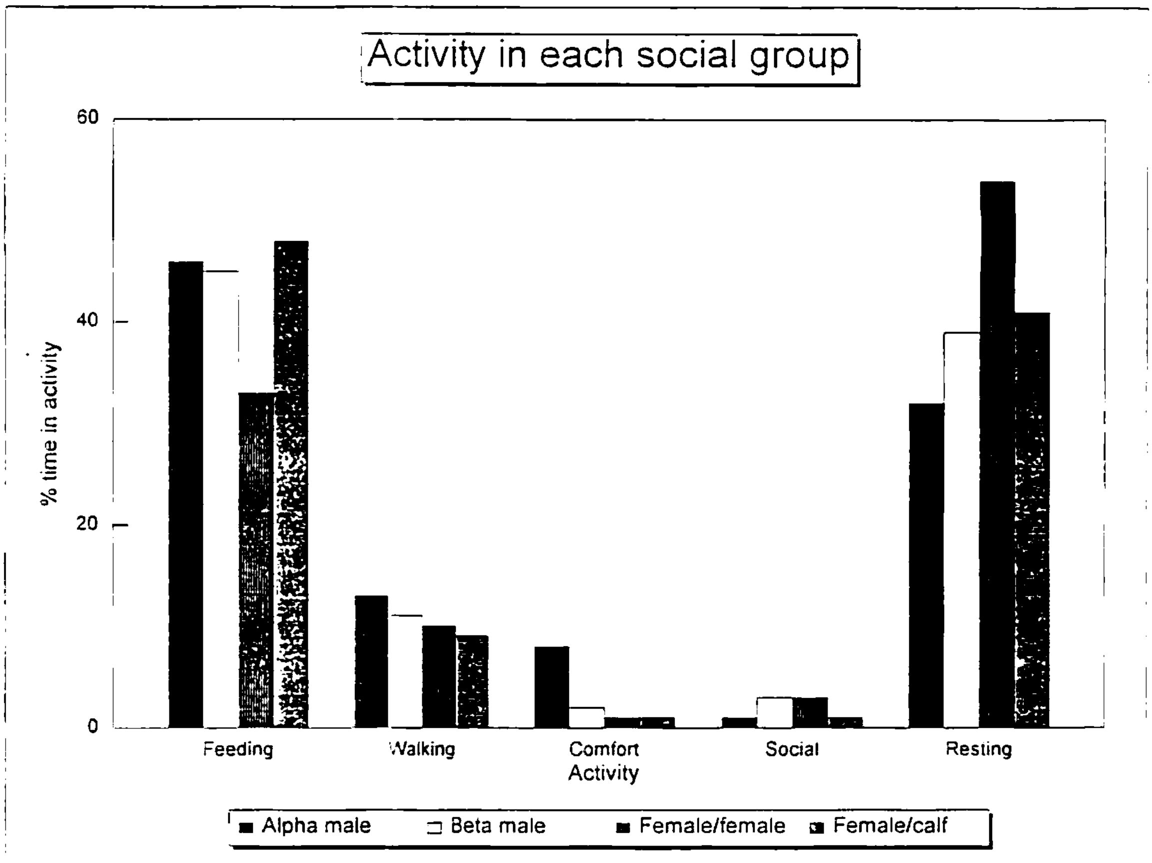
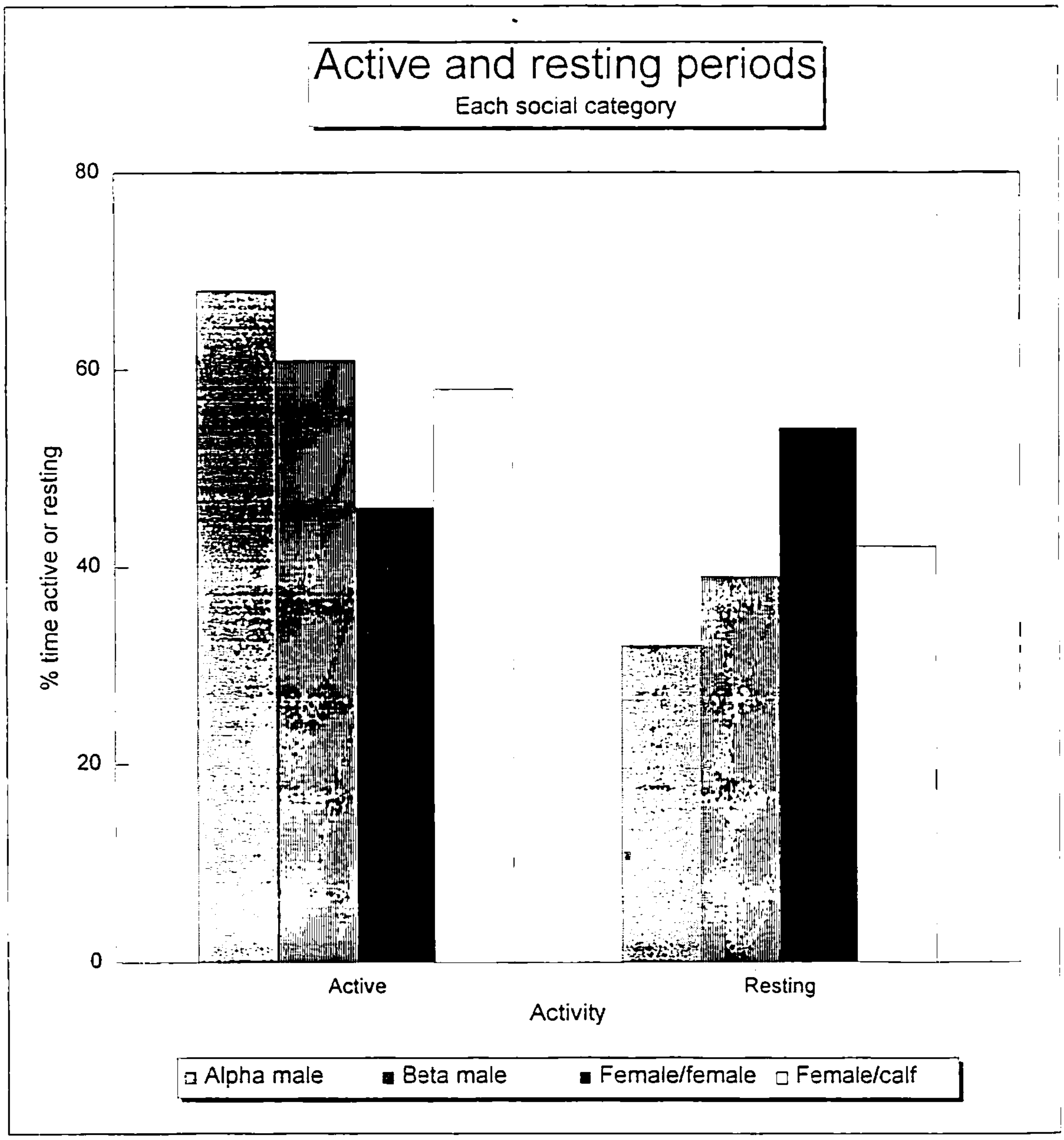

Activity in each social group
60
40
20
0
% time in activity
Feeding
Walking
Comfort Activity
Social
Resting
Alpha male
Beta male
Female/female
Female/calf

Fig 5a



Active and resting periods
Each social category
80
60
40
20
0
% time active or resting
Active
Resting
Activity
Alpha male
Beta male
Female/female
Female/calf

Fig 5b

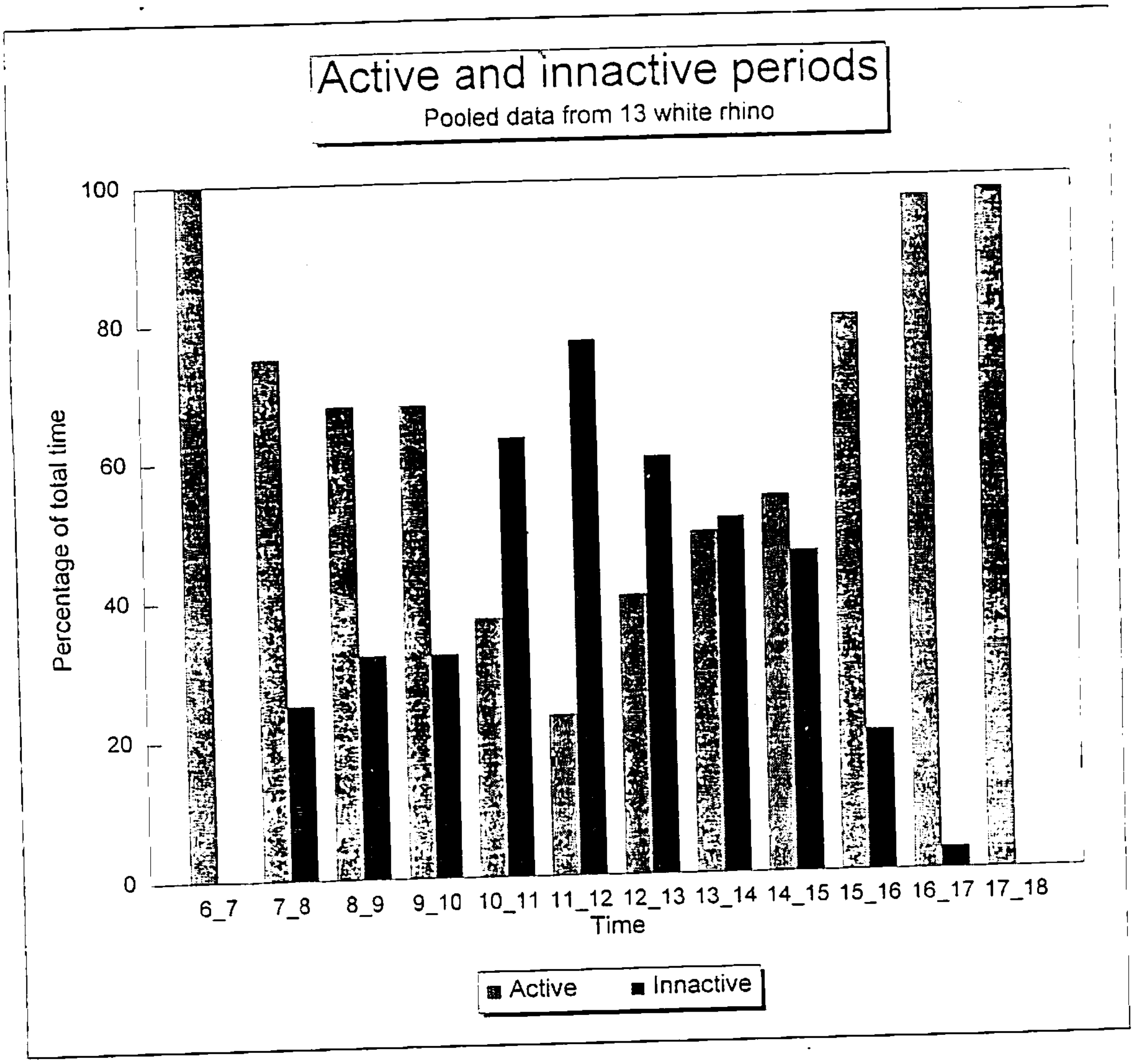

Active and innactive periods
Pooled data from 13 white rhino
Percentage of total time
100
80
60
40
20
0
6_7
7_8
8_9
9_10
10_11
11_12
12_13
13_14
14_15
15_16
16_17
17_18
Time
Active
Innactive

