THE IMPACTS OF TRANSLOCATING BLACK RHINOCEROS (*Diceros bicornis*, Linn. 1758) TO LAKE NAKURU NATIONAL PARK, KENYA.

BY

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DECLARATION

THIS THESIS IS MY ORIGINAL WORK AND TO THE BEST OF MY KNOWLEDGE IT HAS NOT BEEN PRESENTED IN ANY OTHER UNIVERSITY.

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DEDICATION

DEDICATED TO MY PARENTS MR. DAVID WAWERU AND LATE MRS TABITHA WAITHERA.

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ABSTRACT

In a bid to save the few remaining black rhinoceros in Kenya, the Government with assistance from local and international conservation agencies, established the first black rhinoceros sanctuary at Lake Nakuru National Park (LNNP) in 1987. A total of 17 rhinoceroses were translocated to the park, mainly from Solio Ranch Game Reserve (SRGR). This was in addition to the already existing two rhinoceroses. At the end of the translocation exercise, the total population was 19 rhinoceroses (8 females and 11 males), giving a sex ratio of 1:1.4. This was significantly different from the 1:1 ratio expected for rhinoceros in the wild.

The translocated rhinoceros settled in the southern part of the park. The males had an average home range size and standard errors of 7.3 $\pm$ 0.2 km^2 and 11.2 $\pm$ 2.4 km^2 during the wet and dry season, respectively. The females mean home range size was 8.4 $\pm$ 2.3 km^2 and 15.2 $\pm$ 4.6 km^2 during the wet and dry season, respectively. The female home ranges were significantly larger than those of the males during both seasons. However a high percentage home range overlap was observed.

A total of 73 different food plants were fed on in LNNP as compared to only 54 in SRGR. A total of 37 plant species were common to both areas. However 36 new plant species absent in SRGR were included in the rhinoceroses diet in LNNP. Data on browse availability indicated that LNNP was a more suitable habitat for rhinoceros as compared to SRGR. The development activities associated with the establishment of the rhinoceros sanctuary at LNNP were noted to have affected the ecology of the park and its animals in different ways.

CHAPTER 1

1.0 GENERAL INTRODUCTION AND LITERATURE REVIEW

1.1 General Description of the Black Rhinoceros

The black rhinoceros (Diceros bicornis Linn. 1758) is a massive, primitive looking animal. It has two frontal horns which are centrally placed on the forehead, one is front of the other. The skin is approximately two centimetres thick with a natural grey colour. However in most cases the skin takes the colour of soil in the area in which the individual lives, due to wallowing (Goddard, 1967a; 1967b; Mukinya, 1973; Schenkel and Schenkel, 1969).

The black rhinoceros has no hairs except on the fringe of the ear pinnae and tail tufts (Guggisberg, 1948). Sweat glands are absent and this attributes to its involvement in prolonged wallowing in mud and dust for thermorelugatory purposes. Besides this, wallowing is believed to have an effect on skin condition and protects animals against ectoparasites, mainly biting flies and ticks (Schenkel and Schenkel, 1969). Present and conspicuous are the rib-like folds along its body flakes. These folds are wholly independent of the actual ribs beneath.

The horns are outgrowths of the skin consisting of a compact mass of agglutinated fibres called keratin.

They do not repose on a knob or bone like the horns of ungulates and they can actually fray (Grzimek, 1969; Ryder, 1962). The rhinoceros horn grows throughout life and in case of breakage the horn regrows. The horn is slightly concave and it is held at the base by a thick skin surrounding it and not attached to the skull. The horn is used for defence, fighting between males and females, that precedes mating, and digging up minerals at salt licks (Goddard, 1967 a; 1970; Schenkel and Schenkel, 1969; Grzimek, 1969; Mukinya 1973; Guggisberg, 1966.

The body weight in adult animals ranges between 700 kg and 1200 kg (King, 1969; Guggisberg, 1948). The shoulder height is between 1.40-1.60 metres and the body length along the body curve from tip of nose to the base of the tail is 3.7 metre (Freeman and King, 1969). Earless rhinoceros have been recorded from a number of populations in Eastern and Southern Africa (Goddard, 1969; Hitchins and Anderson, 1980). This is attributed to predation on black rhinoceros calves by spotted hyenas. Grzimek (1969) and Goddard (1969) suggest that a genetic character, sex influenced for sex linked gene could also be responsible for a congenital deformity.

When charging a rhinoceros can reach a speed of 50-56 km/hr, however, they travel very slowly even when not feeding, certainly nowhere near as fast as a man walking (Grzimek, 1969). They are not good swimmers, although they have been observed feeding on Typha spp. in shallow waters. They can inhabit areas at altitudes as high as 2879 metres above sea level and mostly live in dense bush, sparse forests, open grassy plains and in semi-deserts (Goddard, 1967a). They dislike heat combined with high humidity (Schenkel and Schenkel, 1969). Klingel and Klingel (1966) observed rhinoceros feed on their dung, and when engaged in this activity, they move from one heap to another. This is expected to compensate for mineral deficiency, especially when salt licks are not available. A rhinoceros scrapes its dung using the hind legs leaving two trench marks, in the process the hind legs are thrown backwards alternately with force (Schenkel and Schenkel, 1969). When sleeping a rhinoceros generally lies on its belly, slightly off centre with the fore legs tucked beneath the body and the hind legs extended forward. The head rests on the ground facing front. Only on very rare occasions will the animals lies flat on its flank with all legs extended sideways (Schenkel and Schenkel, 1969).

A gestation period of 458-540 days has been reported (Ulmer, 1958; Gowda, 1967; Goddard, 1967a). Intercalving intervals of 25-27 months have been reported for East Africa (Goddard, 1970; Mukinya, 1973) and 33-38 months in South Africa by Hitchins and Anderson (1980). The oestrus cycle has been observed to range between 26-46 days and the oestrus duration of receptivity only lasts one day (Hitchins and Anderson, 1980). In captivity rhinoceros have been observed to suspend oestrus cycles for as long as 5 months, at least once a year.

The teeth are peculiar and have no incisors or canines in either jaw (Ritchie, 1963). The adults normally have 4 premolars and 3 molars (Goddard, 1970). The eruption sequence is from anterior to posterior. The 3 molars are large, ridged structures which are used principally in feeding. The teeth consist of dentine and enamel only; the cement layer is absent (Goddard, 1970, Mukinya, 1973). Sexual dimorphism in horns and differences in urination behaviour between males and females have been described by Schenkel and Schenkel (1969); Mukinya 1973; and Waweru (1985). It has also been observed that dung scraping is more predominant in males. Sometimes the rhinoceros have been observed to scrap without defaecation and may even trample over small bushes (if available) in the process (Schenkel and Schenkel, 1969).

1.2 Taxonomy of the Black Rhinoceros

The rhinoceros belongs to the order Perissodactyla (odd toed ungulates) which is divided into two suborders namely Hippomorpha and Ceratomorpha. The latter has two super-families, Tapiroidea and Rhinocerotoidea. Rhinocerotoidea has only one family Rhinocerotidae subdivided into two sub-families Rhinocerotinae and Dicerorhininae. The sub-family Rhinocerotinae has one genus Rhinoceros with two species R. unicornis and R. sondaicus. The sub-family dicerorhininae has three genera each with one species. These are the genus-Didermocerus, species - D. sumatrensis and genus Ceratotherium, species - C. simum and genus - Diceros, species - D. bicornis. The species D. bicornis is further subdivided into seven subspecies according to Groves (1967) (Table 1.1). Genetically the subspecies are similar and the differences might be as a result of the various habitats that they live in.

The family Rhinocerotoidea first appeared 60 million years ago and had 34 different species (Cumming, 1987). Today only 5 of these exist, 3 in Asia and 2 in Africa, all in a precarious state. The family is today one of the most endangered. All five species are listed in the I.U.C.N. Red data Book (IUCN, 1978). The R. unicornis has benefited from protection in reserves where approximately 2500 animal exist. For D. sumatrensis only about 500-700 animals exist all in the wild while R. sondaicus has only about 50 individuals remaining. The last one has no representation in zoos, unlike others.

The D. bicornis is well represented in the zoos and has about 4000 individuals protected in reserves. The C. simum is well represented in zoos and the population in protected areas are showing an upward trend.

1.3: Black Rhinoceros Status in Africa

In the past 20 years the black rhinoceros population in Africa has declined rapidly. In 1970 the population stood at 65,00 individuals, today the total is less than 3600, a loss of 94%, the highest loss recorded for any other large mammal within that period (Cumming, 1987: Western and Vigne, 1985). The remaining few are in fragmentary populations with

Table 1.1: Taxonomic position of the Black Rhino (Diceros bicornis)

Order	: Perissodactyla
Suborder	: Ceratomorpha
Superfamily	: Rhinocerotoidea
Family	: Rhinocerotidae
Subfamily	: Rhinocerotinae (one horned)
Genus	: Rhinoceros
Species	: R. unicornis (Indian Rhino)
	: R. sondaicus (Javan Rhino)
Subfamily	: Dicerorhininae (two horned)
Genus	: Didermocerus
Species	: D.sumatrensis
Genus	: Ceratotherium
Species	: C.simum
Genus	: Diceros
Species	: D.bicornis
Subspecies*	: D.b.chobiensis
	: D.b.longipes
	: D.b.minor
	: D.b.michaeli
	: D.b.brucii
	: D.b.ladoensis
	: D.b.bicornis

* - Genetically the subspecies are the same and the differences might be due to the different habitats they live in (Cumming, 1987).

small groups scattered over large areas. An example is the Selous Game Reserve in Tanzania, with an area of about 55000 sq.km. and only about 100 individuals or less remaining (Cumming, 1987). The major cause of this decline is poaching by well organised and armed men, enhanced by the high prices paid for the rhinoceros horn (Martin, 1982).

Figure 1.1 shows that the black rhinoceros range, before 1900 extended from West Africa to Somalia in the East and from the southern boundary of the Sahara desert to South Africa. This range has declined sharply leaving only small pockets in a few countries, whereas in others the species has completely disappeared (Western and Vigne, 1985). Table 1.2 indicates that between 1980 and 1987 the population declined from 14785 to 3800 with some countries having none.

Out of the 17 countries which had black rhinoceros by 1980 only 12 had any left by 1987 and the numbers were quite low. Only Zimbabwe, South Africa, Namibia, Zambia, Kenya and Tanzania have population of more than 100 individuals. Kenya, South Africa and Namibia show signs of population increase. This is attributed

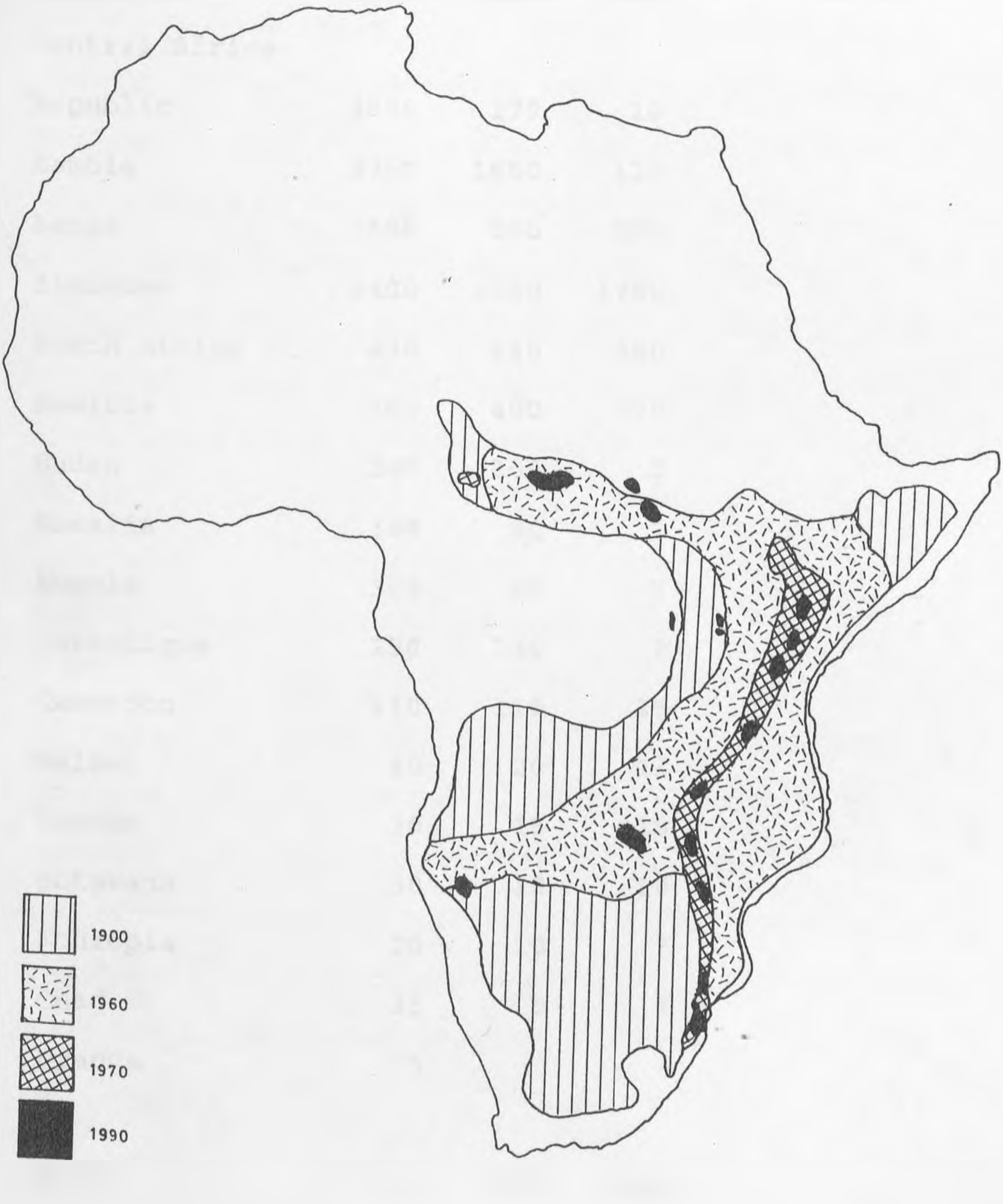

Figure 1.1: Black Rhinoceros distribution in Africa (1900-1990)

Table 1.2 : Black Rhinoceros Status in Africa

COUNTRY	1980	1984	1987
Tanzania	3795	3130	270
Central Africa Republic	3000	170	10
Zambia	2750	1650	110
Kenya	1500	550	520
Zimbabwe	1400	1680	1760
South Africa	630	640	580
Namibia	300	400	470
Sudan	300	100	3
Somalia	300	90	?
Angola	300	90	?
Mozambique	250	130	?
Cameroon	110	110	25
Malawi	40	20	25
Rwanda	30	15	15
Botswana	30	10	10
Ethiopia	20	10	?
Chad	25	5	5
Uganda	5	-	-
TOTAL	14785	8800	3800

to the intensified antipoaching campaigns and translocation of small isolated population to safe sanctuaries.

The above uses have contributed to the threat in survival of the rhinoceros in the wild. All the cures recorded above are beliefs and have no medical certification. The greatest use of the horn is in the Far East, where the dominant market for rhinoceros products has been. However the horn is used in Yemen to make dagger handles which are worn by men to signify wealth and status in the society (Martin, 1982).

1.4: Black Rhinoceros in Kenya

In Kenya, by the turn of this century, the species (Diceros bicornis) occurred in large numbers in all parts of the country excluding the coastal strip and around Lake Victoria. As late as 1970, Kenya had an estimated 20,000 black rhinoceros (Western, 1984). By 1973 black rhinoceros were distributed all over the rangelands with an exception of the highly settled areas (Mukinya, 1973). They were abundant in Tsavo National Park, Masailand, Ukambani, North Eastern province, Turkana and Samburu districts (Mukinya, 1973) (fig. 1.2). Pressure for more agricultural land, poaching and severe drought, have contributed to the disappearance of the species from most parts of the country (Stewart, 1970; Mukinya, 1973; Grzimek,1969).

By 1980, the population was estimated to be about 1500 individuals and in 1984 only about 500 rhinoceros were estimated to be in Kenya (Western and Vigne, 1985). Today the population is estimated to be less than 400 individuals which are scattered in small fragmented populations in protected areas and private reserves in the country (Jenkins, 1985) (Table 1.3). The present estimates may be low because rhinoceros are difficult to count accurately from the air and worse on the ground because the species lives in low densities in thick bush and are mainly solitary (Goddard, 1967a).

1.5: Uses of Rhinoceros Body Parts (Martin, 1983).