Fig 5c

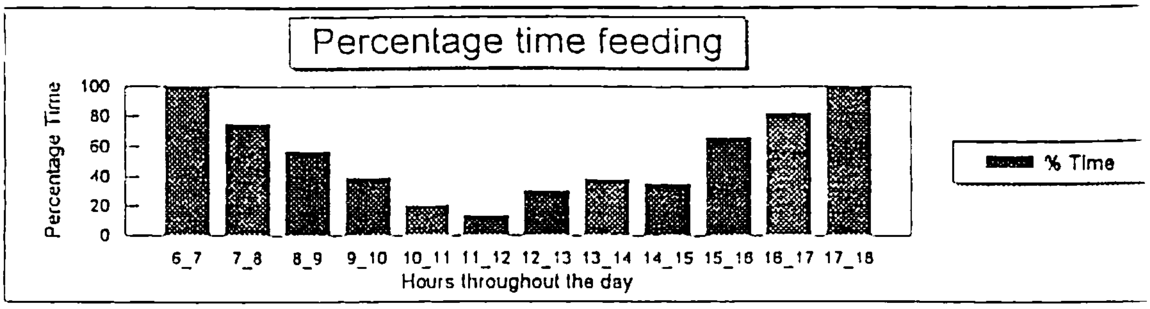


Fig.5d

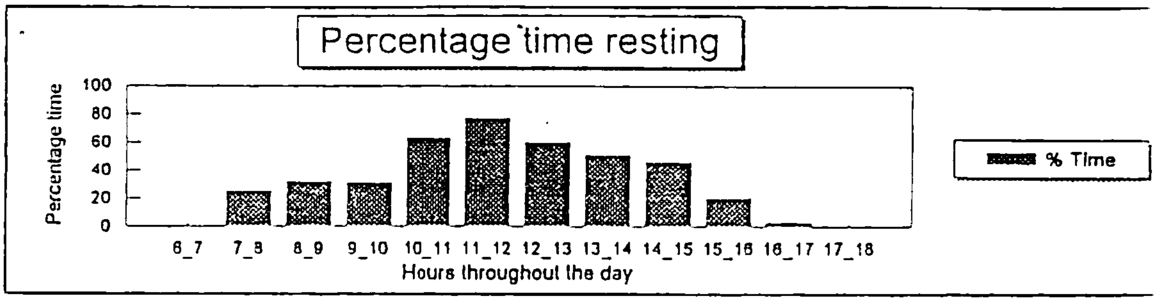


Fig.5e

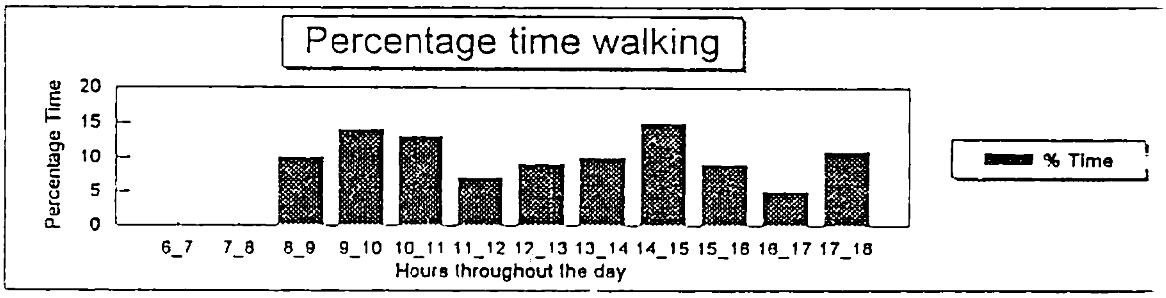


Fig.5f

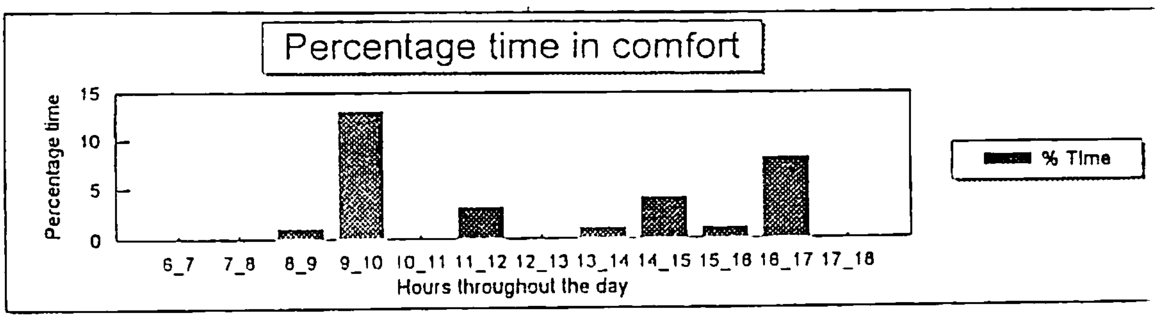


Fig.5g

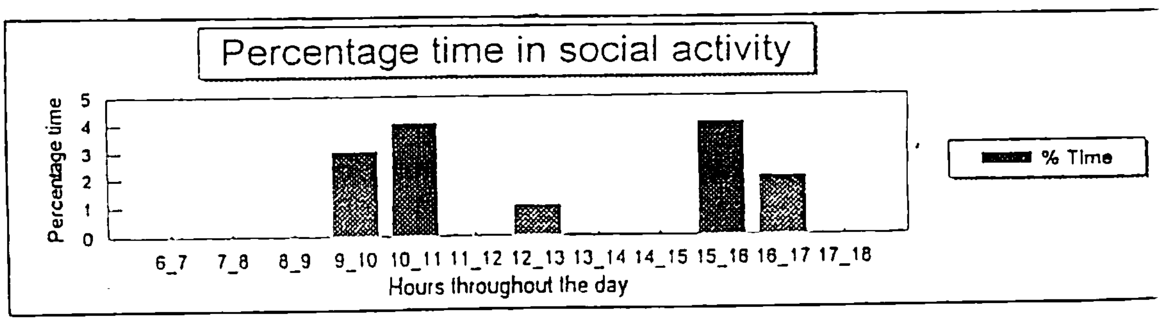
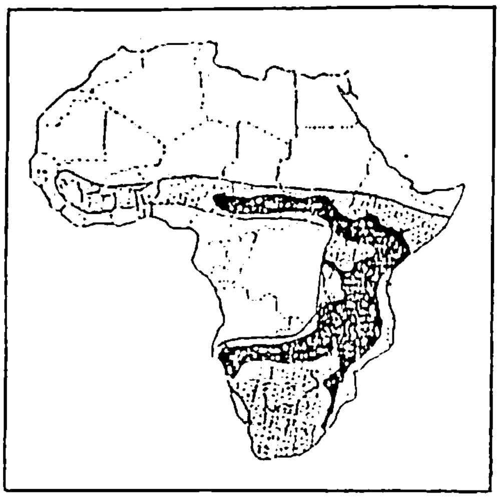
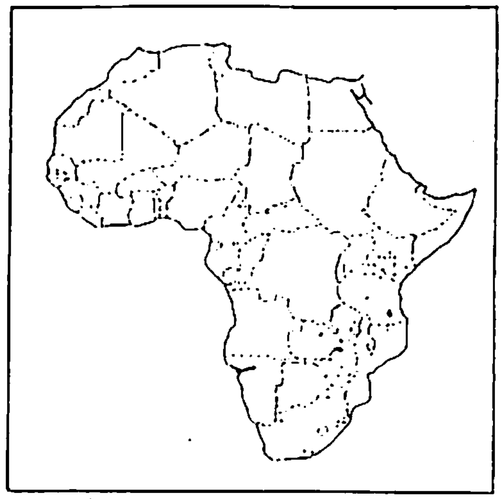


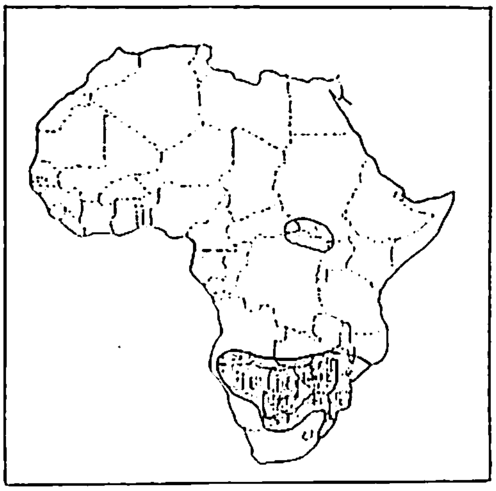
Fig.5h



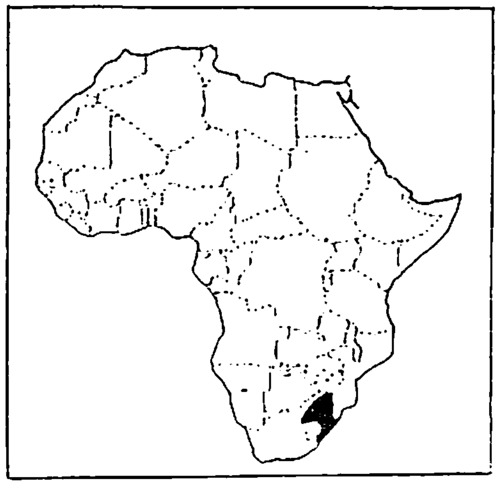
Former distribution of the black rhinoceros. Light shading indicates probable distribution around 1700; dark shading indicates distribution in 1900 (adapted from Cumming 1987).



Distribution of the black rhinoceros in 1987 (adapted from Cumming 1987).



Probable distribution of the white rhinoceros around 1700.



Distribution of the white rhinoceros in 1987.

Fig 6.

Present and former distribution of white and black rhino. (Cumming et.al. 1990).

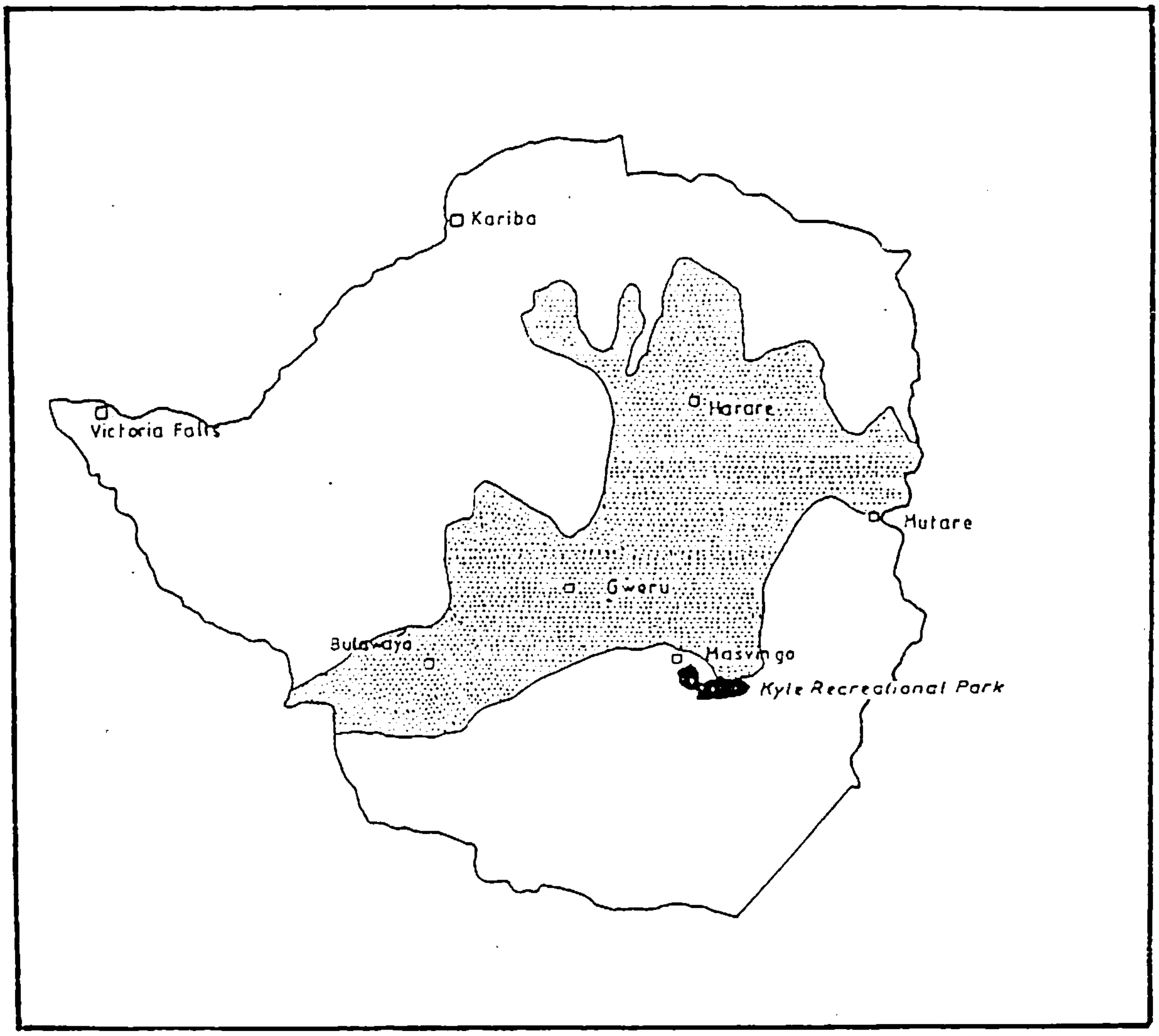


Fig 7.

Zimbabwe showing highveld and location of
Kyle Recreational Park.

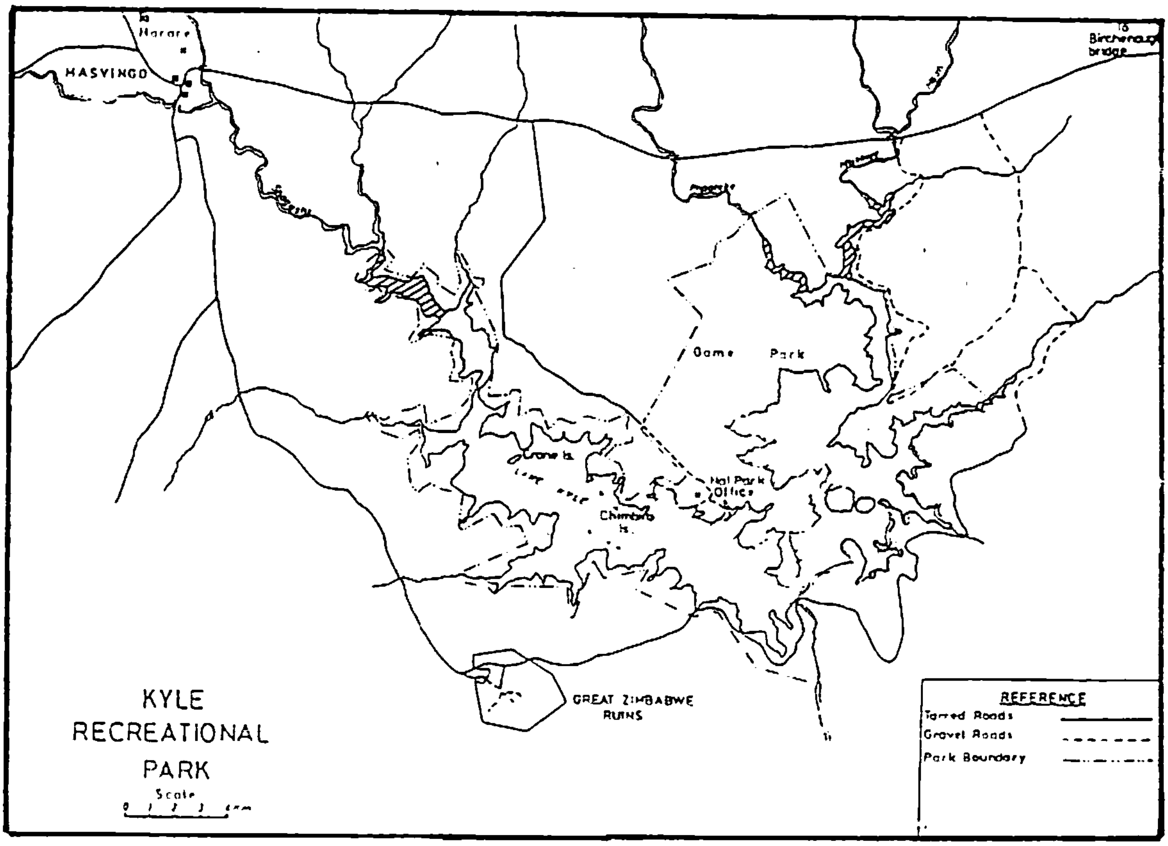


Fig 8.

Kyle Recreational Park showing Lake Muturikwe, Masvingo Town and the Great Zimbabwe Monument.

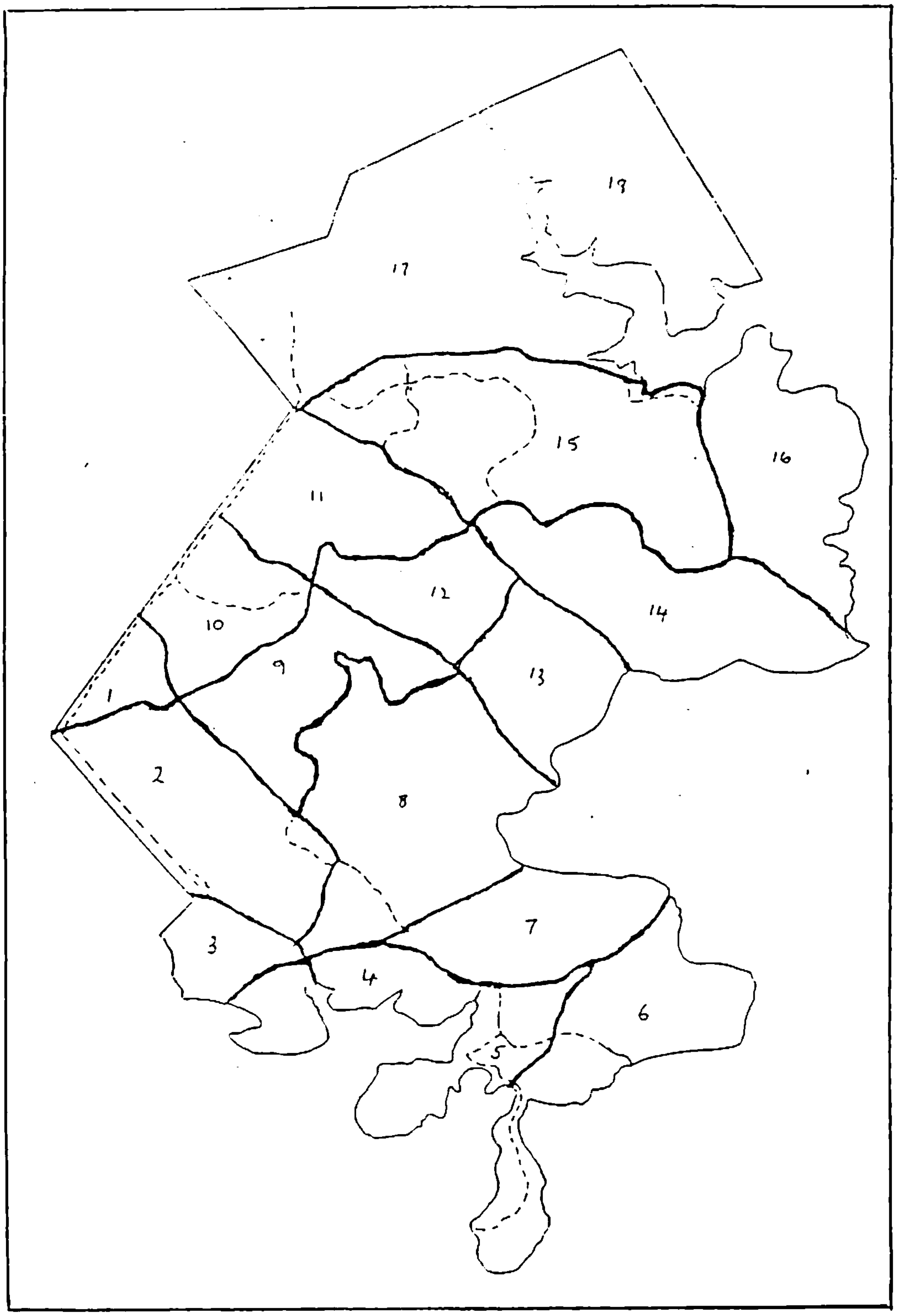


Fig 9.