Part	Use
Horn	Believed to stimulate sexual performance

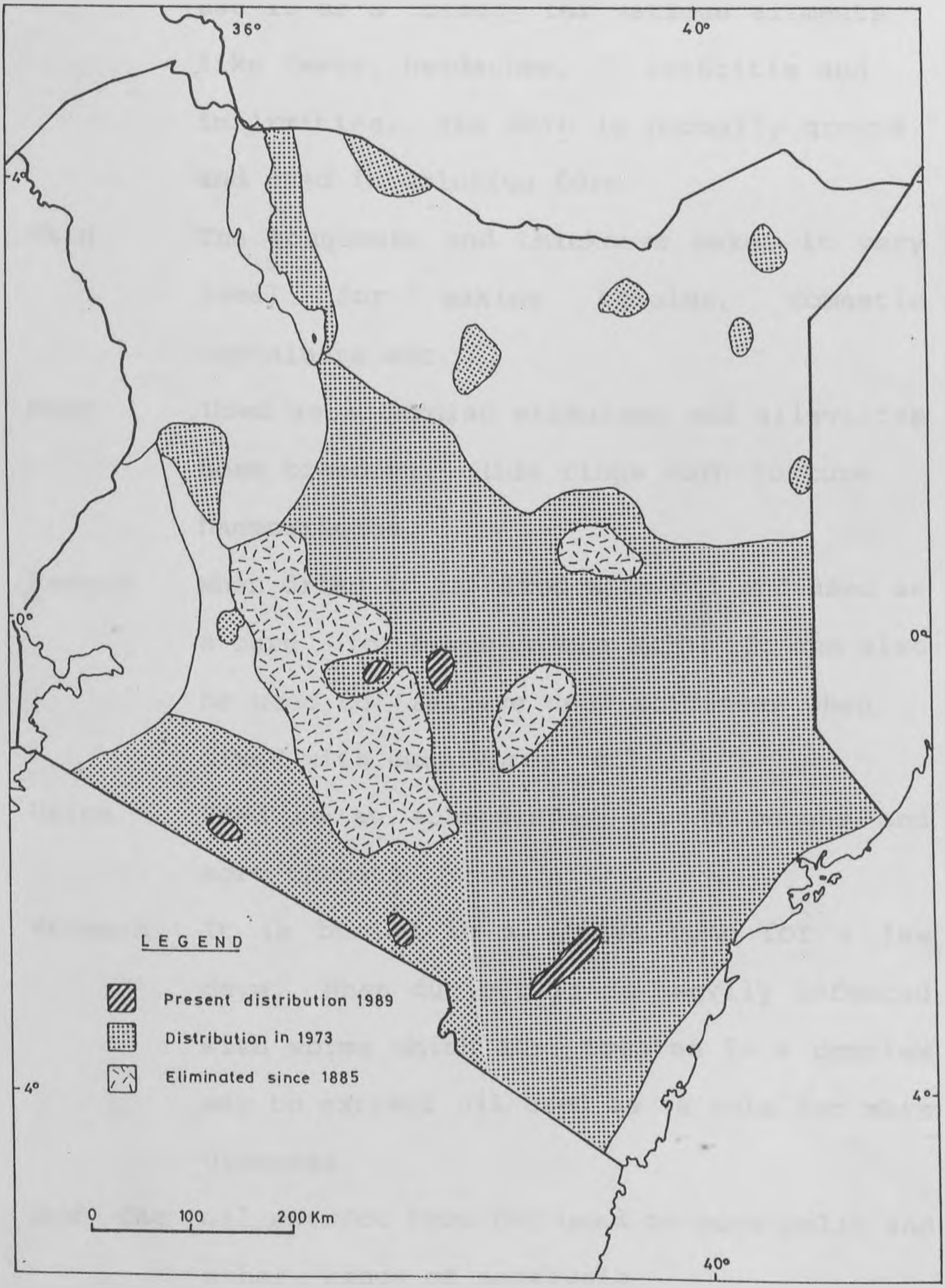

Figure 1.2: Black Rhinoceros distribution in Kenya

hence an aphrodisiac. However its major use is as a remedy for various ailments like fever, headaches, arthritis and infirmities. The horn is normally ground and used in solution form.

Skin	The toughness and thickness makes it very ideal for making shields, domestic containers etc.
Meat	Used as a Cardiac stimulant and alleviates nose breeding. Hide rings worn to cure haemorrhoids.
Faeces	When dried it is mixed with oil and used as a cure for bumps on the skin. It can also be used to relieve neck stiffness when mixed with eucalyptus oil.
Urine	Used as an aphrodisiac, cures coughs and sore throats.
Stomach	It is buried in a refuse dump for a few days. When dug out it is heavily infested with worms which are treated in a complex way to extract oil used as a cure for skin diseases.
Body fat	Oil extract from fat used to cure polio and other kinds of paralysis.

Table 1.3: Present black rhinoceros population and distribution in Kenya.

Area	Status	No. of Rhinos
Amboseli	NP	10
Ngulia	RS	9
Nairobi	NP	61
Masai Mara	NR	25
Lake Nakuru	RS	21
Meru	NP	0
Aberdare (Salient)	RS	37
Solio	PR	69
Ngare Sergoi	PR	13
Oljogi	PR	11
Mt. Kenya (GR)	PR	3
Tsavo	NP	50-100
Mt. Kenya	NP	8
Mt. Kulal	UP	3
Mt. Marsabit	NP	6
Ngeng Valley	PR	10
Loita Hills	UP	14
Laikipia Ranch	PR	43
Total		393-443

Note: NP---National Park, NR---National Reserve
RS---Rhino Sanctuary, UP---Unprotected area
PR---Private Ranch

Source Kenya Wildlife Service files (1988).

Due to the solitary behaviour, current low densities and the fact that females are only receptive for one day during the oestrus cycle (Hitchins and Anderson, 1980), it is very difficult of successful copulation to take place. The chances of a male being available during the receptive period are very limited thereby catalysing the current decline. However the major cause for the decline in population size has been poaching which initially reduced the population to its present size (Martin, 1982). The overall status is very poor recovery rates and the extinction threat prevails.

However of late a few areas have experienced high recovery rates, an example is Solio ranch game reserve with a 15 % per annum recovery rate (Brett, 1990). The possibility for the future survival of this species is by active management to enhance reproduction, through ensuring successful mating. This can be possible only by providing a conductive breeding environment. In addition poaching should be reduced to save levels, and the marketing of the horn and other rhinoceros products eliminated (Martin, 1983).

The plight of the black rhinoceros in Kenya did not go unnoticed by conservationists either at national and international levels. The Kenya government in collaboration with conservation agencies formed a "Kenya Rhino Rescue" steering committee (Jerkins, 1985) which after several meetings developed the black rhinoceros conservation programme in Kenya to establish a series of special rhinoceros sanctuaries in the country. Those earmarked for this exercise were, Lake Nakuru, Nairobi, Aberdares and Tsavo National parks.

Lake Nakuru National Park, the first in the series, has been completed and rhinoceros translocated there from Solio Ranch Game Reserve SRGR. The work of the committee was to organize the development of infrastructure, capture, translocate and solicit for funds. In these sanctuaries, breeding population were to be established to provide stocks for reintroduction to areas where the rhinoceros has been exterminate. Other conservation measures in Kenya include the establishment of surveillance units to protect and to monitor known populations in protected areas which are not sanctuaries. This study deals with the current black rhinoceros translocation and establishment of the first special rhinoceros sanctuary at Lake Nakuru National Park.

1. 6: Justification of the Study

The establishment of Lake Nakuru National Park (LNNP) rhinoceros sanctuary is the most significant move the Kenya overnment has undertaken towards the conservation of the black rhinoceros. This move involves development of infrastructure and a major translocation exercise. All these activities are expected to have an effect on he ecology of LNNP. The rhinoceroses themselves may be affected by the movement from their former habitat to the new one. In the past translocation has been known to save endangered animals from extinction, but sometimes it has failed because of factors that were unknown or not fully understood. An example is the translocation by the Game Department of the Rothschild's giraffe from Soi to Maralal which was unsuccessful (Evans 1970).

This study covers the ecology of LNNP, and the black rhinoceros translocation. Since Nakuru is the first National black rhinoceros sanctuary, the findings of this study will have relevance for decision-makers in designing, planning and managing other rhinoceros sanctuaries in Kenya and beyond. The study will also provide baseline information about the black rhinoceros ecology in Lake Nakuru and give proposals for future research.

1.7: Objectives

The objectives of this study were as follows:-

A: To identify and describe the Lake Nakuru Rhinoceros sanctuary.

B: To document the capture and translocation of rhinoceros from Solio Ranch Game Reserve.

C: To describe the vegetation distribution, density and availability of rhinoceros browse in both study areas.

D: To describe the habitat utilisation and dietary composition of rhinoceros before and after translocation.

E: To describe the spatial distribution of the rhinoceros at Lake Nakuru National Park.

F: To describe the effects of the translocation on the ecology of Lake Nakuru National Park.

To achieve each of the above objectives different data collection techniques were used as described in each of the following chapters.

CHAPTER 2

STUDY AREAS

2.1: INTRODUCTION

For any translocation exercise to be successful, it is always important to understand both the ecology of the new area and that of the animal being translocated. In this particular case Lake Nakuru National Park (LNNP) was earmarked to become the first, Government owned black rhinoceros sanctuary in Kenya. The rhinoceros were to be captured from the Solio Ranch Game Reserve (SRGR), and translocated to LNNP. The project activities were therefore conducted both at LNNP and SRGR.

The major study area however was LNNP, which was to become the new home for these translocated rhinoceros. However vegetation analysis studies were conducted at SRGR to give an idea of browse composition and availability in the rhinoceros former habitat. Figure 2.1 shows the location of both study areas in relation to one another.

2.2: SOLIO RANCH GAME RESERVE

Solio Ranch Game Reserve occupies an area of

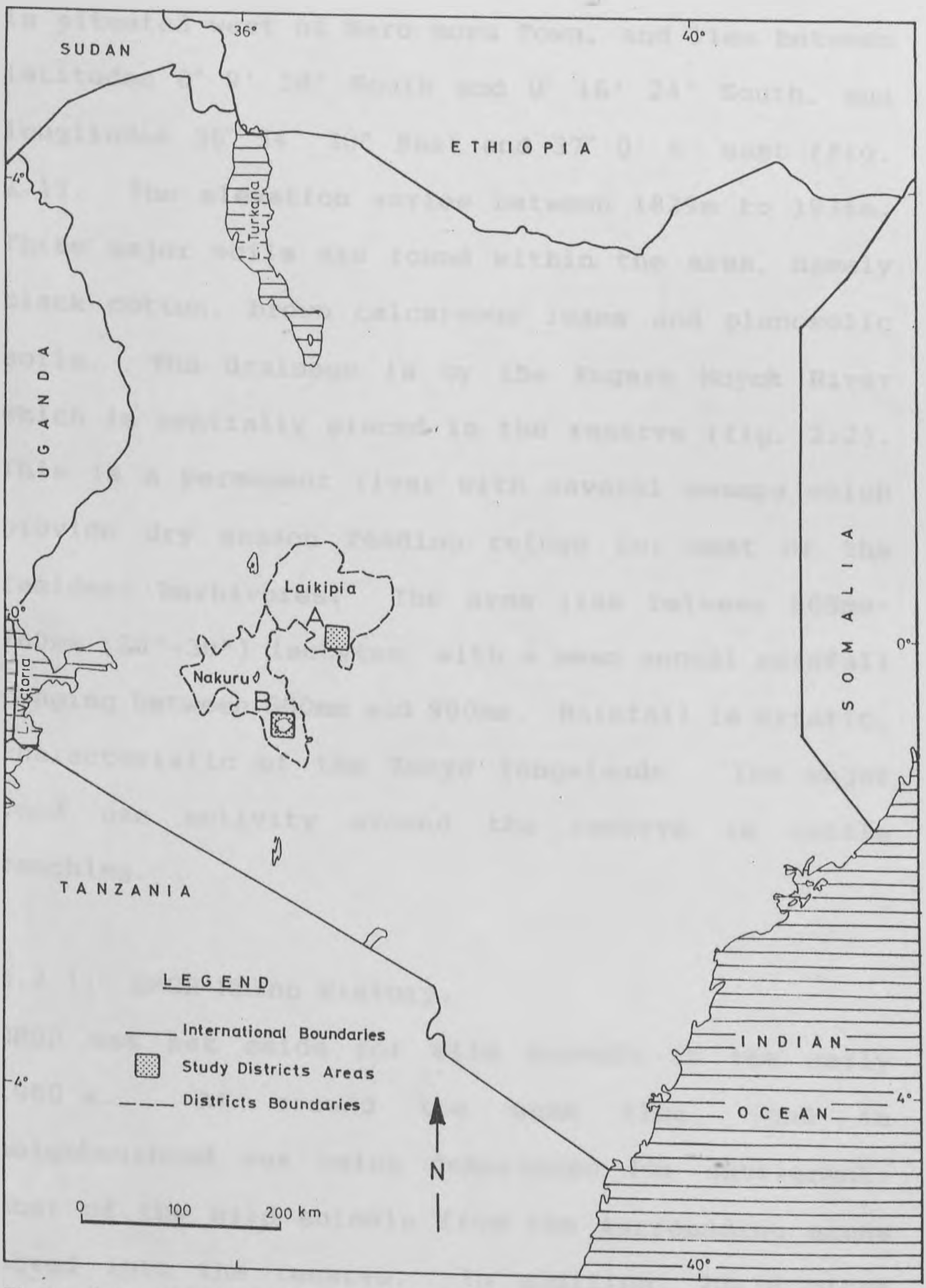

Figure 2.1: Location of study areas: Laikipia and Nakuru Districts

approximately 52 square kms within Solio Ranch. It is situated west of Naro moru Town, and lies between latitudes 0° 9' 18" South and 0° 16' 24" South, and longitudes 36° 54' 30" East and 37° 0' 6" east (fig. 2.1). The elevation varies between 1829m to 1936m. Three major soils are found within the area, namely black cotton, brown calcareous loams and planosolic soils. The drainage is by the Engare Moyok River which is centrally placed in the reserve (fig. 2.2). This is a permanent river with several swamps which provide dry season feeding refuge for most of the resident herbivores. The area lies between 508mm-760mm (20"-30") isohytes, with a mean annual rainfall ranging between 500mm and 900mm. Rainfall is erratic, characteristic of the Kenya rangelands. The major land use activity around the reserve is cattle ranching.

2.2.1: SRGR Rhino History.

SRGR was set aside for wild animals in the early 1960's. At around the same time, land in neighbourhood was being demarcated for settlement. Most of the wild animals from the surrounding areas moved into the reserve. In addition, 20-30 black rhinoceros were captured from the surrounding settled areas, and translocated into the SRGR. Another 18

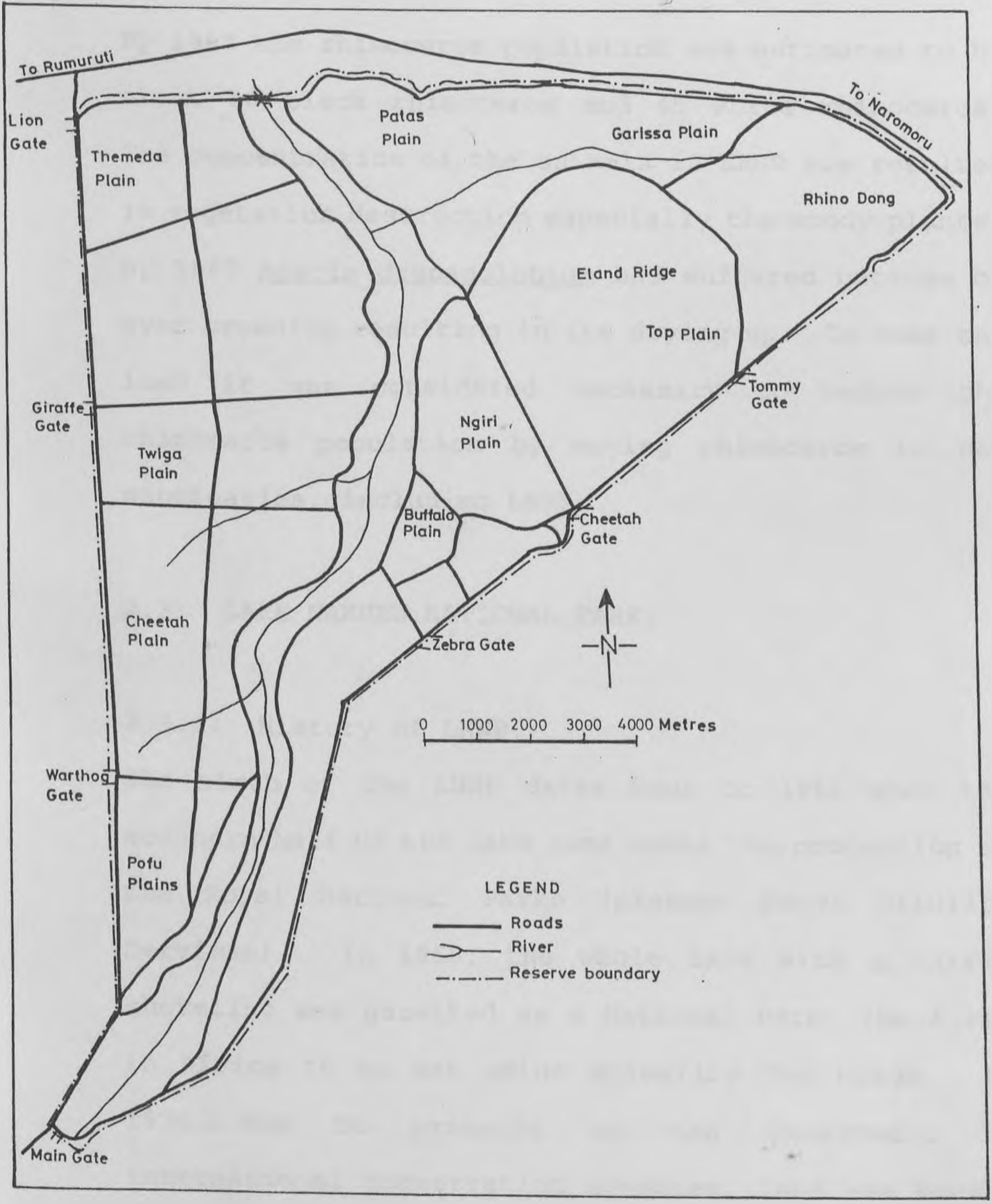

Fig. 2.2: Solio Ranch Game Reserve

white rhinoceros were imported from South Africa.

By 1987 the rhinoceros population was estimated to be about 80 black rhinoceros and 45 white rhinoceros. The concentration of the animals in SRGR has resulted in vegetation destruction especially the woody plants. By 1987 <u>Acacia</u> <u>drepanolobium</u> had suffered because of over browsing resulting in its drying up. To ease the load it was considered necessary to reduce the rhinoceros population by moving rhinoceros to new sanctuaries, including LNNP.

2.3: LAKE NAKURU NATIONAL PARK.

2.3.1: History of LNNP.

The birth of the LNNP dates back to 1961 when the southern half of the lake came under the protection of the Royal National Parks (present Kenya Wildlife Services). In 1968, the whole lake with a narrow shoreline was gazetted as a National Park, the first in Africa to be set aside primarily for birds. In 1974 due to pressure on the Government by international conservation agencies, land was bought from ranches around the park and the park boundaries were extended to cover the present day 187.9 square kms. In 1976 the whole park was fenced with chain link all around except for a six kilometre section on the western side of the park. In 1986 a solar electric fence was erected along the inside of the old fence. The latter has 12 high tension wire strands, six of which are live. Each of these live wires carry 5 kilovolts (park records). By 1986 the park had only two black rhinoceros believed to have moved into the park in the early 1960's from Eburru Hills. Other wild animals of LNNP are given in table 2.1. A total of 25 different animal species are found in LNNP.

TABLE 2.1: CHECKLIST OF WILD ANIMALS IN LNNP.

COMMON NAME	SCIENTIFIC NAME
Waterbuck	Kobus defassa
Impala	Aepyceros melampus
Thompsons gazelle	Gazella thomsoni
Reedbuck (bohor's)	Redunca redunca
Buffalo	Syncerus caffer
Bushbuck	Tragelaphus scriptus
Dikdik	Modoqua kirkii
Hippopotamus	Hippopotamous amphibius
Mountain Reedbuck	Redunca fulvorufula
Warthog	Phacochoerus aethiopicus
Colobus monkey	Colubus abyssinicus
Baboon	Papio anubis

Vervet monkey	*Cercopithecus aethiops*
Leopard	*Panthera pardus*
Black backed jackal	*Canis mesomelas*
Spotted hyena	*Crocuta crocuta*
Zebra	*Equus burcheli*
Eland	*Tourotragus oryx*
Grant's gazelle	*Gazella granti*
Black rhinoceros	*Diceros bicornis*
White rhinoceros	*Ceratotherium simum*
Rothchild's giraffe	*Giraffa camelapardalis*
Bat eared fox	*Otocyon megalotis*
Rock hyrax	*Procavia johnstonii*
Lion	*Panthera leo*

2.3.2: Geographical location

Lake Nakuru National Park, occupies an area of about 187.9 sq.kms and is situated 3 km south of Nakuru town, which is about 160 kms from Nairobi along the A104 Transafrican Highway (fig.2.3). It lies between latitudes 0° 17' south, and 0° 30' and between longitudes 36° 2' east and 36° 9' east. The study area lies on the floor of the Great Rift Valley. It has an average altitude of 1759m (5771ft). The pear shaped lake is centrally located, and like most of the Rift Valley lakes is shallow and alkaline with a maximum depth of 2.75m in wet season (Mavuti, 1975).

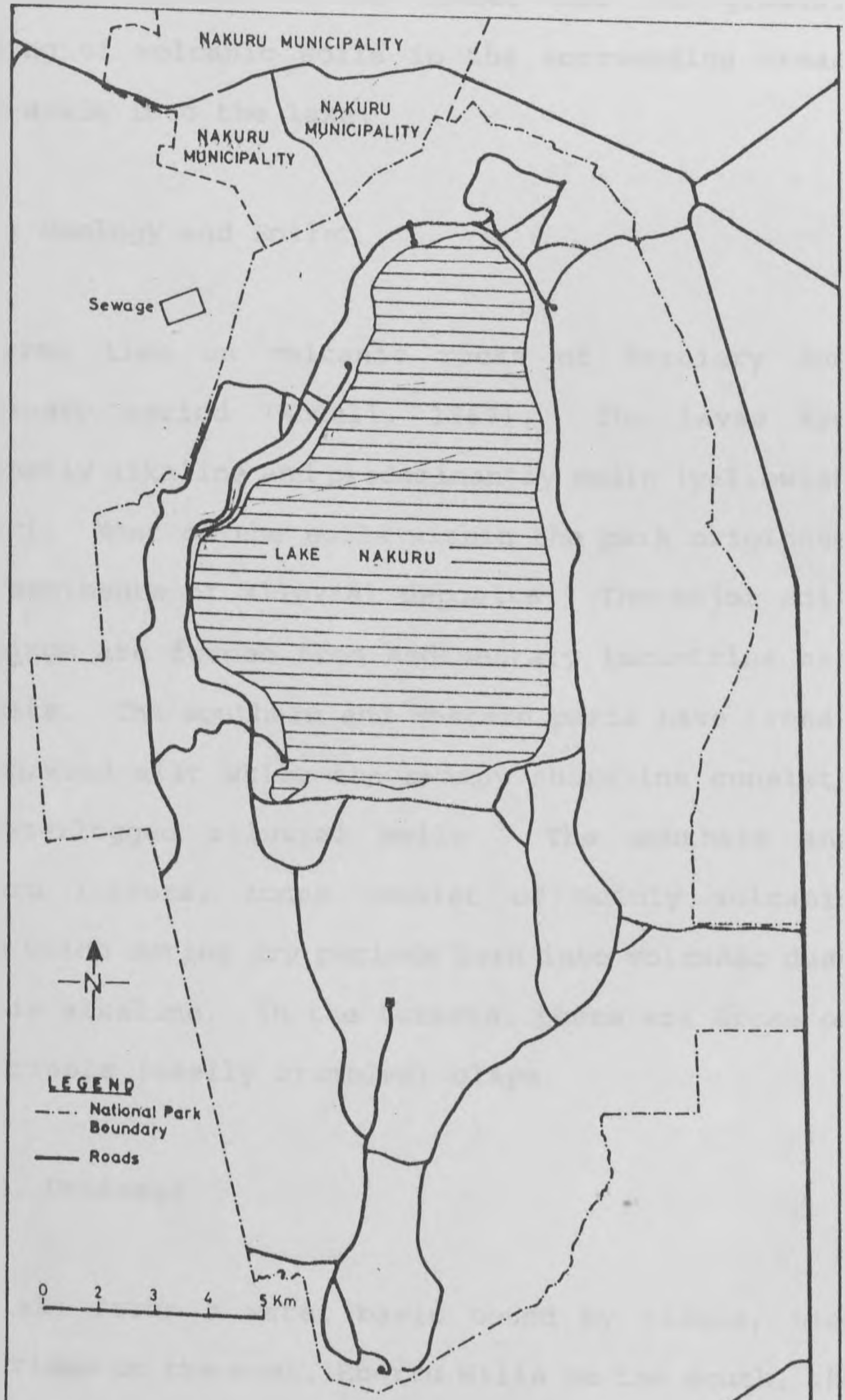

Figure 2.3: Lake Nakuru National Park

The lake water has high mineral concentration (PH 10.5) due to lack of an outlet and the gradual leaching of volcanic soils in the sorrounding areas which drain into the lake.

2.3.3: Geology and Soils.

The area lies on volcanic rocks of Tertiary and Quaternary period (McCall, 1967). The lavas are distinctly alkaline and predominantly sodic (yellowish colour). Most of the soils within the park originate from sediments of alluvial deposits. The major soil groupings are formed from sedimentary lacustrine ash deposits. The southern and Western parts have trona-impregnated silt while the swampy shoreline consists of waterlogged alluvial soils. The southern and western littoral zones consist of mainly volcanic soils which during dry periods turn into volcanic dust that is alkaline. In the forests, there are areas of red friable (easily crumbled) clays.

2.3.4: Drainage.

The lake forms a water basin bound by ridges, Lion Hill ridge on the east, Eburru Hills on the south, the Baboon Cliffs (extension of the Mau escarpment) on the west and Menengai crater on the north. The lake covers a surface area of 42 sq. km. Five seasonal rivers and few major springs drain into the lake and they are the main source of fresh water (fig. 2.4). The springs include the Baharini, Pelican Corner, and Nderit swamp, and a few others located on the eastern shore of the lake.

2.3.5: Climate in LNNP.

The area lies between the 760mm - 1015mm (30" - 40") isohytes. Rainfall is bimodal with one peak in April and another in November. The park has seasonal rainfall with a mean annual rainfall of 876 ($\pm$) 143mm. Long rains start in March or April and short rains in November. A dry season follows the onset of long rains. However, the pattern of rainfall is quite variable from year to year. Off season rains may occur or there may be none. Rainfall data analysed for 9 years 1980-1988 indicates an upward trend since 1984 when it was lowest (fig. 2.5). The area experiences hot days and cold nights, characteristic of the Rift Valley floor.

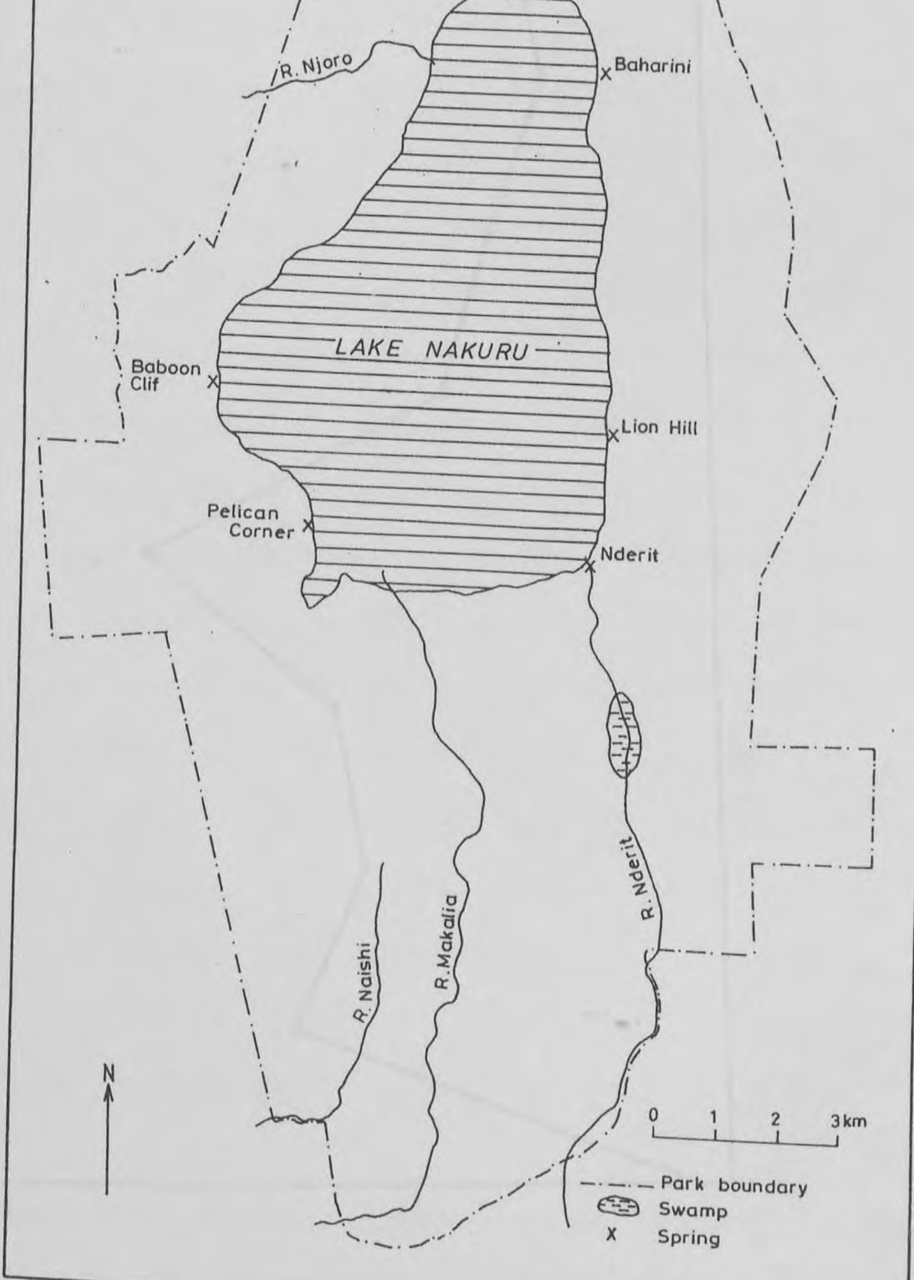

Fig. 2.4: Drainage of Lake Nakuru National Park

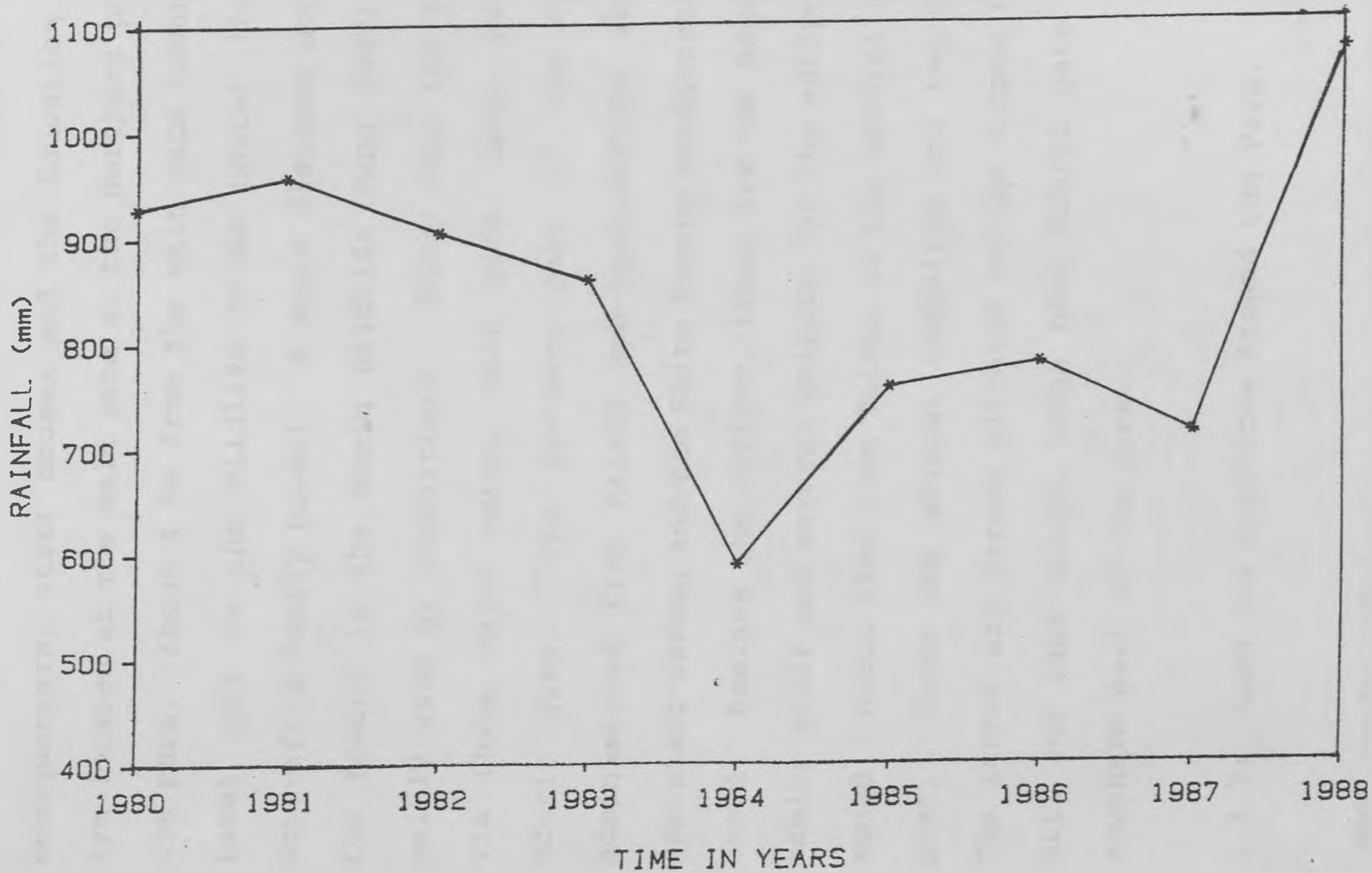

Fig. 2.5: TOTAL ANNUAL RAINFALL FOR NAKURU

2.3.6: Infrastructure.

The Park infrastructure is shown in Figure 2.6. The headquarters, staff houses and the Education centre are located at the main gate at the Northern part of the park. About 4 km from the main gate towards the Lanet gate is the Wildlife Clubs hostel (formerly Hopcraft's family house). A short distance north of the hostel is the World Wildlife Fund (WWF) house mainly used by researchers. Entry into the park is via three major gates, Main gate, Lanet gate and Nderit gate. The southern part of the Park is administered from Naishi sub-headquarters where an assistant warden and the Rhino Rescue headquarters are based. Besides the offices, there are two houses for senior staff and several unipots for the antipoaching squad. About 5kms from Naishi is the Nganyoi rangers post. There are several campsites and two lodges. The latter are Sarova situated on the slopes of Lion hill and Lake Nakuru lodge near Nderit gate in the southern part of the park.

2.3.7: Land Use Practices Around the Park.