The study area, showing blocks used during rhino searches.

HABITAT TYPES IN THE STUDY AREA.

(a) *Acacia* wooded grassland savanna.

(b) *Terminalia* wooded grassland savanna

(c) Grassland with termitaria communities

(d) Miombo woodland

(e) Grassed mixed woodland

(f) Grassed *Peltophorum africanum* woodland

(g) *Loudetia* grassed *Combretum* woodland

(h) *Lodetia* grassed mixed woodland

(i) Bushed drainage line grassland

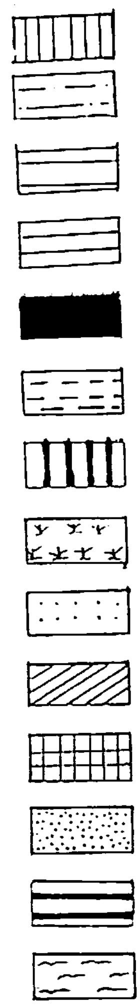
(j) Grassed dense mixed successional woodland

(k) Un-grassed successional *Acacia*/*Peltophorum* woodland

(l) Lake-shore grassland

(m) Grassed *Albizia amara* woodland

(n) Granite hill woodland



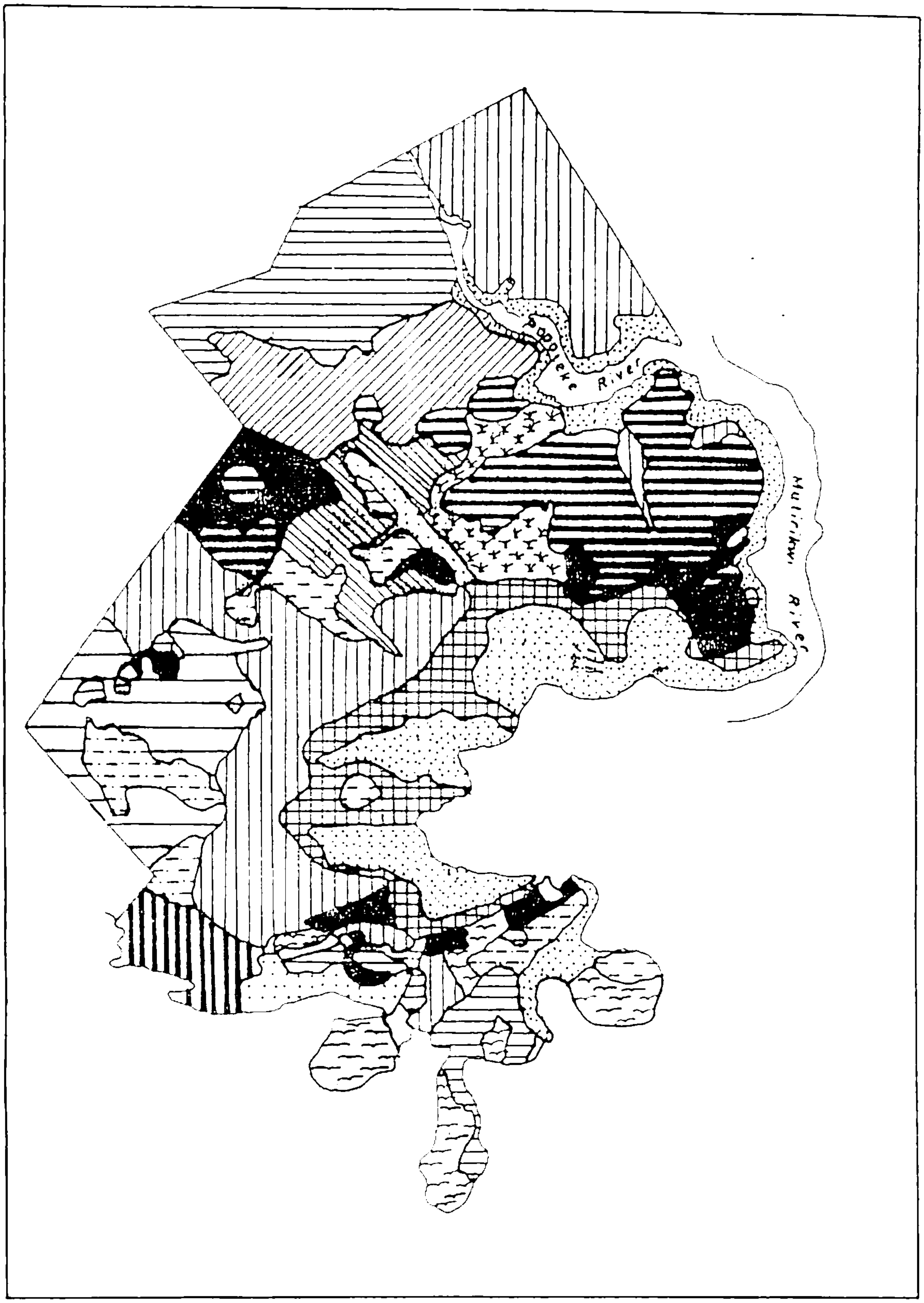


Fig 10
Habitat types in the study area

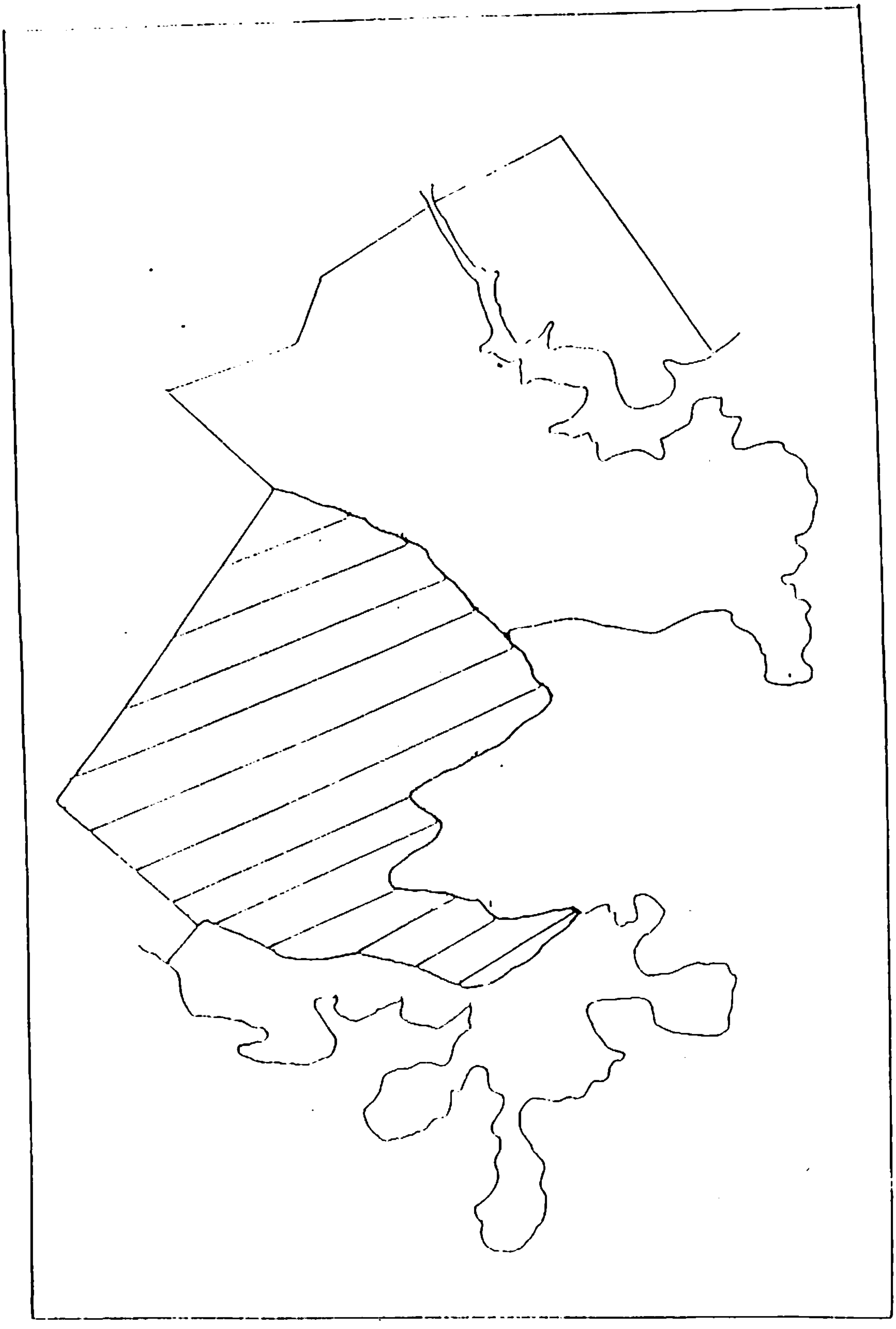


Fig 11
The study area showing the area of prime white rhino habitat

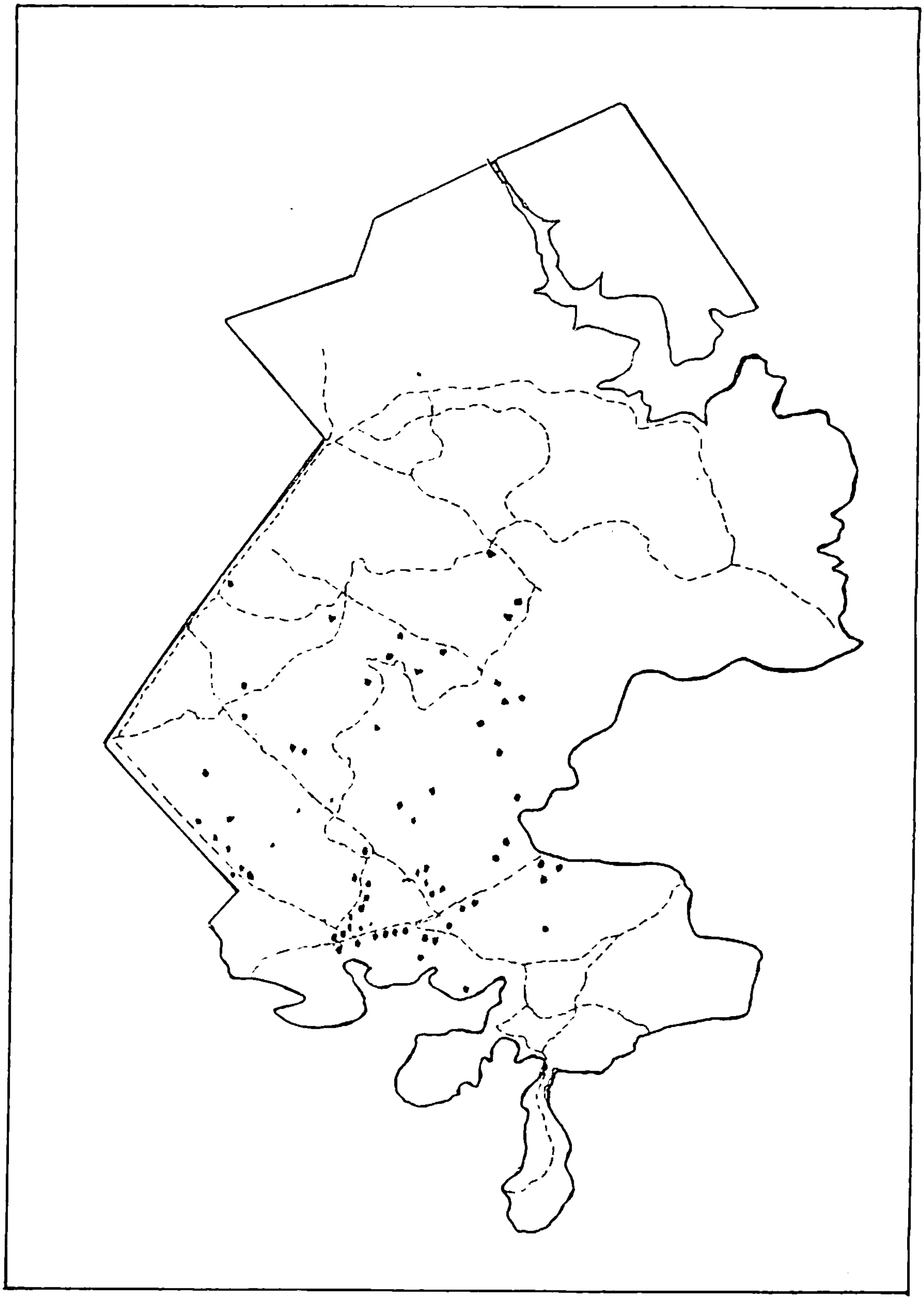


Fig 12.

Location of rhino dropping showing areas of high occupancy.

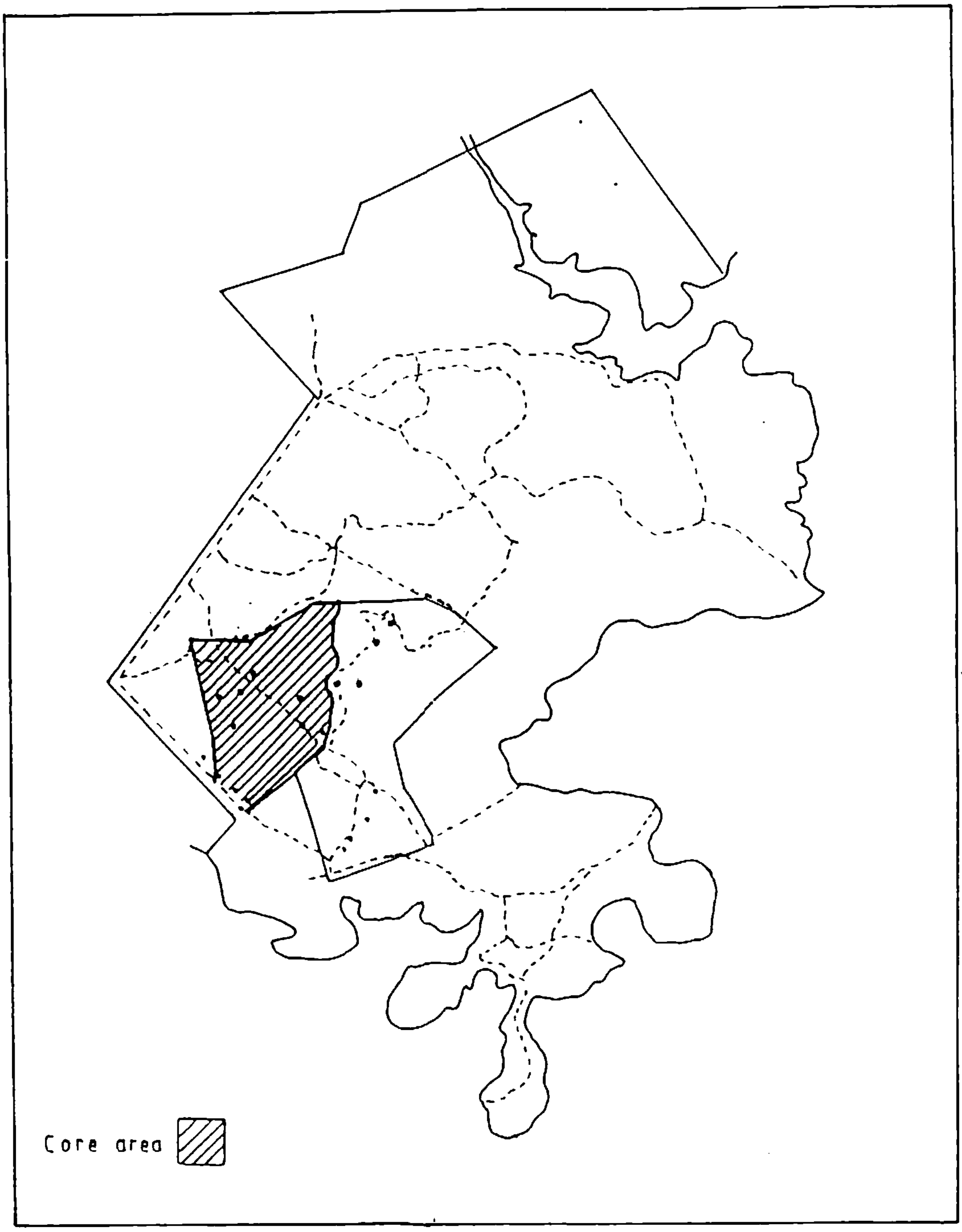


Fig 13

Territory and midden sites of the white rhino territorial bull

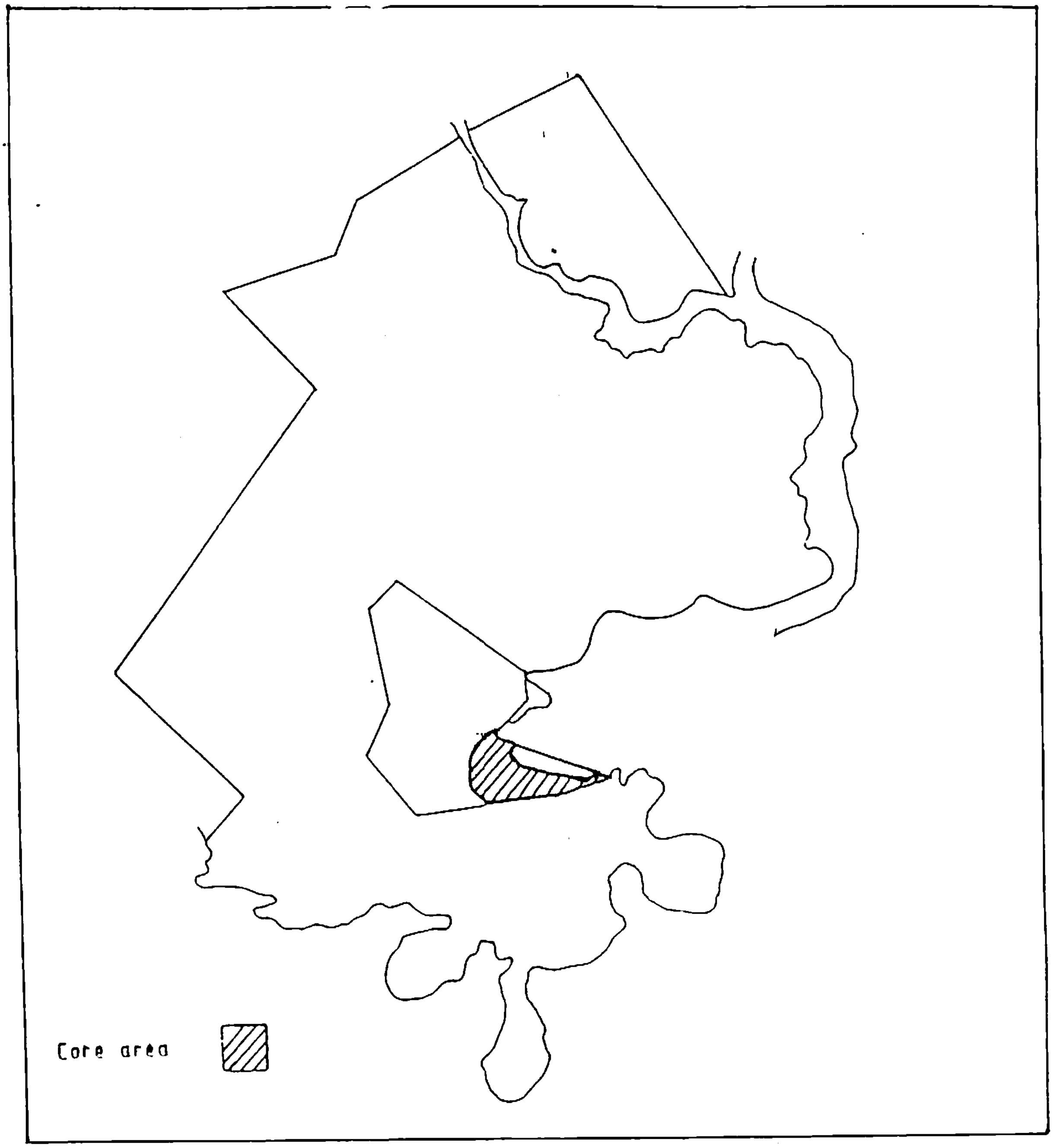


Fig 14

Range of beta bull No. 4

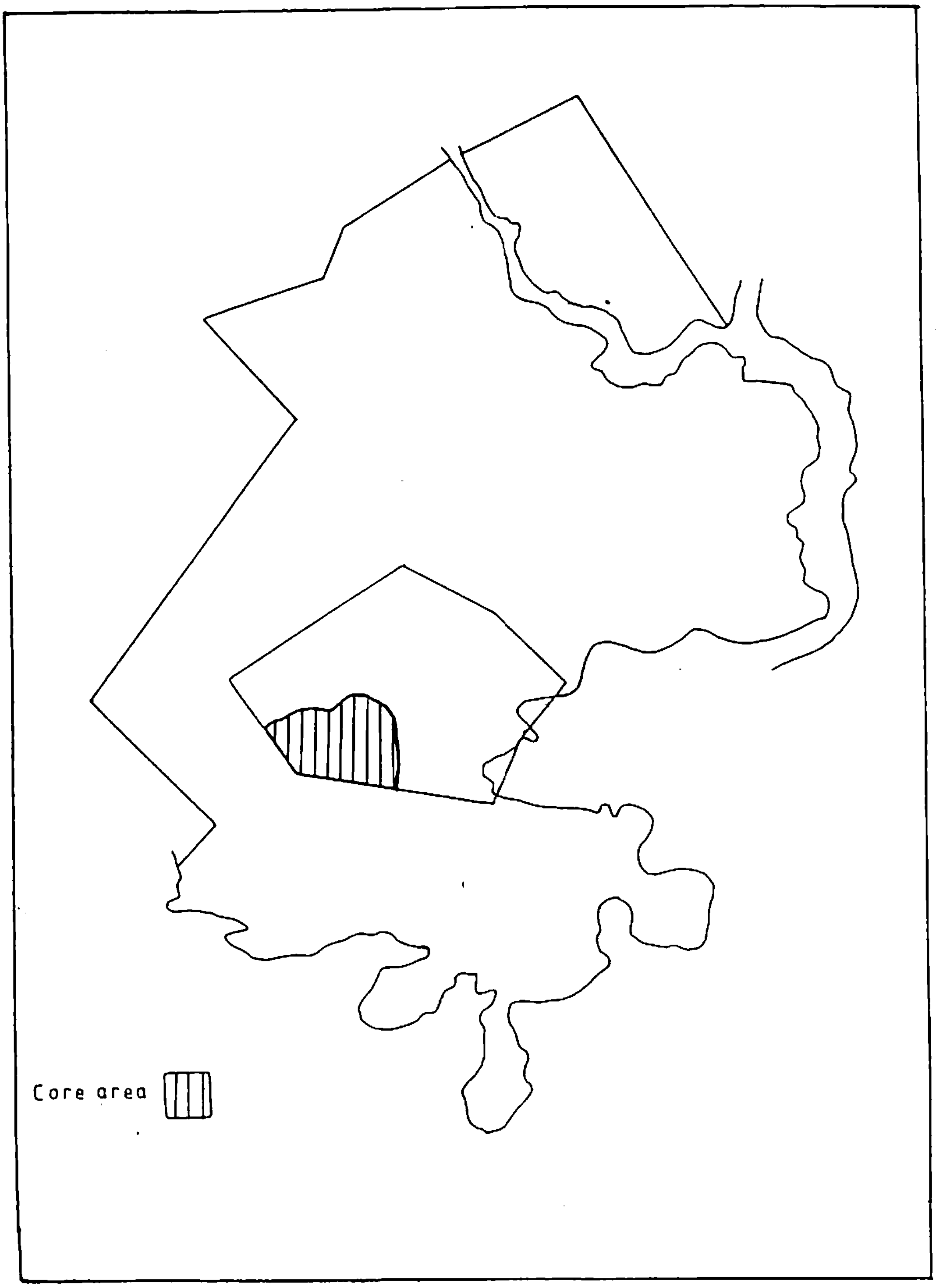


Fig 15a
Range of female/female group No.2 and 5

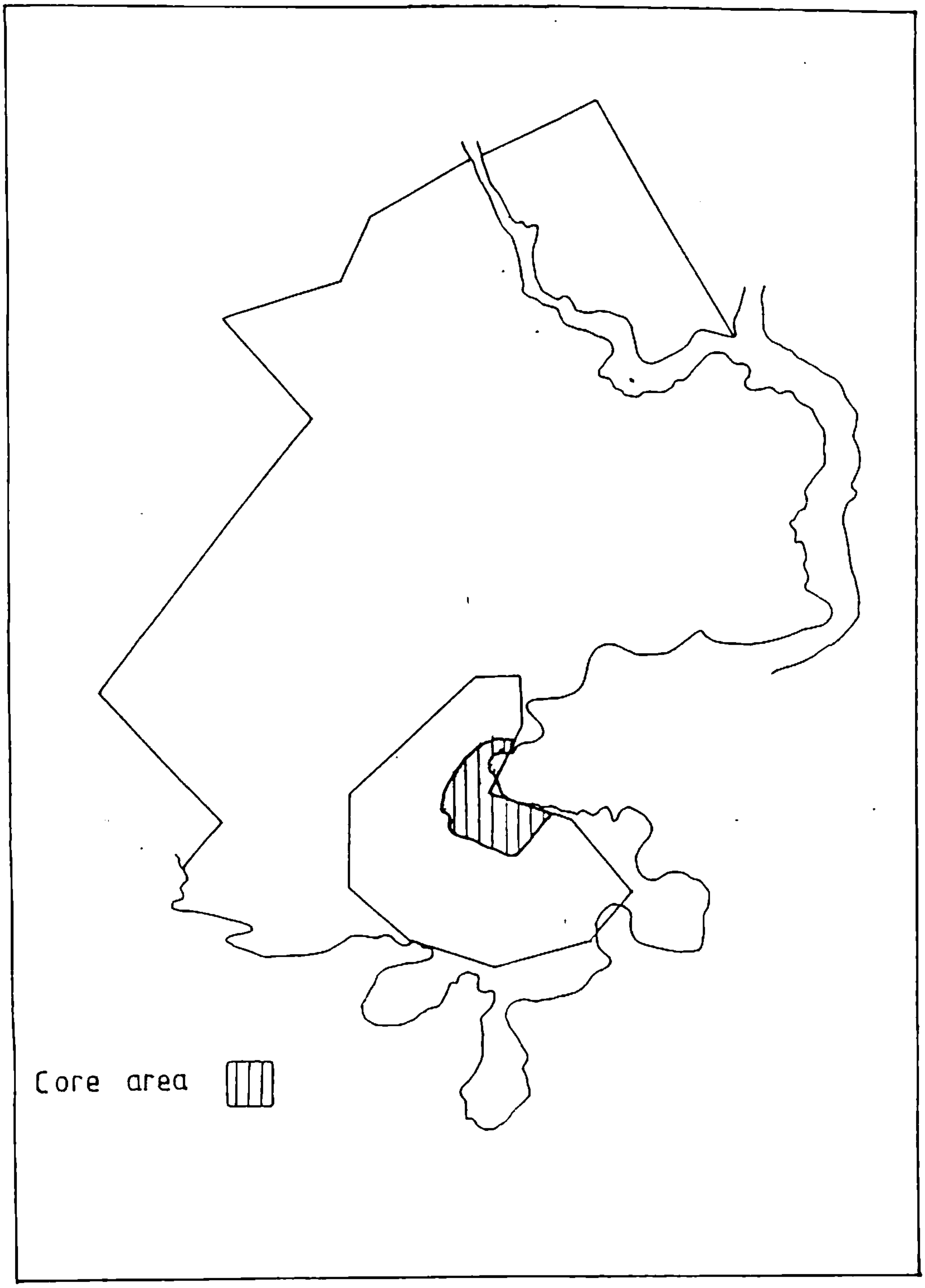


Fig 15b
Range of female/femaie group No.6 and 9

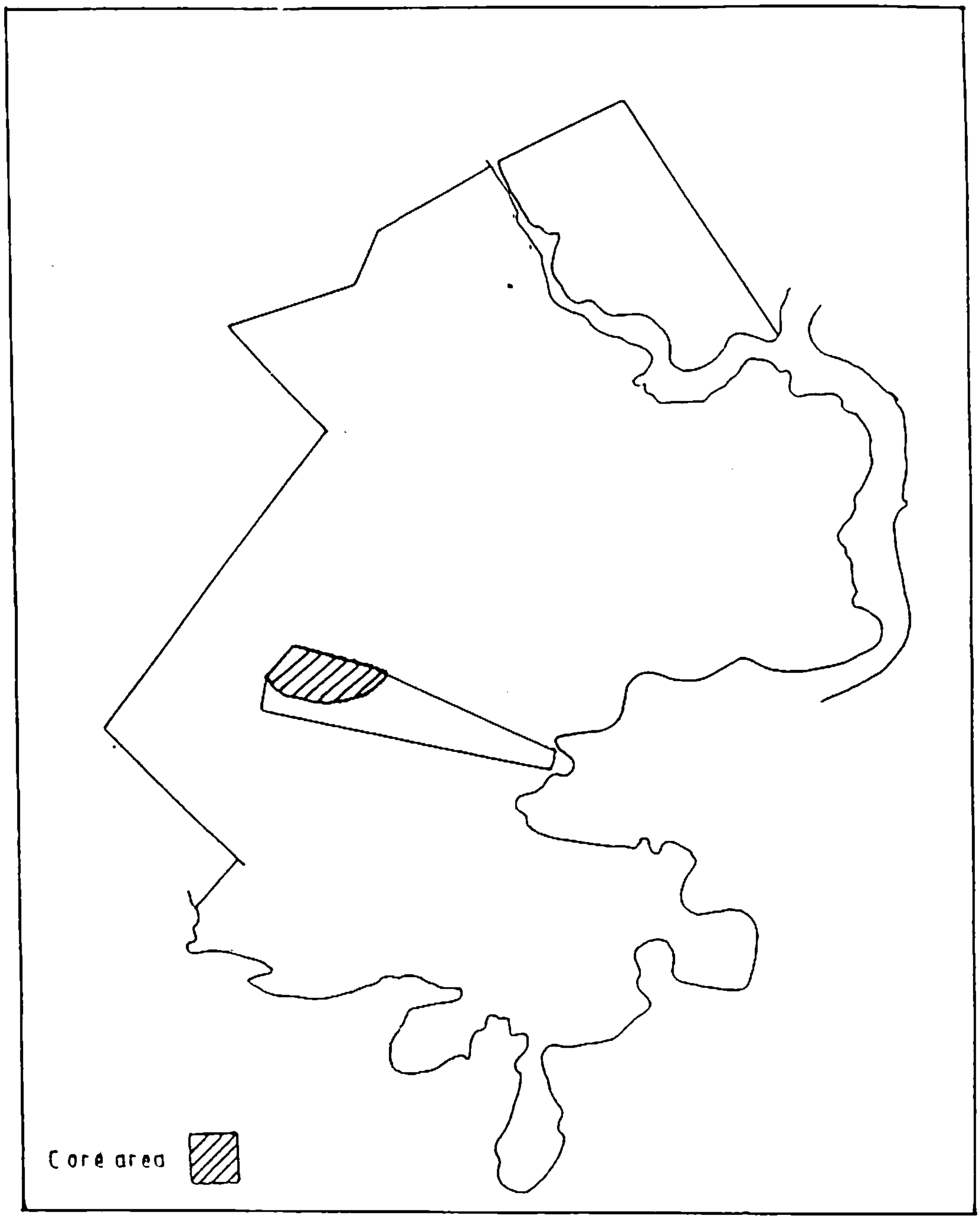


Fig 16a