LNNP can be referred to as a "terrestrial island". It is sorrounded by different land use activites but the

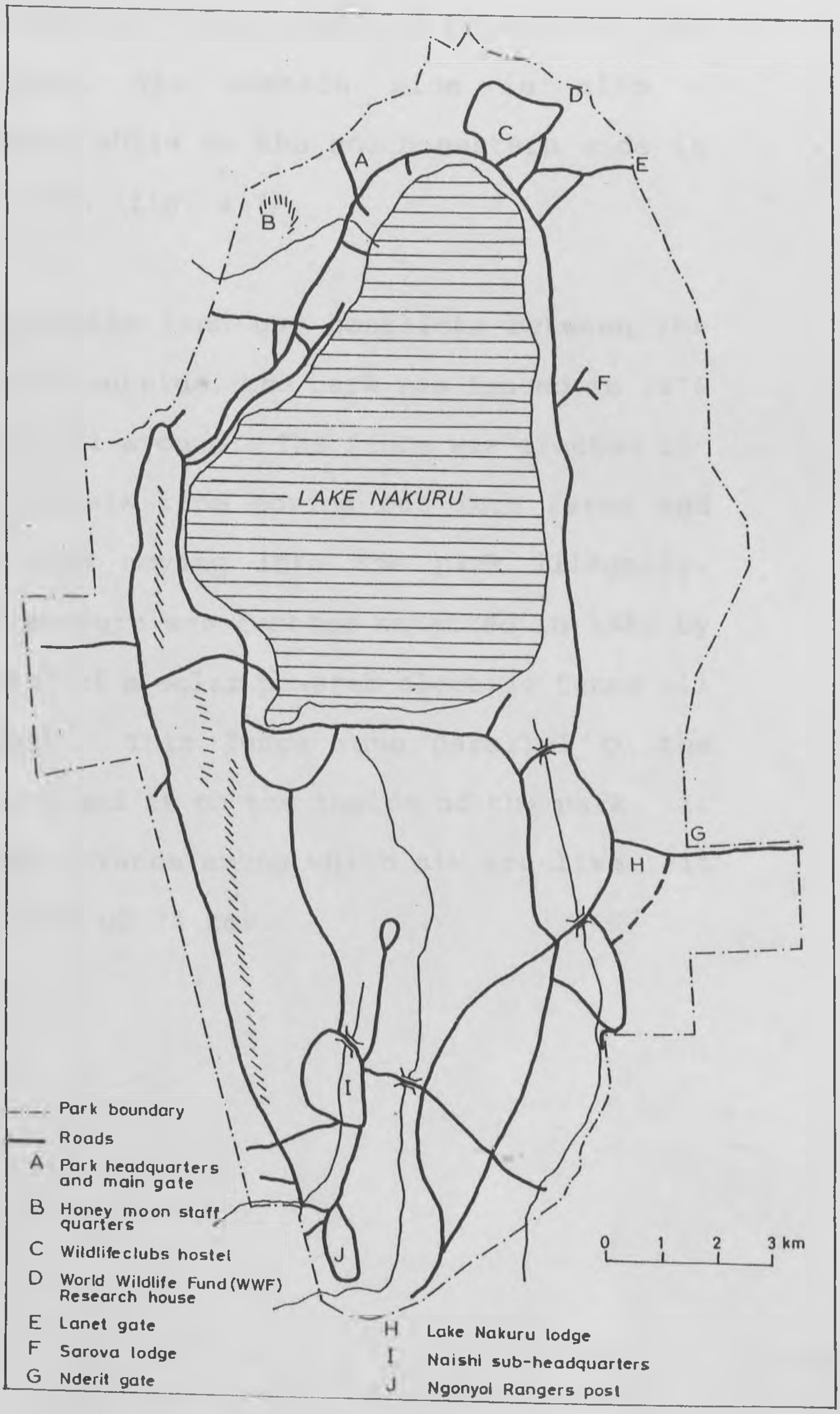

Fig. 2.6. Infrastructure in Lake Nakuru National Park

main one is agriculture. On the north is Nakuru town while on the west and southern sides there exists settlement schemes which were recently subdivided into individual plots. The eastern side is also a settlement scheme while on the south eastern side is the Delamere ranch (fig. 2.7).

In order to minimize land use conflicts between the National Park and outside, the park was fenced in 1976 with chain link all around. The fence was erected to prevent wild animals from moving out into farms and human beings from moving into the park illegally. This security measure was further enhanced in 1986 by the construction of a solar powered electric fence all around the park. This fence runs parallel to the chain link fence and is on the inside of the park. It has twelve wire strands among which six are live. It covers a distance of 74 kms.

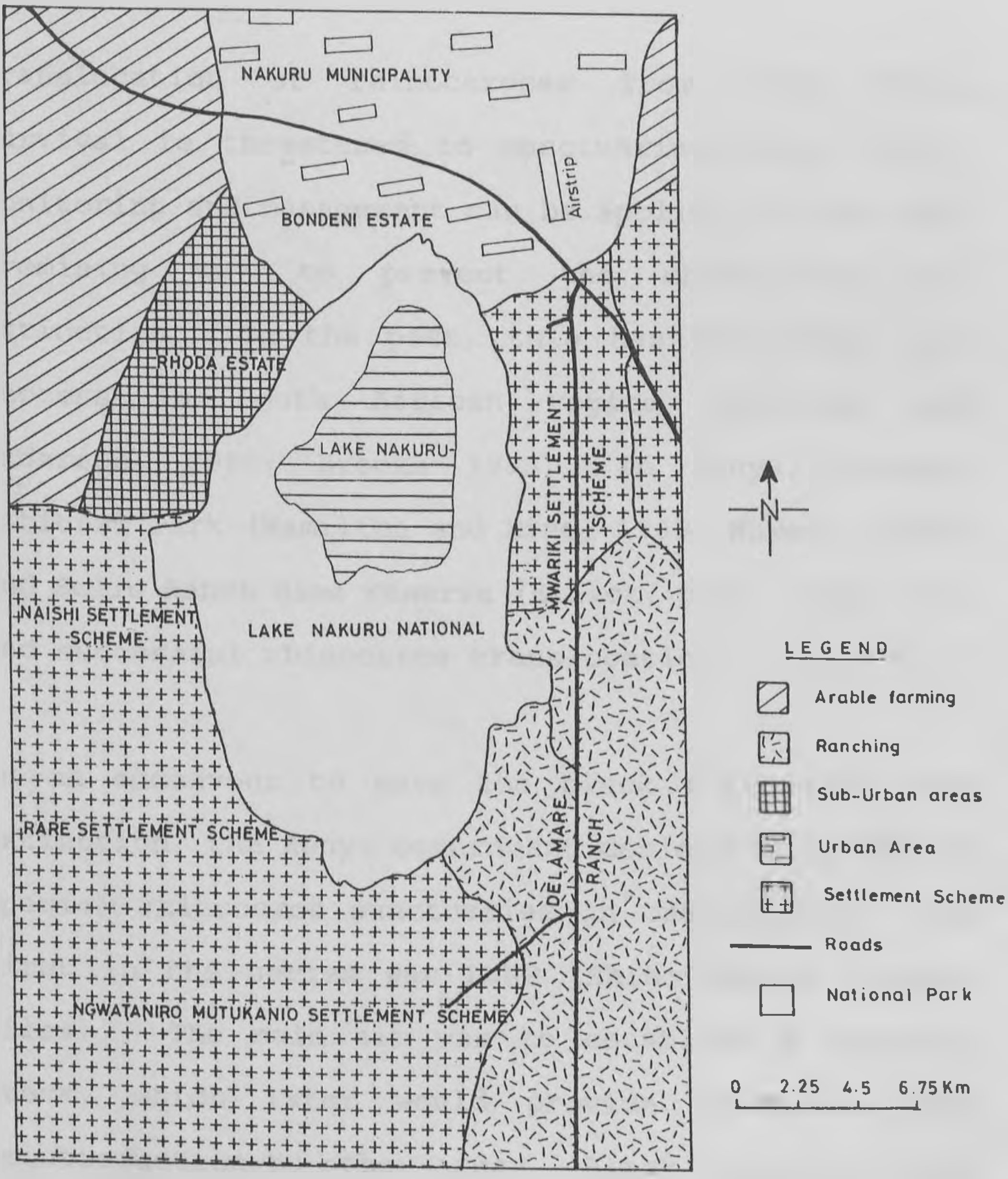

Figure 2.7: Land Use Practices around Lake Nakuru National Park

CHAPTER 3

CAPTURE AND TRANSLOCATION

3.1: INTRODUCTION

Translocation of rhinoceroses from areas where survival is threatened to sanctuaries where active monitoring and management can be applied, is the most promising way to prevent the rhinoceros from extinction. In the past, this has been done with success in South African region (Hitchins and Anderson, 1980; Brooks 1983). In Kenya, Nairobi National Park (Hamilton and King, 1969; Waweru, 1985) and Solio Ranch Game reserve (Elliot, pers, comm) have had successful rhinoceros translocation.

In an endeavour to save the black rhinoceros from extinction, the Kenya Government decided to establish special rhinoceros sanctuaries in the country. The first in the series was LNNP (Rhino Rescue Project files). The main aim was to establish a breeding stock, which later would provide rhinoceros for reintroduction to other areas. Black rhinoceros were captured from SRGR and translocated to LNNP.

This chapter mainly deals with the capture exercise at

SRGR and subsequent transportation of the captured rhinoceros to LNNP where they were released.

3.2: METHODS

3.2.1: Capture

The exercise started at 0630 hours when all the capture personnel assembled at the giraffe gate in SRGR (fig. 2.2). A single engine aircraft was airborne by them. The aircraft crew included a pilot and an observer (spotter). Once a rhinoceros was spotted, the pilot communicated with the ground crew using a VHF radio. The ground crew was divided into a darting team and a support team. Once a rhinoceros was located by aircraft, the darting team drove to a location near the rhinoceros and then stalked the animal on foot. At close range they sexed, identified and subjectively aged it. Only subadults were supposed to be captured. This was because these are expected to have a longer breeding life span and can easily adapt to a new habitat. If the rhinoceros was the right candidate it was darted, if not the search exercise was repeated.

Darting was done using Carfentanyl or large Animal Immobilon (LAI) drugs depending on what was available. The dose depended on animal size and age. After scoring a dart the rhinoceros took on average 7-10 minutes to be completely immobilised. During this time its movements were monitored from the aircraft. When the animal was down, the support team drove to the spot. The area was cleared of obstructing vegetation because in most cases the rhinoceros mainly went down in thickets making clearing of vegetation necessary.

The rhinoceros was rolled onto a sledge (which had a canvas mattress). On the sledge it was tied firmly by ropes to prevent it from rolling over. As this was going on body linear measurements were taken and the molar casts made on plasticin, these were to be used later to determine age class. Each individual was notched on the ear using a unique pattern (fig.3.1). While still on the ground the rhinoceros was injected with approximately 1 cc of Azaperone tranquilizer to keep it down in case of the Immobilon getting light. The sledge bearing the rhinoceros was then loaded onto a lorry and transported to the holding pens, located a short distance outside the reserve. Here the rhinoceros was released into the holding pen.

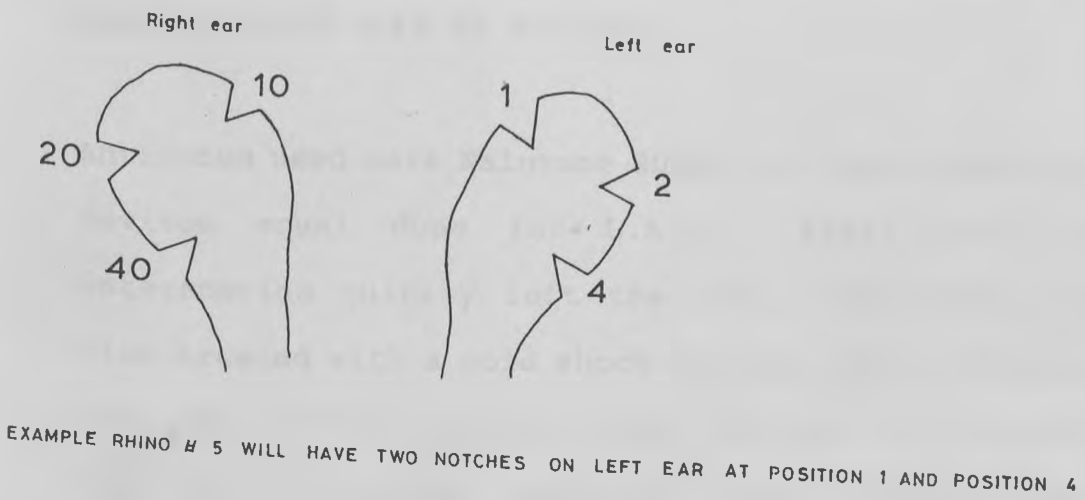

Fig 3.1: Ear Notch Pattern

3.2.2: Revival in the Holding Pens

At the holding pens the sledge was unloaded and pulled into the first pen (fig. 3.2). The gate was secured, the rhinoceros untied and rolled off the sledge, and the latter pulled out of the pen. The rhinoceros was then injected with an antidote.

Antidotes used were Naloxone 200mg for Carfentanyl and Revivon equal dose for L.A.I. After this the veterenarian quickly left the pen. The animal was also treated with a cold shock to make revival faster. The post revival period ranged between 3-4 minutes. Once up, the animal wandered around the pen in a drowsy manner, drank water and then cautiously walked into other empty pens. After reaching the last empty pen the interlinking gate was closed.

3.2.3: Crate Training

A rhinoceros was held in a holding pens for 7-14 days during which time it was closely monitored by a veterinarian and fed by the Game Capture Unit personnel. During this period each rhinoceros was trained to feed in a crate that was later to be used for holding the rhinoceros during transportation to LNNP.

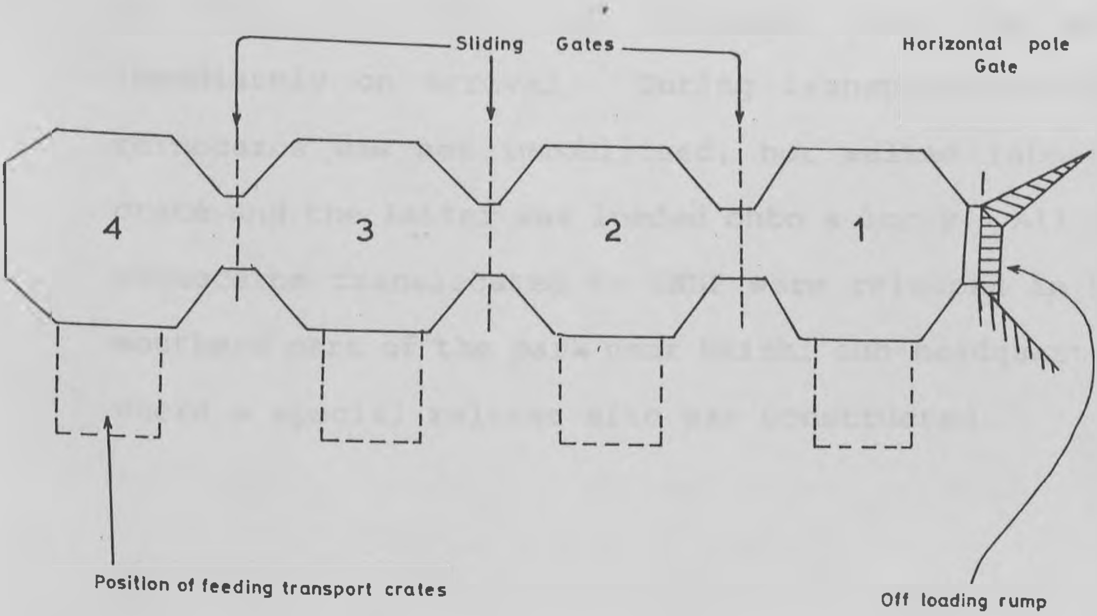

Fig 3.2: Ground Plan for the Holding Pens at SRGR and Position of Feeding Crates

The time a rhinoceros was held in the pen depended on how easily it got accustomed to the crate. Finally each rhinoceros was separately transported in a crate by lorry to LNNP, and released into the wild immediately on arrival. During transportation the rhinoceros was not immobilised, but walked into the crate and the latter was loaded onto a lorry. All the rhinoceros translocated to LNNP were released in the southern part of the park near Naishi sub-headquarters where a special release site was constructed.

3.3: RESULTS

3.3.1: Black rhinoceros distribution in SRGR before capture.

The data presented in table 3.1 was collected during my visits to SRGR and supplemented with data available in the reserve records. The sex ratio and percentage composition were calculated from data, the results were as follows:-

Sex Ratios: Adults -----Female : Male = 1:1.5
Calves ----Male : Female = 1:1.3

Percentage composition:

Adults		Calves
Female	Male	ALL
31	47.9	21.1

F--Females

M-- Males

3.3.2: Results of the Capture exercise at SRGR.

The capture exercise was undertaken in four phases. Each phase involved, capture, crate training, transportation and release.

Table 3.1: The distribution of black rhinoceros in SRGR before the capture exercise. The blocks used in the tables are shown in figure 3.3.

Block	Adults		calves			Total
	F	M	F	M	not sexed	
1	2	4	2	-	-	8
2	3	2	-	2	-	8
3	2	-	-	-	-	2
4	1	2	-	-	-	3
5	1	1	-	-	-	2
6	-	2	-	-	-	2
7	5	3	2	-	2	12
8	2	6	-	1	-	9
9	2	4	-	-	2	8
10	4	10	1	1	1	17
	22	34	5	4	6	71

F---Females, M---Males

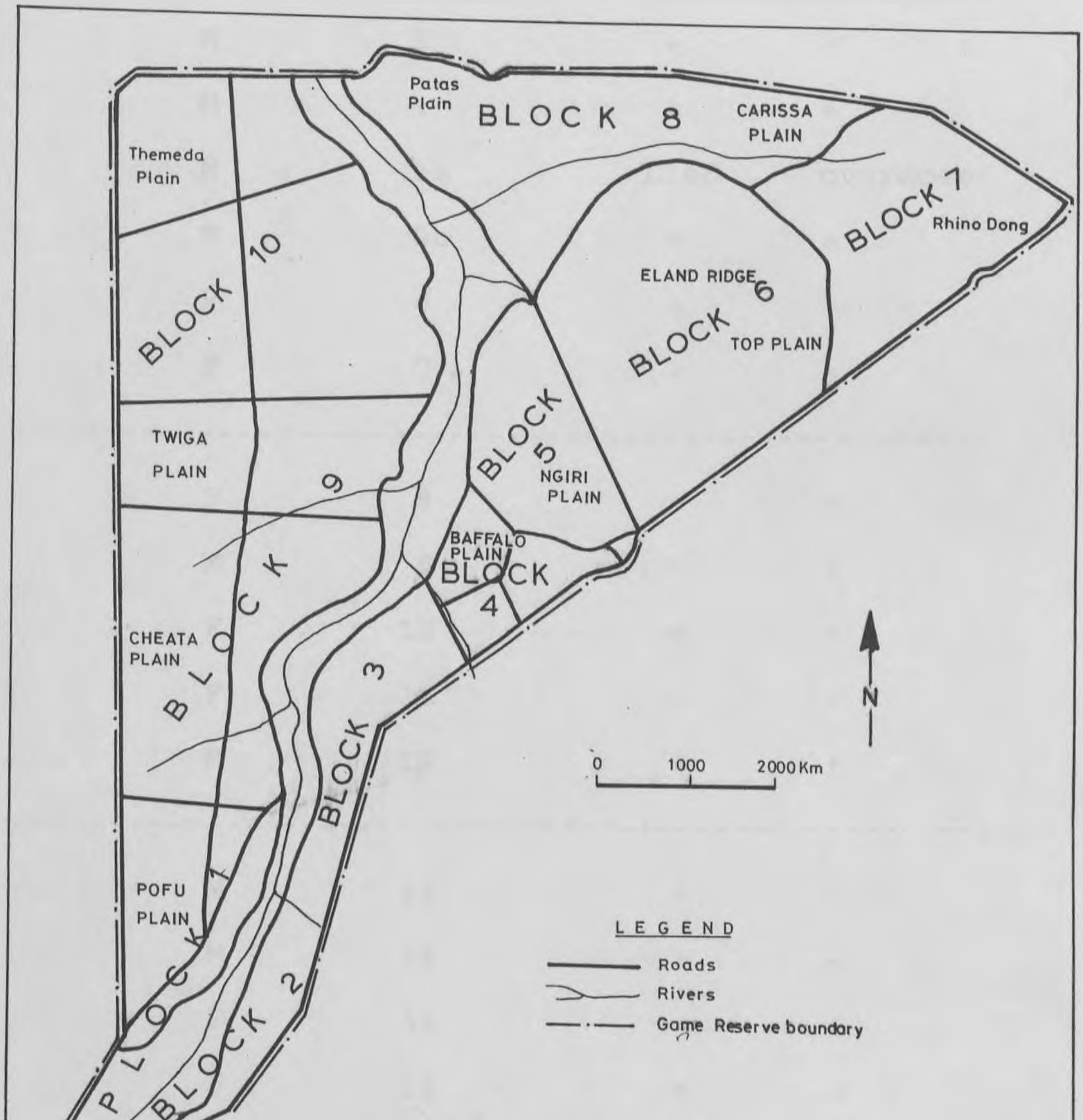

Fig. 3.3: Rhinoceros distribution blocks in SRGR

Table 3.2: The phases, number of rhinoceros captured and fate.

PHASE	SEX	EAR NOTCH NO.	FATE	REMARKS
	M	3	+	+
	M	4	+	+
1	M	5a	Died	overdose
	M	5b	+	+
	F	6	+	+
	F	7	+	+
	F	8	+	+
	M	9	+	+
2	F	10	+	+
	F	11	+	+
	M	12	+	+
	M	13	+	+
	M	14	+	+
3	F	15	+	+
	F	16	+	+
	F	17a	Released	Wrong age
4	M	17	+	+

M --- Male, F --- Female, + ----- Successfully captured and released at LNNP

3.3.3: Black Rhinoceros Population in LNNP at end of Translocation.

Table 3.3: The population status of black rhinoceros in LNNP after the translocation, and their origin.

Sex & Id/no.	Eat notch no.	Age *	Source
Female 1	-	A	Indigenous
Male 1	-	A	"
Male 2	1	S/A	Lewa Downs
Male 3	2	A	Nairobi Park
Male 4	3	6-10	SRGR
Male 5	4	4-6	"
Male 6	5	10-12	"
Female 2	6	15-19	"
Female 3	7	2-4	"
Female 4	8	7-8	"
Male 7	9	6-8	"
Female 5	10	8-9	"
Female 6	11	7-13	"
Male 8	12	2-4	"
Male 9	13	7-13	"
Female 7	14	S/A	"
Male 10	15	S/A	"
Female 8	16	S/A	"
Male 11	17	S/A	"

A --- Adult, SA---subadult.

A total of 19 black rhinoceros (8 females and 11 Males) made up the population at LNNP by end of the translocation exercise. The fate of these rhinoceros have been one birth of a male calf in October 1988, and one relocation of female no.3 to Lewa Downs in early 1989.

The cause of this relocation was serious attacks by another rhinoceros in LNNP. Therefore the population still stands at 19 individuals, with a sex ratio, females:males of 1:1:4. This does not represent the 1:1 sex ratio reported for rhinoceros populations in the wild.

3.3: DISCUSSION

The pioneering black rhinoceros population at SRGR was composed of a few indigenous and translocated rhinoceros. The translocated rhinoceros were captured from the areas surrounding the reserve, which were settled in the early 1960's. These rhinoceros which numbered about 20 individuals had bred and increased to at least 71 individuals by early 1987. This high breeding success can be attributed to: (a) the size of the reserve which is small enough to allow for easy contact between opposite sexes especially during oestrus, (b) high food availability due to the low number of competitors, (c) enhanced security against poachers.

During my visits a total of 71 rhinoceroses were counted. Block 10 (figure 3.2) had the highest number of rhinoceros, 23.9% of the total population. This block lies within the most suitable habitat for rhinoceros in terms of cover and food availability. It covers the *Scutia*/*Carissa*, and the *Carissa*/*Scutia*/*Tarchonanthus* mixed bushland. The two habitat types provide both food and cover for the rhinoceros. Another Block number 7 had 16.9% of the total rhinoceros population. This block is situated on the eastern corner near Naromoro. This is mainly Scutia/Rhus bushland and Acacia drepanolobium shrubland with Carissa/Scutia/Tarchonanthus bushland.

However the distribution of black rhinoceros in the SRGR before capture was all over the reserve. Interblock movement was evident and was dependent on water distribution. During the wet season the feeding grounds were further away from the swamp as compared with the dry season when feeding was concentrated within the swamp and along the valleys. In the wet season water is available all over the park in pools and shallow dams. Individual rhinoceros were observed to maintain specific home ranges whose sizes varied seasonally. A unique observation is the movement of rhinoceros to the swamp region during the dry season when water and green browse is scarce. This movement pattern was observed for the other herbivores. The swamp is therefore a dry season concentration area for all animals in the SRGR.

The sex ratio of 1:1.4 (females:males) is significantly higher than the unit ratio, expected in wild rhinoceros populations. This observation has been recorded elsewhere by Goddard (1970), Mukinya

(1973), and Waweru (1985). However in these cases a sex ratio deviating from the normal was recorded although not significantly higher than the expected.

In fact males are more than females in the existing populations of rhinoceros in the wild. This study and another carried out at Nairobi National Park by Waweru (1985) indicates that in translocated populations the bias in sex ratio is higher than in the non-disturbed populations. This can be attributed to the fact that males are more readily available in the field and are easier to locate and capture. However in the case of SRGR the number of adult males was higher than the number of adult females. The ratio in the identified calves showed no significant difference. This leads to the conclusion that the sex ratio at translocation should be maintained at 1:1. However for the purpose of establishing a breeding population the ratio should be having a bias towards of females. This implies that there should be more females and may be just a few selected breeding males.

The story about the LNNP rhinoceros population before translocation is not clear. There is no documented information on the indigenous rhinoceros. Information collected from herdsmen who used to work in the area (former cattle ranch) which today is the park indicates that three rhinoceros moved from the Eburru hills region into the area around early 1960's. By early 1980's foot prints of two rhinoceros used to be seen. These two were identified as a female and a male. It remains a mystery as to why they had not been breeding over the years. However these two rhinceros were settled in different areas of the park. The failure for the two in breeding can be attributed to the low probability of meeting when the female is in oestrus. The receptive period in a rhinoceros is normally 1-2 days (Hitchins and Anderson, 1980) in addition the male has to be in attendance for sometime which can be upto 6 days.

The capture exercise was successifully conducted with only one casualty. A total of 17 black rhinoceros were captured and successfully translocated to LNNP. Among these 15 were from SRGR one male from Nairobi National Park and another from Lewa Downs farm. The only casualty was one male which died as a result of an overdose at capture. The cause of this overdose was the objective way of estimating the age in the wild whereby a subadult was mistaken for an adult. A female had to be released after capture because it was younger than the accepted age class.

By the end of the exercise the total population in LNNP was 19 black rhinoceros which comprised 11 males and 8 females. The sex ratio was 1:1.4, which is significantly higher than the expected unit sex ratio in wild rhinoceros populations. All have settled except one, female number 3 which was relocated to Lewa Downs farm after being attacked by another rhinoceros. As this was taking place a male calf was delivered in late 1988 by female number 2 which was pregnant at time of capture. In addition another two calves have been delivered since then. This is a clear indication that the rhinoceroses translocated to LNNP are doing alright and the translocation was a success. It also gives a new hope for the survival of the black rhinoceros in Kenya.

CHAPTER 4

VEGETATION

4.1: Introduction:

Woody plants form the major food source for the black rhinoceros which is entirely a browser. Determination of both quantity and quality of the browse are important in assessing the suitability of a given habitat to rhinoceros. This chapter deals with the species composition, density and above ground biomass availability in the two habitats, SRGR and LNNP. All the browse plants were sampled and analysed for the above.

4.2: Methods:

4.2.1: Quantitative Vegetation Survey - Point Centered Quarter (PCQ) Technique.

Vegetation in LNNP and SRGR was grouped into 9 vegetation stands depending on species composition. Although the two areas had equal number of stands, the species composition was different. In each stand at least 2 transects were laid out. The number of transects in a given stand depended on the size of the stand and the distribution of vegetation within the stand. The stands were mapped out from aerial photographs of 1979 and a landsat imagery of 1982.

The transects varied in length depending on the width of the stand. The minimum length was 50 metres. The vegetation survey technique applied is a modified form of the Points Centered Quarter Method (PCQ) (Morisita 1954, Cottam & Curtis, 1956; Mueller - Dombois & Ellenberg, 1974). Each transect was subdivided into 10m intervals and the points marked. The first point was always 0 and was not sampled. At each sampling point 4 quarters were established through a cross formed by two lines, one line was the compass direction and the second is a line running perpendicular to the compass direction through the sampling point. Working in a clockwise manner all the quarters were numbered 1-4 starting from the compass direction. In each quarter one plant of each species nearest to the point, was measured. Several measurements were taken, the distance to the mid-point of the plant from the sampling point, the height from the ground, and the stem diameter. All these measurements were recorded on a field note book and transfered to data forms later, (Appendix 1).
Data obtained was used to calculate the density and species composition for each stand. The species composition was obtained by recording all the

different species identified and their relative frequencies. The formulae below were used and a computer programme developed for the analysis.

Formulae used for the PCQ data analysis:

$$\text{Relative Density} = \frac{\text{individual of a spp.}}{\text{total individuals of all spp.}} \times 100$$

$$\text{Density} = \frac{\text{R D}}{100} \times \text{total density of all spp.}$$

$$\text{Dominance} = \text{density of spp.} \times \text{average dominance value for spp.}$$

$$\text{Relative Dominance} = \frac{\text{dominance for a spp.}}{\text{total dominance for all spp.}} \times 100$$

$$\text{Frequency} = \frac{\text{No. of points at which spp. occurs}}{\text{total No. of points sampled}}$$

$$\text{Relative Frequency} = \frac{\text{Frequency value for a spp.}}{\text{total of frequency values for all spp.}} \times 100$$

Importance value = Relative density + Relative dominance + Relative frequency.

$$\text{Total density of all spp.} = \frac{\text{Unit Area}}{\text{Mean point to plant distance}}$$

where unit area refers to the size of the sample area in the same units as those for the mean area per plant on the basis of which density is to be expressed, e.g. if density is to be per sq km and mean area/plant is in units of square metres, the unit area value in the calculation would be 1,000,000 (the number of square metres in one square kilometre).

This technique has an advantage since it does not require laying out of plot boundaries, saves time, eliminates the personal error from judging whether boundary individuals are inside or outside (Mueller-Dombois & Ellenberg, 1974).

4.2.2: Line Intercept Technique:

This method of measuring cover was described by Canfied (1941). It is based on the principle of reducing the belt transect which has two dimensions of length and width to a line with only one dimension namely length.

A measuring tape was laid out on the ground and the crowns that overlay or intercept the line were measured. Two measurements, one across and the other along the canopy were recorded to the nearest centimetre. In addition the canopy depth was also measured and recorded. This method has an advantage for measuring the crown cover of woody plants, shrubs and trees. The sources of error are in the relative accuracy of vertical projection and the crown outline itself. Doubermire (1968) came out in favour of rounding out canopy edges and "filling in" internal gaps on the argument that these gaps may be part of the ecological territory of an individual plant. However, density is better assessed by other methods e.g. PCQ.

The transects sampled were the same as those done earlier in PCQ. Data obtained was used to compute for the crown cover within the study area for the purpose of biomass determination. The crown cover is calculated by averaging the intercept along transect and perpendicular measurement then substituting in the formula.

$$CC = \frac{(D1 + D2)}{4} \Pi$$

where CC = canopy area.

$$II = \text{constant } \frac{22}{7}$$

DI = intercept along transect.

D2 = perpendicular intercept.

The purpose of using two diametres D1 & D2 is because plant crowns do not usually form a perfect circle, and therefore it is necessary to run at least a second diameter perpendicular to the first one.

The canopy volume is obtained by assuming that plant crowns assume the form of a cylindrical cone and applying the formulae:

$CV = 1/3 \ r^2L.$ CV - canopy volume.

where $II = \frac{22}{7}$

$r = \frac{D1 + D2}{4}$ D1 - 1st diameter

D2 - 2nd diameter

L = Crown depth measured from where the branching starts to the top.

The results are expressed in M^3 .

The browse biomass for each species was calculated using the following regression equation (Western *et al*., 1982):-

AGDM = 1.0433 log CV + 0.0707

where AGDM - Above ground dry mass
CV - canopy volume
Slope - 1.40303
Constant - 0.707

The AGDM is expressed as Kgm^{-3} of canopy volume.

The mean canopy volume for each species in each stand is computed and multiplied by its mean AGDM to give the mean available browse biomass for each species in the stand. This is multiplied by the density values to give the total available browse biomass values for each species which when sumed gives the total for the whole stand. The stand totals are summed to give the total available browse biomass for the whole study area.

4.3: RESULTS.

4.3.1: Lake Nakuru National Park.

Vegetation studies were conducted in LNNP (before any rhinos were released and also after release of rhinos.The vegetation in LNNP was subdivided into four major vegetation communities based on structural classification (fig.4.1.). Each of the vegetation communities is further divided into several classes depending on the species composition and growth form. It is worth noting that these classifications were basically for the purpose of this study which was mainly invloved in the woody plants (major rhino food source). The vegetation is described below:-

1: FORESHORE VEGETAION.