Range of female/calf group No.1 and female calf

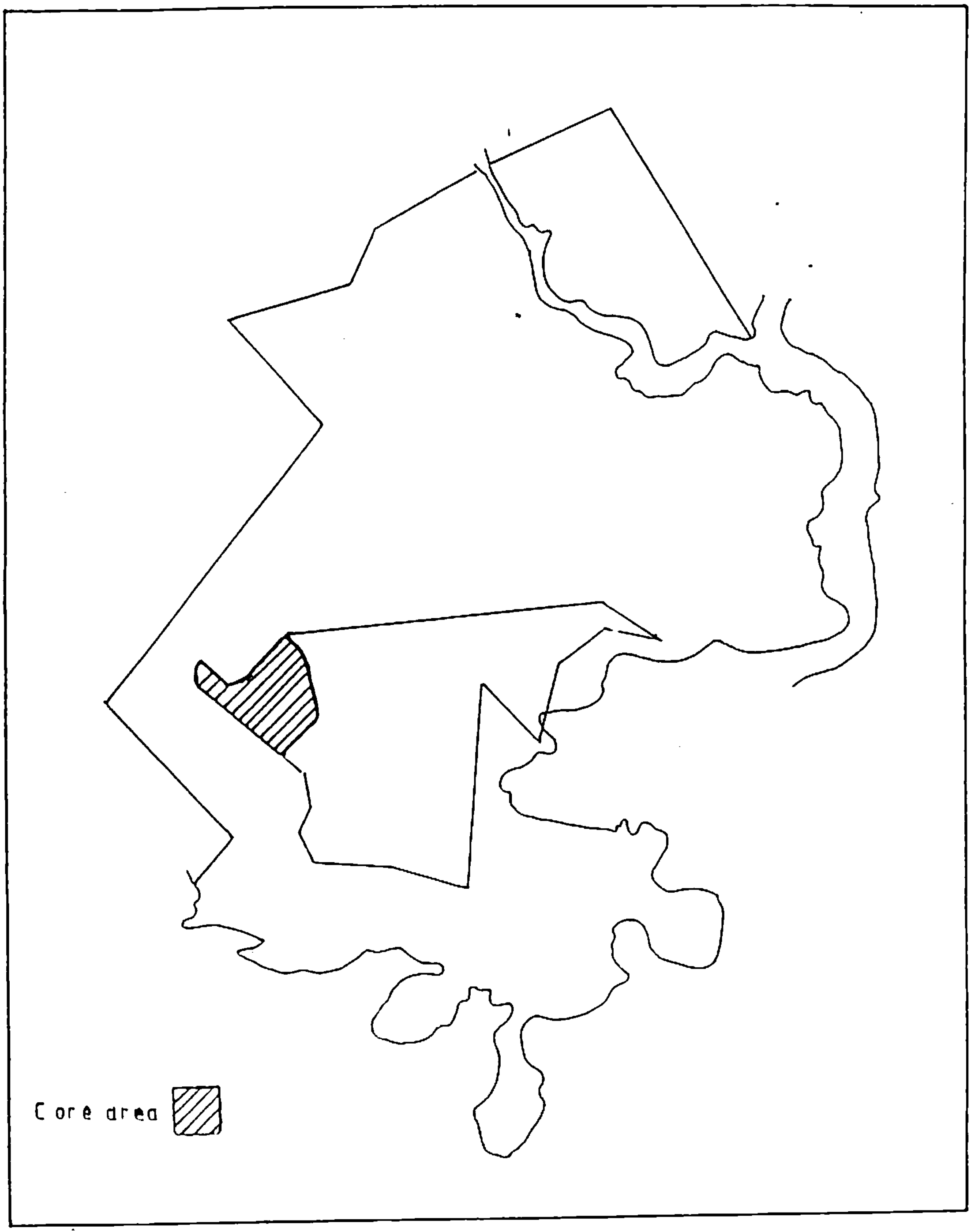


Fig 16b

Range of female/calf group No.3 and male calf

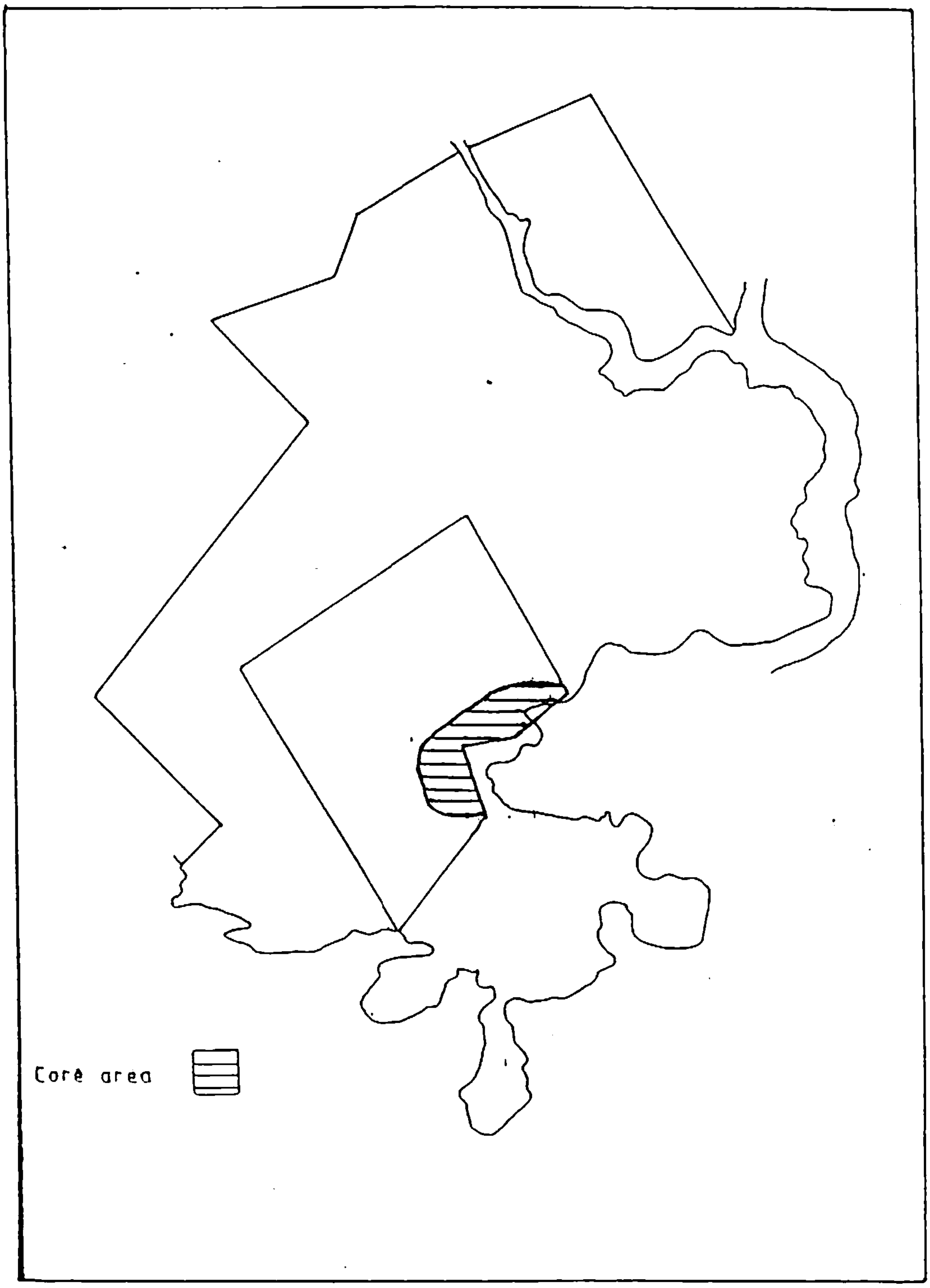


Fig 17

Range of sub-adult male companions

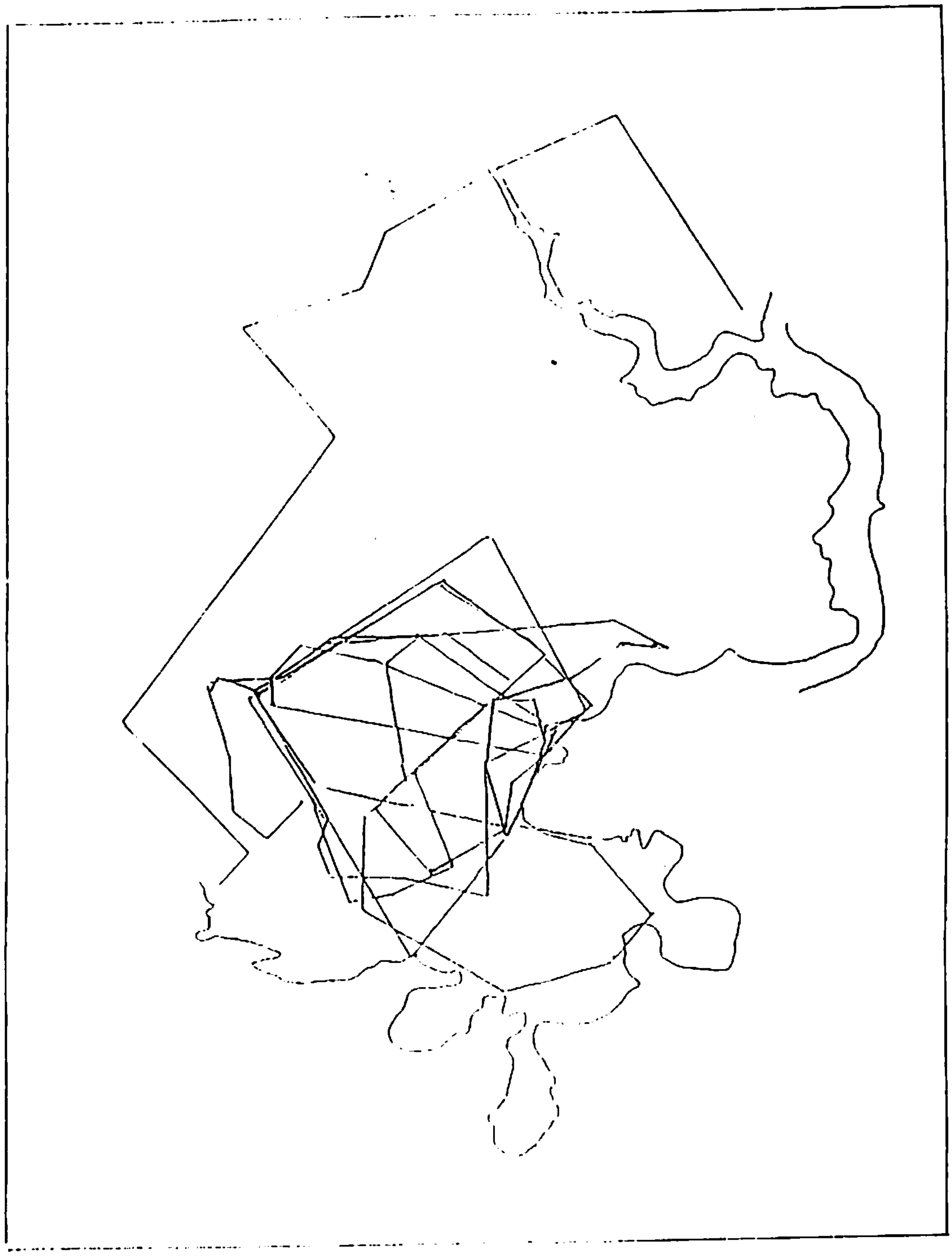


Fig 18

Range overlap

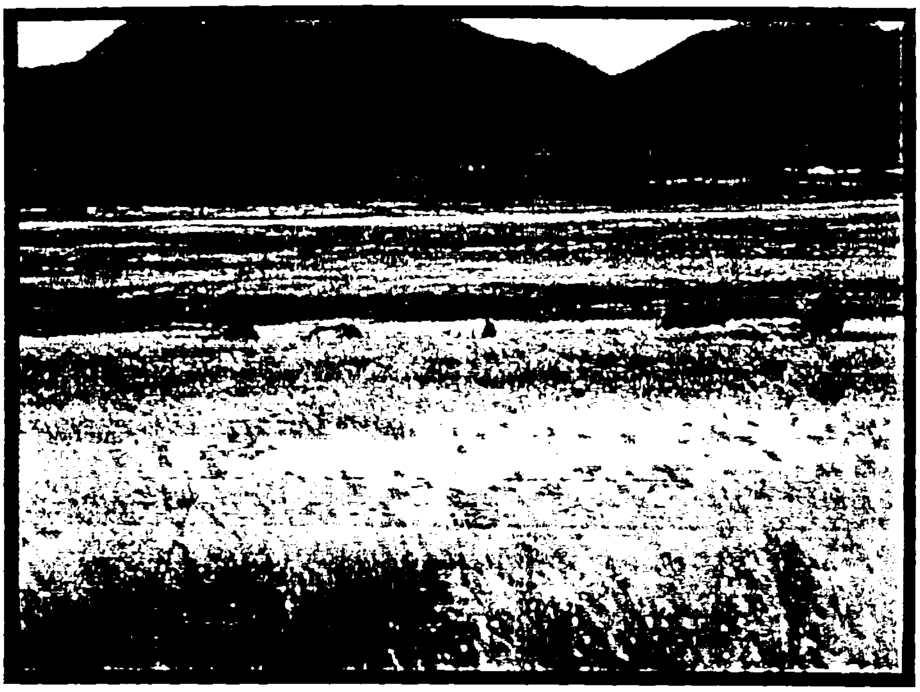


Plate 1
Lakeshore grassland

Plate 2
Changes in tall grassland due to over-utilisation.
Area colonized by short *Panicum atrosanguineum.*