This vegetation community is subdivided into three classes:-

Littoral zone: This area is covered by shallow water all the time except during the dry season when the waterline recedes leaving the area exposed. The major plants are aquatic dominated by the algae. This is the major feeding zone for the flamingoes and other

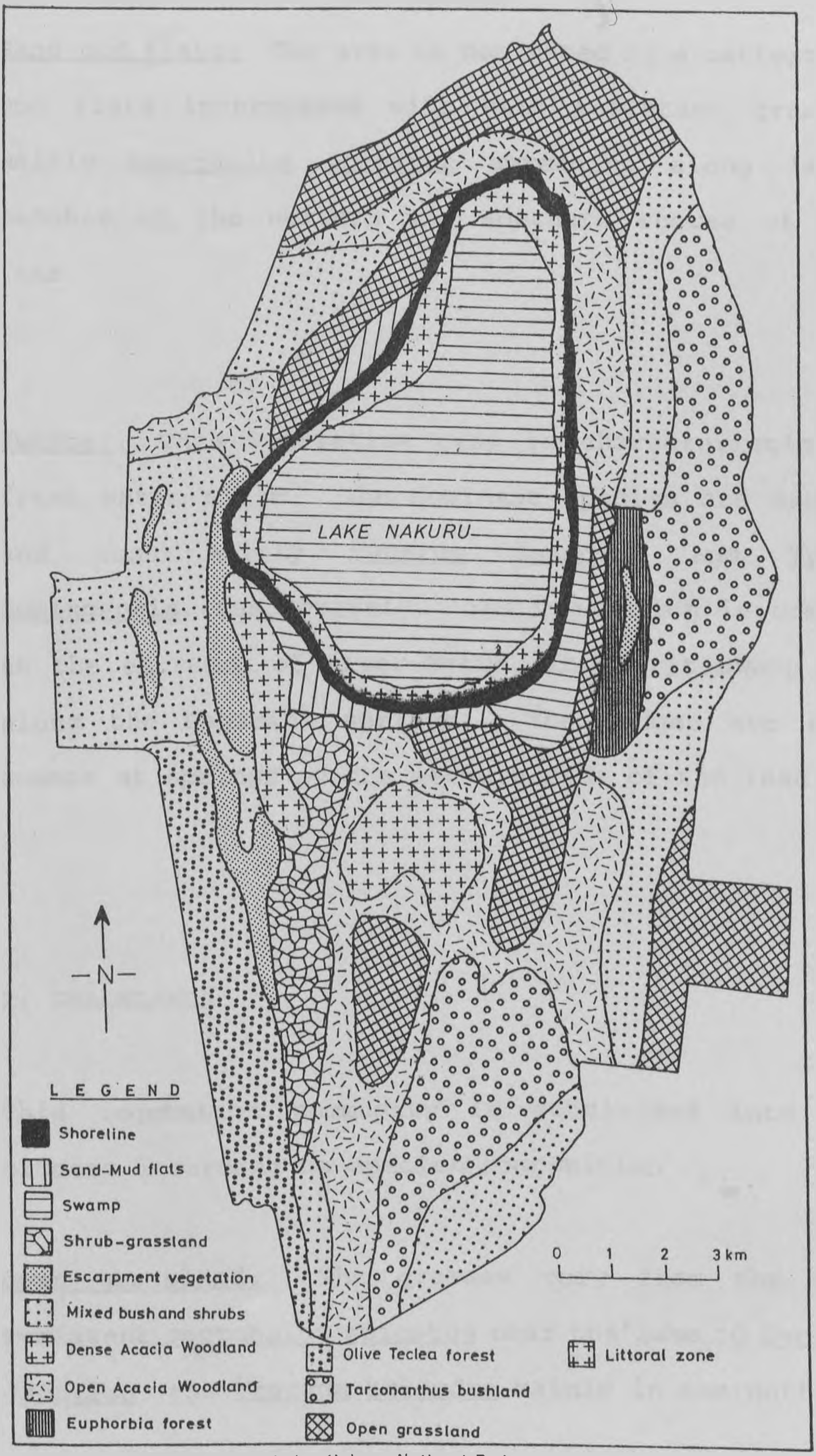

Fig. 4.1: Vegetation Map. Lake Nakuru National Park

bird communities in Lake Nakuru.

Sand-mud flats: The area is dominated by a pattern of mud flats interpersed with salt resistant grasses mainly *Sporobolus spicatus* spreading along large patches of the western and southern shores of the lake.

Swamps: This vegetation type is characteristic of fresh water areas. The dominant species are sedges and rush mainly *Cyperus immensus* and *Typha domingensis*, respectively. The vegetation is common at the entrance of river Njoro, in Nderit swamp and along the Baharini springs. The sedges are also common at springs on the western side of the lake.

2: GRASSLANDS.

This vegetation community is subdivided into two classes according to species composition.

Open grassland: The grasses vary from the salt resistant *sporobolus spicatus* near the lake to *Cynodon dactylon*, and *Themeda triandra* mainly in the nothern part of the park. In the southern part of the park the dominant species include Themeda triandra, Cynodon dactylon, Chloris gayana and Hyparrhenia spp. These grasses are common near the Naishi sub-headquarters and the east of Lake Nakuru Lodge.

Shrub Grassland: This vegetation type predominates the central area between the Nasoit hill and the western escarpment south of the lake. The dominant grasses are Themeda triandra and Cynodon dactylon. Several shrubs are common in this area, these are Aspilia mossambicensis, Tarchonanthus camphoratus, Lantana triphylla, Cordia ovalis and Grewia similis.

3: BUSHLAND.

Under this vegetation community there three classes namely escarpment vegetation, Tarchonanthus bushland, and mixed bush/shrubland.

Escarpment Vegetation: It is situated on the slopes of the cliffs on the western side of the Park and a small section on the Lion hill on the east. The dominant species are Croton dichogamus, Iboza spp, Tarchonanthus camphoratus and Stegoniata spp. the grasses include Andropogon chinesis and Eleusine spp.
Tarchonanthus Bushland: This is a pure stand of

Tarchonanthus camphoratus interspersed by occasional Cordia ovalis and Maerua triphylla. Also present is the Lantana triphylla, Psiada punculata, Aloe graminicola and Ocimum suave. The major grasses are Themeda triandra and Cynodon dactylon.

Mixed Bush/Shrubland: This vegetation type is found on the eastern, southeastern and the northern parts of the Park. The dominant species includes Tarchonanthus camphoratus, Cordia ovalis, Euphoria candelabrum, Maytenus heretophylla and Tinnea aethiopica. Also present are Aloe graminicola young Teclea simplicifolia and Hypoestis verticillaris.

4: WOODLANDS.

There are four major forests in LNNP which differ in both structure and composition. These forests are described below.

Open Acacia Woodland: this is situated on the nothern and south-western shores of the lake. The dominant species is Acacia xanthophloea which forms open stands. The undergrowth is composed of annual forbs and herbs which are grazed to the ground during dry season leaving the forest floor almost bare. The dominant species are Achyranthes aspera and Urtica massaica.

Dense Acacia Woodland: Situate to the south of the lake is a thick stand of Acacia xanthophloea with dense undergrowth composed mainly of Rhus natalensis, Capparis tomentosa, Abutilon spp. and Erythrococca bongensis. Also present is Toddalia asiatica and Gnidia subcordata. This vegetation is interpersed by open glades covered by grasses.

Olive-Teclea Forest: A dense stand of mixed hard woods dominate the south-western part of the park. The major species are wild olive (Olea africana) and Teclea simplicifolia. Other species include Cordia ovalis, Euclea divinorum, Tarchonanthus camphoratus, Grewia similis and Tinnea Aethiopica. Occassional Acacia gerrardii is present.

Euphorbia Forest: This is a pure stand of mature Euphorbia candelabrum found on the south western slopes of lion hill. Other woody species present include Cussonia holstii, Obetia pinnatifida, Cordia ovalis and a few Acacia xanthophloea (which emerge above the general canopy). Results of vegetation surveys carried out in this area have indicated the invasion of the floor by several species. These include, Teclea simplicifolia, Grewia similis, and Tarenna graviolens. Also present is young Obetia pinnatifida. Young Euphorbia candelabrum was not recorded in the forest during the surveys.

4.3.2: SOLIO RANCH GAME RESERVE.

Results discussed in this section are from a vegetation survey conducted in the area before the beginning of the translocation. The vegetation was classified into seven classes based on the species composition and structural appearance in the area (fig. 4.2). To align the class boundaries a landsat image of 1982 was used and the ground surveys were conducted to ascertain the species composition and densities (Table 4.3B). The study was concentrated mainly on woody vegetation, though herbaceous species encountered along the transects were recorded.

A: SWAMP VEGETATION.

This vegetation type is found along the Engare Moyok river which occupies the central part of the reserve. The major plants the Cyperus articulatus, Cyperus immensis and Typha latifolia in the southern part of

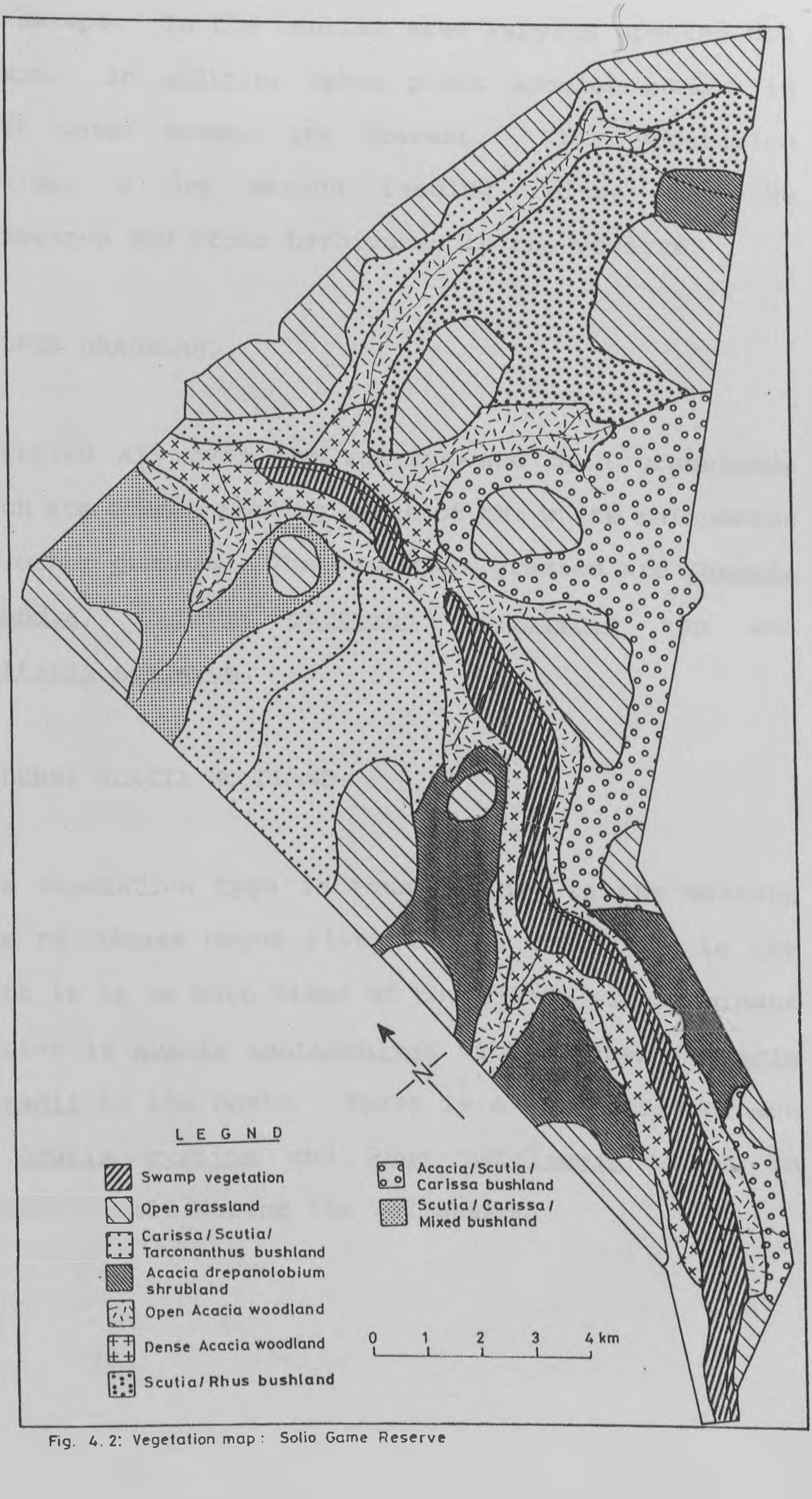

Fig. 4. 2: Vegetation map : Solio Game Reserve

the swamps. In the central area Papyrus species are common. In addition other plant species common in fresh water swamps are present. This vegetation provides a dry season feeding refuge for the rhinoceros and other herbivores in the reserve.

B: OPEN GRASSLAND.

Scattered all over the reserve are open grasslands which are common feeding sites of the white rhinoceros and other grazers. The commonest grasses are Themeda triandra, Cynodon dactylon Brachiaria spp and Digitaria scalarum.

C: DENSE ACACIA WOODLAND.

This vegetation type is found mainly in the western side of Engare Moyok river in the south but in the north it is on both sides of the river. The dominant species is Acacia xanthophloea with scattered Acacia gerradii in the north. There is a dense undergrowth of Scutia myrtina and Rhus natalensis which is impenetratable during the wet season.

D: OPEN ACACIA WOODLAND.

It is observed on the periphery of the dense Acacia woodland and in the valleys. Acacia xanthophloea is the dominant species. The undergrowth is mainly open and almost bare (during the dry season). Present in the understorey are scattered Achyranthes aspera, Erythrococca bongensis and Hypoestis verticillaris. These plants are heavily browsed during the dry season.

E: ACACIA DREPANOLOBIUM SHRUBLAND.

This vegetation type is situated on the western side of the reserve. It is a pure stand of mature Acacia drepanolobium (whistling thorn). Also present in the area are scattered Psiadia punculata and Hibiscus micranthus.

F: CARISSA/SCUTTA BUSHLAND.

Situated on the north-western side of the Reserve is a bushland composed of mainly, Carissa edulis and Scutia murtina species. Also present but occassionally, is Acacia drepanolobium and Tarchonanthus camphoratus.

G: ACACIA/SCUTIA/RHUS BUSHLAND.

This vegetation type is located in the south-eastern part of the Reserve. The dominant plants are Acacia drepanolobium with thick bushes of Scutia murtina and Rhus natalensis. It is one of the major black rhinoceros habitats.

H: SCUTIA/CARISSA/RHUS BUSHLAND.

This bushland type is located at the north-western part of the Reserve. The dominant species are Scutia myrtina, carissa edulis and Rhus natalensis. Also present are Psiadia punculata and Maytenus heterophylla. This is another important rhino habitat.

I: SCUTIA/RHUS BUSHLAND.

This is a common vegetation type south of Naroibo Dam. The dominant species are scutia myrtina and Rhus natalensis. In addition scattered Acacia drepanolobium and Psiadia punculata are present. All these habitat are inhabited by black rhinoceros. However water is mainly from Engare Moyok river which is the dry season concentration area for herbivores in

Solio Game Reserve.

4.3.3: Browse Species Composition and Density

1. Lake Nakuru National Park.

Table 4.3.A indicates that the woody vegetation in LNNP was composed of 67 species which belong to 30 families. The family compositae was the most important in terms of the number of species followed by *Malvaceae*. The leguminosae family in which *Acacia xantholophloea* belongs never occured dominantly in terms of species numbers. However in terms of density the most important species was *Acacia xanthopholea* followed by *Tarchonanthus camphoratus* and *Ocimum suave*. *Commelina benghalensis* although a herbaceous plant was well represented. Others included *Psiadia punculata*, *Lantana triphylla*, *Maytenus heterophylla*, *Aspilia mossambicensis* and *Senecio petitianus*. The total density for all woody vegetation for the whole study area was 4.2x10 stems/ sq km.

2. Solio Game Reserve

Solio Game Reserve is a relatively open and small area as compared to LNNP. A total of 41 species from 25

Table 4.1: Browse Species Composition and Densities in Lake Nakuru National Park.

Species	Density (stems km)	Percentage Composition	Family
Cordia ovalis	49213	1.20	BORAGINACEAE
Grewia similis	141403	3.32	TILIACEAE
Secomone stenophylla	535	0.01	ASCLEPIADACEAE
Abutilon spp.	80973	1.90	MALVACEAE
Asparagus fulcatus	82654	1.94	LILIACEAE
Euphorbia candelabrum	101453	2.38	EUPHORBIACEAE
Hibiscus micranthus	75684	1.78	MALVACEAE
Pavonia patens	6113	0.14	"
Pupalia lappacea	654	1.53	AMARANTHACEAE
Solanum spp.	145704	3.42	SOLANACEAE
Tinnea aethiopica	71433	1.68	LABIATAE
Capparis tomentosa	35302	0.83	CAPPARACEAE
Maerua triphylla	158901	3.73	"
Rhus natalensis	96433	2.26	ANACARDIACEAE
Euclea divinorum	3131	0.07	EBENACEAE
Carissa edulis	60	-	COMPOSITAE
Asparagus africana	12706	0.30	LILIACEAE
Senecio petitianus	176417	4.14	COMPOSITAE
Commelina africana	821	0.02	COMMELINACEAE
Commelina benghalensis	26486	0.62	"

Sansevieria parva	5966	0.14	AGAVACEAE
Aloe spp.	139486	3.27	LILIACEAE
Sarcostema viminale	16066	0.38	ASCLEPIADACEAE
Croton dichogamous	1345	0.03	EUPHORBIACEAE
Acacia xanthophloea	345912	8.12	LEGUMINOSAE
Acacia gerrardii	74356	1.74	"
Tarchonanthus camphoratus	321213	7.54	COMPOSITAE
Tagetes minuta	64508	1.51	"
Bidens pilosa	1041	0.02	"
Lantana triphylla	193096	4.30	VERBENACEAE
Commicarpus penduncuIosus	14770	0.35	NYCTAGINACEAE
Dregea schimperi	10388	0.24	ASCLEPIADACEAE
Erythrococca bongensis	25714	0.60	EUPHORBIACEAE
Archyranthes aspera	147007	3.45	AMARANTHACEAE
Psiadia punculata	184762	4.34	COMPOSITAE
Teclea simplicifolia	47918	1.12	RUTACEACEAE
Celosia anthelmintica	1793	0.04	AMARANTHACEAE
Aspilia mossambicensis	176510	4.14	COMPOSITAE
Helinus integrifolius	350	0.01	RHAMNACEAE
Rhamnus studdo	181	-	"
Tarenna fraviolus	5934	0.14	RUTACEAE
Vernonia spp.	60	-	LABIATAE
Dombeya bongessiae	18170	0.43	STERCULIACEAE

Leucus spp.	60	-	LABIATAE
Leonotis nepetifolia	13794	0.32	"
Ocium suave	205417	4.82	"
Hibiscus flavifolius	79547	1.87	MALVACEAE
Maytenus heterophylla	171285	4.02	CELASTRACEAE
Hibiscus aponeuris	6888	0.16	MALVACEAE
Olea africana	7461	0.18	OLEACEAE
Notonia patraea	15493	0.36	COMPOSITAE
Plectranthus cylindrica	67564	1.59	LABIATAE
Plectranthus barbatus	43310	1.02	"
Hibiscus fuscus	38499	0.90	MALVACEAE
Canthium schimperianum	2452	0.06	RUBIACEAE
Gnidia subcordata	2529	0.06	THYMELACEAE
Kendrostis foetidissima	3509	0.08	CUCURBITACEAE
Crassocephalum manii	14021	0.33	COMPOSITAE
Lippia javanica	120	-	VERBENACEAE
Barleria spp.	164651	3.86	ACANTHACEAE
Hypoestis verticillaris	165099	3.87	ACANTHACEAE
Cyphostema spp.	364	0.01	VITACEAE
Wurbugia ugandensis	145	-	CANELLACEAE
Grewia trichocarpa	9701	0.23	TILIACEAE
Ziziphus mucronata	749	0.02	RHAMNACEAE
Opuntia spp.	95314	2.24	CACTACEAE
Gutenbergia cordifolia	49407	1.16	COMPOSITAE
Total Density (stems/km2)	422001	100.35	

Table 4.2: Browse Species Composition and Density in Solio Ranch Game Reserve.

Species Composition	Density (stems/km)	Percentage	Family
Acacia drepanolobium	143240	26.84	LEGUMINOSAE
Hibiscus micranthus	39913	7.48	MALVACEAE
Scutia myrtina	36535	6.85	RHAMNACEAE
Achyranthes aspera	16518	3.10	AMARANTHACEAE
Psiadia punculata	45958	8.61	COMPOSITAE
Leonotis nepetifolia	876	0.16	LABIATAE
Jasminum spp.	794	0.15	OLEACEAE
Aloe spp.	10102	1.89	LILIACEAE
Gutenbergia cordifolia	1417	0.27	COMPOSITAE
Capparis tomentosa	4486	0.84	CAPPARACEAE
Commelina spp.	2060	0.39	COMMELINACEAE
Lantana triphylla	24190	4.53	VERBENACEAE
Notonia petraea	1468	0.28	COMPOSITAE
Asparagus fulcatus	32226	6.04	LILIACEAE
Grewia similis	16210	3.04	TILIACEAE
Kalanche spp.	13734	2.57	CRASSULACEAE
Maytenus heterophylla	14246	2.67	CELASTRACEAE
Rhus natalensis	22250	4.17	ANACARDIACEAE
Kendrostis foetidissima	7098	1.33	CUCURBITACEAE
Olea africana	3988	0.75	OLEACEAE
Plectranthus spp.	340	0.06	LABIATAE

Asparagus africana	6140	1.15	LILIACEAE
Carissa edulis	26280	4.49	COMPOSITAE
Abutilon spp.	8875	1.66	MALVACEAE
Solanum incanum	4714	0.88	SOLANACEAE
Hypoestis verticillaris	13550	2.54	ACANTHACEAE
Euclea divinorum	10093	1.89	EBENACEAE
Clausena anisata	697	0.13	
Tinnea aethiopica	255	0.05	LABIATAE
Erythrococca bongensis	8610'	1.61	EUPHORBIACEAE
Acacia xanthophloea	9207	1.73	LEGUMINOSAE
Chenopodium fasciculosum	130	0.02	CHENOPODIACEAE
Aerva lanata	3429	0.64	AMARANTHACEAE
Commicarpus penduncculosus	598	0.11	COMPOSITAE
Dregea schimperi	256	0.05	ASCLEPIADACEAE
TOTAL	532798	99.47	

families were encountered during the survey (Table 4.3 B). In respect to species numbers the family Compositae had the highest, followed by Labiatae. On density values, Acacia drepanolobium had the highest, followed by Psidia punculata, Asparagus fulcatus, Carissa edulis and Lantana triphylla. The total density for all the woody plants encountered in the study was 5.3x10 stems/km^2 .

4.3.4: Community Similarity index.

Jaccard's Coefficient (Southwood, 1978) was calculated for the two study areas. The formula is based on the presence and absence relationships between the numbers of species common to the two study areas (LNNP and SRGR) and the total number of species.

The formula is:-

$$ISj = \frac{c \times 100}{a+b+c}$$

where ISj ----- Jaccard's Index of Similarlity.

a ----- number of species unique to LNNP.

b ----- number of species unique to SGR.

c ----- number of species common to both LNNP and SRGR

When values in Tables 4.3A and 4.3B are substituted in the above formula the results are:-

$$ISj = \frac{32}{35+9+32} \times 100 = 42\%$$

Giving equal weight to presence and absence of all species the two vegetation communities are different as opposed to what one would have expected at first observation of the data (Tables 4.3A and 4.3B).

4.3.5: Available Above Ground Browse Biomass.

Table 4.3C represent results of the above ground browse biomass in the two study areas expressed in tonnes/km^2 . The results indicate that LNNP had a total density of 7.4×10^4 tonnes/km^2 . The SGR had a total density of 3.1×10^3 tonnes/km^2 . In terms of biomass in LNNP the most important species were Acacia xanthophloea followed by Euphorbia candelabrum, Tarchonanthus camphoratus, Rhus natalensis and Maytenus heterophylla. The least important species included Commelina africana, Chenopodium fasciculosum, Pupalia lappacea and Plectranthus cylindirica.

In SRGR the most important species in terms of biomass was Acacia xanthophloea and others included Acacia drepanolobium and Scutia myrtina. Of least importance were Comicarpus penduncolosus, Celosia anthelmintica, Dregia spp. Gutenbergia cordifolia and Acacia brevispica

Table 4.3: Above Ground Browse Biomass (TBB -- total above ground biomass, ABB*--available browse biomass in tonnes/km^2).

Species	L.N.N.P. TBB	L.N.N.P. ABB	S.R.G.R. TBB	S.R.G.R. ABB
Cordia ovalis	860.3	541.9	10.2	7.5
Grewia similis	1016.5	895.3	5.7	5.0
Secomone stenophylla	0.5	0.5	0	0
Abutilon spp.	42.9	42.9	0.2	0.2
Asparagus fulcatus	0.2	0.2	4.2	3.9
Euphorbia candelabrum	4959.4	1007.0	2.1	0.8
Hibiscus micranthus	10.6	10.6	1.2	1.2
Pupalia lappacea	0.1	0.1	0	0
Pavonia patens	8.5	8.5	0	0
Tinnea aethiopica	82.9	63.8	0.2	0.2
Capparis tomentosa	327.2	247.2	0.1	0.1
Maerua triphylla	961.4	413.7	64.2	64.0
Rhus natalensis	1517.9	1214.3	64.5	56.2
Euclea divinorum	37.3	14.9	23.2	20.0
Asparagus africana	1.4	1.3	0.6	0.6
Chenopodium fasciculosum	0.1	0.1	0	0
Carissa edulis	0	0	95.9	78.2
Solanum incanum	5.8	5.8	0.02	0.02

*---- Plants which were $\leq$ 2.5 were considered as readily available to the rhinoceros.

+---- Percentage ABB/TBB.

Senecio petitianus	1346.8	932.4	0	0
Commelina benghalensis	0.5	0.5	0.1	0.1
Aloe spp.	7.0	7.0	0.1	0.1
Sarcostem viminale	58.6	23.5	2.4	1.8
Croton dichogamus	2.7	2.7	0	0
Acacia xanthlophloea	56580.0	16974.0	2442.0	1958.3
Acacia gerrardii	88.6	35.4	0	0
Tarchonanthus camphoratus	3700.0	1587.2	21.3	16.0
Lantana triphylla	113.6	113.6	1.6	1.6
Erythrococca bongensis	21.0	21.0	1.6	1.6
Achyranthes aspera	16.2	16.2	0.2	0.2
Psidia punculata	133.0	112.3	6.9	6.9
Teclea simplicifolia	246.3	95.0	0	0
Aspilia mossambicensis	261.2	261.2	0	0
Tarenna graviolus	59.3	32.1	0	0
Vernonia galamensis	31.4	31.4	0	0
Dombeya burgessiae	75.8	75.8	0	0
Leonotis nepetifolia	11.8	11.8	0.02	0.02
Ocimum suave	16.4	16.4	0	0
Hibiscus flavifolius	10.3	10.3	0	0
Maytenus heterophylla	1349.3	859.6	3.1	2.7
Hibiscus aponeuris	0.7	0.7	0	0
Olea africana	300.9	104.5	14.4	6.1
Notonia petraea	15.2	15.2	0.01	0.01
Hibiscus fuscus	58.2	58.2	0	0

Canthium schimperianum	9.3	4.0	1.3	0.8
Gnidia subcordata	14.6	14.6	0	0
Kendrostis foetidissima	7.3	5.8	1.9	1.4
Crassocephalum manii	56.9	39.2	0.5	0.3
Barleria spp.	3.3	3.3	0	0
Hypoestis verticillaris	3.4	3.4	1.2	1.2
Cyphostema spp.	2.3	2.3	0	0
Opuntia spp.	1.4	1.4	0	0
Acacia drepanolobium	0	0	158.9	149.7
Scutia myrtina	0	0	146.1	103.9
Clausena anisata	0	0	0.01	0.01
Acacia brevispica	0	0	0.01	0.01
Kalanchoe spp.	0	0	5.8	5.8
Aerva lanata	0	0	0.6	0.6
Jasminum spp.	0	0	0.03	0.03
Gutenbergia cordifolia	1.4	1.4	0.01	0.01
Dregea spp.	0	0	0.01	0.01
Celosia anthelmintica	0	0	0.01	0.01
Commicarpus penduncLulosus	0	0	0.01	0.01
TOTALS	74443.9	2594.3	3082.67	2494.1

It is worthy noting that most of the species in LNNP were in dense stands and conspicuously larger in size as compared to those in SRGR. The density values in tables 4.3A and 4.3B indicate that there are significant differences in density of individual species in each community. The above ground browse biomass is dependent on the individual plant species growth form, size and density.

4.4: DISCUSSION.

The two habitats appear similar at first glance. In total 42 plant species were common to both study areas. This contributed to the selection of LNNP as the potential home for the black rhinoceros which were to be translocated from SRGR. However besides the species common to both study areas there were others unique in each of the study areas. Results on densities have indicated that LNNP is a richer habitat in terms of species diversity as compared to SRGR. The species also occur in higher densities in LNNP as compared to SRGR.

The open nature of vegetation cover in SRGR makes it a relatively poor habitat as compared to LNNP, and this was the main criteria used when deciding on the translocation. Most of the woody vegetation in SRGR has almost disappeared due to over-browsing. An example is the Acacia drepanolobium stands which show very little regeneration. This being one of the major black rhinoceros food plant, have resulted in the rhinoceros heavily browsing other plant species. The openness of vegetation in SRGR can be attributed to this over-browsing, which is a result of overstocking.

Most of the browse plants in LNNP have not been exposed to serious browsing for a long time. Before the rhinoceroses were translocated to LNNP the only browsers were the Rothchilds' giraffe introduced in 1977 (Kakuyo 1980). Before 1977 the area had no browsers and woody vegetation flourished with very little interference. The giraffe population has built up over the years and today their presence is very obvious due to stunted growth form in young woody plants and the marked browse line in older plants. An example of the plants are Acacia xanthophloea and Maerua triphylla.

The absence of browsers in LNNP for a long time, have resulted in dense woody vegetation with high diversity. Forests like the Euphorbia candelabrum were already above the browse line before the first browsers (Rothchild's giraffe) were introduced in 1977. The SRGR have been having the browsers since its inception in the early 1960s. The giraffes and rhinoceros were translocated into the reserve from the surrounding settlements and this was followed by an influx of grazers. For some time the reserve has been overstocked, this has resulted in vegetation destruction. Some species like Acacia drepanolobium, Achyranthes aspera and Grewia similis have been browsed almost to extermination. This implies that the openness of SRGR vegetation is a result of the existence of high stocking rates of browsers, while the LNNP case can be attributed to the absence of browsers for a long time (park files).

Another factor which could be responsible for the difference is the rainfall regime in each of the study areas. The SRGR falls within the semi-arid zone with erratic rainfall, while LNNP is within the high potential area which has higher and more reliable rainfall. Although the habitats apear similar the Jacard's index of similarity indicates that the two habitats are not similar. The difference is in respect to species composition and can be attributed to the climatic and soil factors.

As indicated in the results the above ground biomass in LNNP is much higher than in SRGR. Biomass of plants is dependent on the plant growth form and the density of the particular plant. However not all the above ground biomass is readily available to the black rhinoceros. Browse material above 3m in height is out of reach for the black rhinoceros, and is termed as unavailable.

The available browse accounts for only 35% in LNNP and 81% in SRGR. This can be attributed to the growth form of the browse plants. In SRGR the plants are relatively shorter than in LNNP. In the latter the plant are very tall and gigantic in nature, especially in Acacia woodland, Olive-Teclea forest and the Euphorbia forest. Some of the plants have a canopy reaching as high as 20m and starting at about 10m above the ground. Most of this browse is unavailable to browsers. Therefore the rhinoceros whose home ranges falls within these vegatation types will depend solely on the undergrowth species for food.

The SRGR had 2.5×10^3 tonnes/km^2 of available browse biomass and supported a population of approximately 71 rhinoceros. This implies that the density was 1.3 individuals/km^2 , and a browse biomass density of 1.9×10^{1} tonnes/km^2 supported one rhinceros. Using the above information, the potential rhinoceros carrying capacity for LNNP was predicted to be at a density of 1.4 rhinoceros/km^2 . This density is not very high when compared to other areas like the Lerai forest in the Ngongoro crater, where Goddard (1967a) reported a density of 9 rhinoceros/km^2.

Using the above density values, LNNP has a potential rhinoceros carrying capacity of about 203 rhinoceroses. However if this figure is attained one would expect a problem in respect to vegetation deterioration as was the case in SRGR. It will be reasonable to maintain the rhinoceros population in LNNP at 100 Individuals the optimum sustainable yield level. A pioneering population of about 40 rhinoceroses should be ideal. These can be allowed to breed freely and build up, to reach about 100 individuals. After this any excess rhinoceros can be translocated to other areas for reintroduction or introduction.

The available browse biomass in LNNP is almost the equal to that of SRGR. This can be attributed to the fact that most of the woody vegetation at LNNP is taller than what the rhinoceros can reach. This results in most of the browse material being unavailable to the rhinoceros. The rhinoceros can only reach browse material which is $\leq$ 2.5 m high (Waweru 1985).

Therefore, although there is a lot of browse material in LNNP, not all of it is available to the rhinoceros, some of the browse is not even available to the Rothschild's giraffe.

CHAPTER 5

FEEDING HABITS

5.1: INTRODUCTION

Feeding studies are aimed at determining the quantitative composition of the animal's diet. This can be achieved by identifying what the animal feeds on, the food distribution and availability in the field. Seasonal variation in the diet is known to occur in animals. Therefore in this study the dietary composition and it's seasonal variation was analysed for both SRGR and LNNP over two seasons, classified as dry (September-December) and wet (March-May).

The microhistological technique was applied in determining the dietary composition. Information obtained from this section were analysed and compared with results obtained on composition and availability of food plants in the two study areas (Chapter 4). The comparisons formed a basis for determining what effects the translocation of the rhinoceros from SRGR to LNNP had on their dietary composition and species preference during the wet and dry seasons.

5.2:METHODS

5.2.1: Microhistological Analysis

Knowledge of the species of plants consumed by herbivores season by season is fundamental for proper grazing/browsing management (Sanders et al., 1980). The commonly used methods for obtaining diet composition have included direct animal observation, Flux (1967): Field (1970); Goddard (1970); Leuthold (1970); Carpenter et al., (1979); Sanders et al., (1980), and Monro (1982). Other techniques involve sampling along the alimentary canal, Kirkpatrick, 1965) from mouth; Varva et al., (1978), Graetz & Wilson (1980) and Holechek and Varva (1981) from the oesophagus; Dirschl (1962), Chippendale (1968), Hansson (1970) from stomach.

Determination of the diet through analysis of faecal material collected from the field has been employed by Storr (1961), Voth and Black (1973), Marti (1982), Waweru (1985), and Barker (1986). Unlike other food habits techniques the microhistological faecal analysis technique has an objective way to provide "proof" for the validity of records reported by an observer. The basis of this technique is the ability to identify disconnected fragments of plants in herbivore faecal material mounted on microscopic slides. The sampling involves gathering of the faecal material which is relatively simple (Peden et al 1973).

A representative sample of what is being eaten by a herbivore population can be obtained from subsampling from 10-50 defaecations per species per study area (Ward, 1970). The basic problem is that plant pigments make identification of epidermal material difficult. (Holechek, 1982). However, sample preparation techniques to reduce this problem have been developed and discussed by Baumgartner and Martin, (1939): Metcalf (1960); Storr (1961); Williams (1969); Varva and Holechek (1980). The hertwig's clearing solution has been used to remove the plant pigments.

5.2.2: Sample Collection

Samples of faecal material were collected from fresh dung. From each dung pile several subsamples were taken, whenever possible, the subsamples were collected from different dung balls where scraping had not fully broken them down. Amount taken for each subsample was about 2 gms.

The subsamples from one defaecation were composited into a single sample. It was not always possible to identify or sex the individuals from which the samples were collected except when the defaecation was witnessed. To enhance the fragment identification the samples were preserved to stop microbial activity by adding equal amounts of common table salt and thoroughly mixing it with the sample. Soil bacteria and fungi can easily dissolve cutin, lignin and cellulose (Hansen et al., 1980) making fragment identification difficult.

The faecal material was washed through a series of sieves, 2000um, 500um, and 250um (Barker, 1986). The material remaining in the 250 um sieve was further washed by running tap water and the filtrate collected in a container placed at the bottom. All the faecal filtrates were oven dried and subjected to the same grinding procedure. The resulting ground samples were put in self sealing polythene bags and stored in a dry place ready for slide preparation.

In order to identify and classify plant fragments by the microhistological technique it is necessary to become familiar with microscopic identification characteristics of the plant species occuring in the study area. This was done by collecting plant reference material covering almost all the plants in the area. The reference material was dried and ground in a Willey mill so as to simulate the condition of plant fragments encountered in faecal samples.