Plate 3
Ungrassed areas colonized by _Peltophorum africanum_ and _Acacia_ spp. Favoured resting places of the white rhino

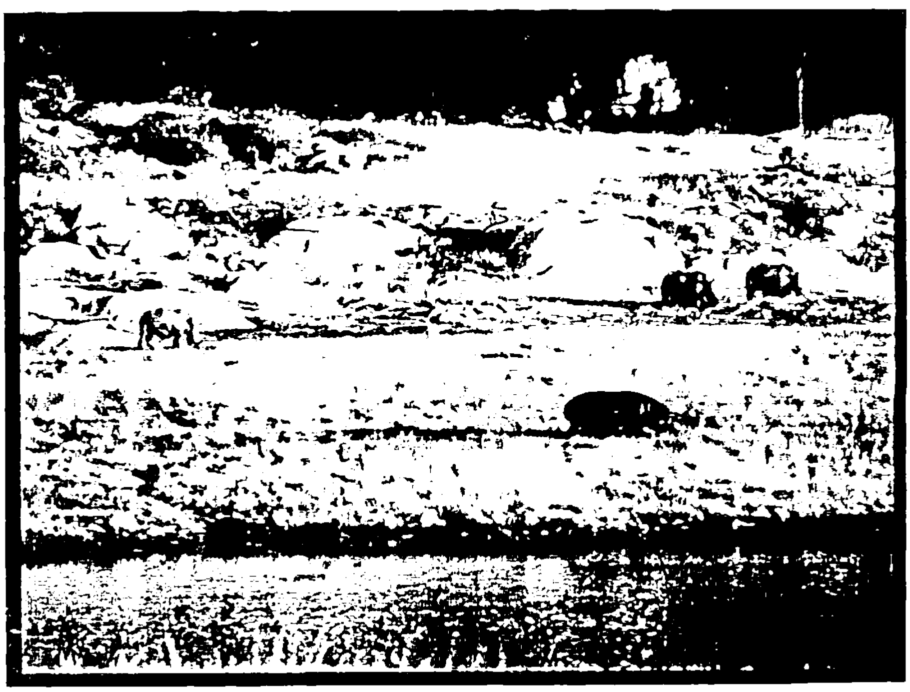


Plate 4
Two megaherbivores compete for lake-shore grasses

Plate 5a
Vegetation photographed from Beacon No.1 showing the same view
1968

Plate 5b
Vegetation photographed from Beacon No. 1 showing the same view
1995

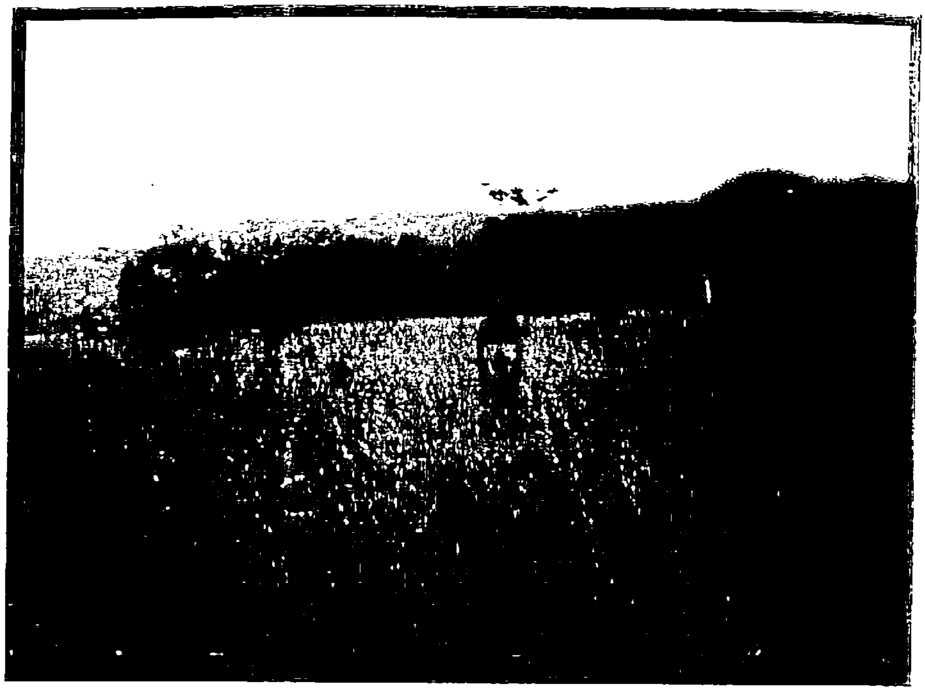


Plate 6a
Vegetation photographed from Beacon No.1 showing the same view
1968

Plate 6b
Vegetation photographed from Beacon No.1 showing the same view
1995

Plate 7
Grassland showing bare areas due to grazing pressure

Plate 8
Rubbing rock regularly used by the white rhino

Plate 9
Alpha male territorial midden showing typical concave centre
(Note female dropping nearby)

Plate 10.
Alpha male new territorial midden showing typical scrapes