5.2.3: Slide preparation

The ground reference sample and prepared feacal sample was placed in test tubes into which sodium hypochloride solution (bleach) was added. The test tube was left until most of the pigment disappeared. The bleach was washed off using warm water. A plastic template measuring 2.5cm by 15.0 cm by 2.0mm with 5.0mm diameter holes spaced at 2.5cm intervals was used to aid in making duplicate slides. A slide was placed under each hole on the tempelate and equal amounts of the sample material placed in each hole. The tempelate controls the amount of sample material placed on each slide. The template is removed and the material evenly spread on the slide using a spatula.

In case of the bleach not adequately clearing the plant fragments, a few drops of Hertwigs clearing solution were added to the sample material on the slide and then heated over alcohol burner until the solution had evaporated without burning the sample. A cover slip was placed over the sample and the slide was then heated until the sample mixture was bubbling evenly. The slide was quickly placed against a cool wet sponge until the large air bubbles were withdrawn from under the cover slip. The edges of the cover slip were then sealed with a bead of "Hoyers" solution (Cavender and Hansen, 1970). The finished slides were dried at 55-60 degrees Centrigade for at least twenty-four (24) hours or until the medium was firm.

During preparation it was very important to avoid sample contamination throughout the process so it was imperative to carefully wash and clean all equipment after each sample was processed during laboratory procedure.

5.2.4: Plant Identification

Identifiable structures of plant tissues usually vary tremendously in relative size, shape and abundance between species. The main cellular characteristics used as clue for identification of plant fragments are cuticle, stomata, cell walls, asperite, glands, trichomes, silica cells, druses, crystals, starch grains and silica-seberose couples as well as cellular configurations, cell size and other morphological characteristics. These include cuticle thickness epidermal tissue - trichomes and sometimes lignified cell walls.

Todd and Hansen (1973) indicated that the relative number of plant fragments of each kind of plant remains similar in passing through the digestive process. They found that digestion reduced the mean weight of fragments rather than eliminating the whole fragment for those plants commonly found in bighorn sheep diets.

Using a binocular compound microscope equipped with phase contrast, the reference slides were studied and for each plant species the identifiable unique characteristics were noted. The feacal sample slides were studied under the same microscope and for each slide 20 microscopic fields were studied. In every field all the identifiable fragments were recorded using the presence or absence technique. A minimum of 3 characteristics were used for species identification. Thus frequency values were recorded and expressed as a percentage of the total number of times a species is identified divided by total of identifiable fragments multiplied by a hundred (100).

The "frequency conversion" technique (Barker 1986) was used as a time-saving sampling procedure where presence (frequency) of a plant species was recorded for each microscopic field instead of counting each fragment.

5.3: RESULTS

5.3.1:Dietary Composition and Preference Rating in LNNP.

Table 5.1 represents the percentage composition and preference rating for plant species identified in the rhinoceros dung during the wet and dry seasons in LNNP. A total of 73 different plant species were identified in the dung. Among these 66 plant species were recorded during the wet season and 65 during the dry season. A total of 8 species were not recorded during the dry season, although present during the wet season. In the wet season 7 species were absent but present in the dry season.

The most important species during the wet season in respect to percentage composition was Abutilon spp. (9.5%) followed by Achyranthes aspera (6.9%), Aspilia mossambicensis (6.1%) and Grewia similis (6.1%). During the dry season the most important species was Rhus natalensis (8.8%) followed by Grewia similis (7.4%), Acacia xanthophloea (6.5%) and Solanum incanum (6.0%).

Preference rating data indicates that in LNNP during the wet season, the most prefered species was Celosia anthelmintica followed by Euclea divinorum and

Abutilon spp. The least prefered was Tarchonanthus camphoratus. Results on preference rating during the dry season indicates that Celosia anthelmintica was the most prefered followed by Euclea divinorum and Kendrostis foetidisma. Plectranthus spp. was the least prefered during the dry season. The Kolmogrov - Smirnov test indicates that there was no significant difference between the diet during the two seasons in LNNP. This implies that the diet was the same during the two seasons ($DN = 0.13$, $n = 73$, $P > 0.05$).

5.3.2: Dietary Composition and Preference Rating in SRGR.

Table 5.2 represents data on composition and preference rating for plants identified in the rhinoceros dung in SRGR. A total of 54 species were recorded. During the dry season 54 species were recorded and 52 during the wet season. The most important during wet season in respect to percentage composition was Achyranthes aspera (7.1%) followed by Acacia xanthophloea (6.1%) and Centompsis rubra (6.0%). During the dry season Acacia xanthophloea(6.1%) was the most important followed by Achyranthes aspera(5.9%), Acacia drepanolobium(5.9%) and Typha domingensis(5.1%).

Preference rating indicates that during the wet season the most preferred species was Acacia brevispica followed by Commicarpus pedunculosus and Dregea schimperi. The least prefered species was Kalanchoe spp. During the dry season, the preference sequence was the same as during the wet season except that the values were slightly lower.

The Kolmogrov - Smirnov test showed that there was no significant difference between the diet during the two seasons (DN = 0.11, n = 54, $P > 0.05$).

5.3.3: Potential Competitors with the Rhinoceros in LNNP.

The only other exclusive browser in LNNP is the rothschild's giraffe, translocated to the park in 1977. The population of these giraffes is now 106 individuals from the initial 18 giraffes which survived and settled. Table 5.1 indicates that there is 45% overlap between the diets of the giraffe and the rhinoceros. This makes it the major potential competitor. Other potential competitors include the impalas and the elands. These are the only known mixed feeders in LNNP.

5.3.4: Comparison of the Rhinoceros Diet in SRGR and LNNP.

A total of 37 different plant species were common in both study areas (Figs. 5.1 and 5.2). This represents a 50.2% overlap in the diet of rhinoceros in both LNNP and SRGR. However in LNNP a total of 36 new plant species were added to the diet.

In respect to preference rating it was noted that the species that were most prefered in SRGR were not prefered in LNNP even when they were present in both areas. The most prefered plant in LNNP was a new plant which was absent in SRGR. The species Euclea divinorum had a higher preference value in LNNP than in SRGR although present in both.

The results also indicated that the grasses were common in the diet in both areas. The number of grass species recorded in LNNP was 9 and 8 during the wet and dry seasons respectively, while in SRGR 4 grass species were recorded during both the wet and dry seasons.

Table 5.1: Seasonal composition of Rhinoceros Diet in LNNP (1988).

Species	% Frequency				Eaten by
	Wet	PR	Dry	PR	Giraffe
Senecio petitianus	0.25	0.06	0	0	+
Maerua triphylla	3.31	0.89	4.29	1.15	+
Aparagus fulcatus	0.51	0.27	0.82	0.42	-
Capparis tomentosa	0.59	0.71	0.69	0.84	+
Solanum incanum	4.92	1.45	6.03	1.77	+
Bidens pilosa	0.56	0.28	0	0	-
Cordia Ovalis	0.69	0.58	1.47	1.23	+
Croton dichogamus	0	0	0.42	0.14	+
Acacia xanthophloea	3.96	0.49	6.45	0.80	+
Dombeya burgessiae	1.38	3.25	1.30	3.02	+
Tagetes minuta	0.61	0.40	0.36	0.24	+
Grewia similis	6.11	1.86	7.40	2.23	+
Rhus natalensis	5.92	2.65	8.84	3.92	+
Achyranthes aspera	6.89	2.02	5.64	1.64	+
Abutilon spp	9.49	5.05	6.18	3.26	+
Psiadia punculata	0.46	0.11	0.83	0.19	+
Tarchonanthus camphoratus	0.17	0.02	1.12	0.15	+
Urtica massaica	0.98	0.14	0.10	0.23	-
Aspilia mossambicensis	6.13	1.50	4.25	1.03	+
Hypoestis verticillaris	1.80	0.47	1.48	0.38	-

PR------- Preference Rating

Tinnea aethiopica	3.54	2.13	5.31	3.17	+
Euclea divinorum	0.44	6.43	0.58	8.43	-
Hibiscus micranthus	2.03	1.15	1.67	0.94	+
Aloe gramicolar	5.55	1.71	4.80	1.47	+
Typha domingensis	0.20	0	0.65	0	-
Lantana triphylla	3.61	0.85	3.00	0.70	+
Dregia schimperi	1.01	4.25	0	0	-
Commelina spp	0.72	1.18	0.41	0.66	+
Plectranthus spp	0.21	0.14	0.17	0.11	-
Kendrostis foetidissima	0.29	3.63	0.63	7.88	-
Datura stramonium	0.49	0	0.33	0	+
Barleria spp	0	0	0.50	0.13	-
Maytenus heterophylla	3.02	0.76	2.50	0.62	-
Teclea simplicifolia	0.57	0.51	0.67	0.61	+
Leonotis nepetifolia	0.66	0.09	0.26	0.81	-
Sanseveria spp	0.33	2.36	0.61	4.36	-
Celosia anthelmintica	0.29	7.25	0.38	9.50	-
Gnidia subcordata	0.37	6.17	0.25	4.17	+
Erythrococca bongensis	1.31	2.22	2.20	3.68	+
Commicarpus penduncułosus	1.61	4.63	0.87	2.49	-
Ocium suave	1.48	0.31	1.25	0.26	+
Opuntia spp	0.54	0.24	0.43	0.19	-
Albizia gummifera	0.61	0	0.23	0	-

Helinus integrifolius	0.09	0	0.36	0	-
Helinus cordifolia	0.22	0.19	0	0	-
Toddalia asiatica	0	0	0.25	0	-
Ricinus communis	0	0	0.02	0	-
Aerva lanata	0.14	0	0	0	-
Conyza spp	0.37	0	0.18	0	+
Amaranthus spinosa	0.75	0	0	0	-
Sonchus spp	0.59	0	0.23	0	-
Vernonia galamensis	0.29	0	0.08	0	-
Crassocephalum manii	0.09	0.27	0.14	0.42	+
Galinsonga ciliata	0.64	0	0	0	-
Euphorbia candelabrum	1.35	0.57	2.15	0.91	+
Phyllanthes maderaspatensis	3.06	0	4.29	0	-
Acacia gerrardii	1.08	0.63	1.36	0.78	+
Trifolium spp	0.25	0	0.24	0	-
Acacia hockii	0.59	0	0.40	0	+
Rhamnus studdo	0.34	0	0.25	0	+
Tarenna graviolus	0	0	0.20	1.43	-
Lycium europaeum	0	0	0.69	0	-
Lippia javanica	0.69	0	0.54	0	+
Cynodon dactylon	1.27	0	0.65	0	-
Digitaria scalarum	0.61	0	0	0	-
Themeda triandra	0.78	0	0.45	0	-
Cenchrus ciliaris	0.69	0	0.23	0	-
Brachiaria spp	0.52	0	0.30	0	-

<u>Panicum</u> <u>maximum</u>	0.64	0	0.40	0	-
<u>Sporobolus</u> spp	0.43	0	0.31	0	-
<u>Cyperus</u> spp	0	0	0.58	0	-
<u>Setaria</u> spp	0.65	0	0.19	0	-
<u>Eleusine</u> spp	0.33	0	0.10	0	-
	100.02		100.00		

Table 5.2: Seasonal Composition of Rhinoceros Diet in SRGR.

Species	% Frequency			
	Wet	PR	Dry	PR
Hibiscus micranthus	2.12	0.28	2.13	0.29
Maerua triphylla	2.33	3.21	3.45	2.90
Kendrostis foetidissima	0.51	0	0.41	0
Acacia xanthophloea	6.12	3.51	6.08	3.54
Solanum incanum	1.41	1.59	1.63	1.86
Asparagus spp	2.13	0.29	1.55	0.22
Maytenus heterophylla	2.77	1.03	4.47	1.69
Capparis tomentosa	0	0	0.18	0.21
Abutilon spp	0.63	0.37	0.29	0.17
Acacia drepanolobium	4.87	0.18	5.86	0.22
Achyranthes aspera	7.13	2.28	5.94	1.93
Scutia myrtina	4.70	0.68	5.03	0.74
Aloe gramicolar	3.38	1.77	3.53	1.88
Tagetes minuta	0.27	0	0.18	0
Acacia gerrardii	0.17	0	0.26	0
Centompsis rubra	6.06	0	4.50	0
Acacia brevispica	2.73	14.17	1.57	13.34
Cyperus spp	2.19	0	3.10	0
Commicarpus penduncolosus	0.72	9.73	0.39	7.45
Clausena anisata	0.17	1.31	0.30	2.31
Plectranthus spp	0.47	2.75	0.28	1.53

Psiadia punculata	1.14	0.16	1.86	0.22
Grewia similis	3.24	1.06	3.66	1.22
Commelina spp	0.56	3.82	1.37	1.33
Rhus natalensis	4.23	1.01	4.32	1.05
Lantana triphylla	1.73	0.38	2.14	0.48
Dovylis caffra	1.99	0	2.08	0
Olea africana	0.55	0.72	0.41	0.55
Datura stramonium	0.52	0	0.23	0
Typha domingensis	4.35	0	5.14	0
Ocimum suave	1.82	0	1.67	0
Croton dichogamus	0.15	0	0.19	0
Aspilia mossambicensis	3.80	0	4.39	0
Cordia ovalis	0.49	0	0.50	0
Euphorbia spp	0.81	0	0.62	0
Pavonia patens	0.72	0	1.25	0
Sarcostema viminale	0.13	0.59	0.30	1.36
Tarchonanthus camphoratus	0.79	0	1.14	0
Dregea schimperi	0.25	5.00	0.32	6.40
Canthium schimperianum	0.18	2.80	0.28	4.67
Sanseveria spp	0.14	2.30	0.21	3.50
Themeda triandra	0.72	0	0.41	0
Cynodon dactylon	2.02	0	0.84	0
Digitaria spp	0.47	0	0.13	0
Brachiaria spp	0.75	0	0.43	0

Carissa edulis	0.87	1.76	1.04	2.14
Hypoestis verticillaris	2.76	1.07	1.60	0.63
Euclea divinorum	3.66	1.92	4.02	2.14
Tinea aethiopica	3.49	9.02	2.57	5.20
Erythrococca bongensis	2.11	1.30	2.48	1.55
Notonia spp	0	0	0.45	1.61
Kalanchoe spp	0.39	0.15	0.26	0.11
Chenopodium fasciculosum	2.20	0	1.04	0
Other dicots	1.77	0	1.25	0
	100.31		100.41	

5.4: DISCUSSION

The feeding habits of the black rhinoceros were studied in both LNNP and SRGR. The LNNP vegetation is mainly evergreen woodland with thick undergrowth which is available all the year around, while SRGR has a typical semi-arid vegetation. This makes LNNP a better habitat as compared with SRGR and does not experience any rapid fluctuations in food quantity and quality. This explains why there was no significant difference between the species composition in the diet of the rhinoceros during the two seasons in the study areas. The only variation noticed was in the amount of each species taken during each season.

A total of 73 different plant species were fed on by the rhinoceros in LNNP as compared with 54 species in SRGR. This implies that LNNP is a richer habitat than SRGR in respect to food diversity. In SRGR the rhinoceros and other herbivores use the Engare Moyok swamps during the dry season. This is confirmed by the high percentage composition of _Typha domingensis_ during the dry season. However some _T. domingensis_ was recorded during the wet season.

During the study, some plants were not identified in the dung although present in the area. This does not necessarily mean that these were ignored by the rhinoceros since there is a possibility that when the dung was collected the individual had not come across the species within it's feeding area although it was present else where in the park. The high number of food plant species recorded for LNNP is not unique because other researchers have recorded higher figures (Goddard, 1968; 1970; Mukinya, 1973; Hall-Martin et al., 1982). These studies have shown that the rhinoceros is a generalised feeder, eating most of what it comes across.

In this study more grasses were recorded indicating that besides browsing the rhinoceros also do graze to substantial levels. This tendency has also been observed in the Ngorongoro crater floor where the rhinoceros were observed to engage in serious grazing (pers. obser.). Other reports on the same behaviour have been recorded by Hall-Martin et al. (1982) in Addo Elephant National Park and Waweru (1985) in Nairobi National Park. This is unlike what other past researchers like Goddard, (1968; 1970); Mukinya, (1973) and Schenkel and Schenkel, (1969) have observed using direct observation of feeding rhinoceros.

The Rothschilds' giraffe translocated to LNNP in 1977 (Kakuyo 1980) are the only serious potential competitors with the rhinoceros for browse. From data on the dietary composition of the two animals it is clear that there is an overlap of about 45% (this study; and Kakuyo 1980). However the feeding behaviour of the two animals differ considerably. The rhinoceros feeds on whole branches about 2 cm diameter (Waweru, 1990) while the giraffe feeds on the growing non lignified tissue. When feeding the rhinoceros is solitary and moves alot, while the giraffes feed in groups. The giraffes can browse as high as 5-7 metres (Pellew, 1983) while a rhinoceros can only reach a height of 2.5 metres (Waweru, 1985). These factors reduce direct competition between the two species so long as there is enough browse material at the different feeding levels and the number of individuals remain low.

The giraffes have been observed to feed on low shrubs when the tall ones are not available. This implies that although there's no competition problem presently, in future when the numbers increase and browse declines, the competition might get serious and affect the vegetation and the animals concerned. As a result of this the population sizes of these two animals should be controlled so as not to go beyond the habitat's carrying capacity. The one which requires immediate attention is the giraffes which breeds very fast as compared to the rhinoceros. This would give the rhinoceros population a chance to build up.

With a total of 37 rhinoceros food plants common in both study areas, the rhinoceros was exposed to a high proportion of familiar food plants in the new habitat. However the results indicated that this did not influence the selection of food plants. Some plants which were absent in SRGR were more prefered than the familiar ones LNNP. This implies that the rhinoceros can easily adopt to new food plants once it is moved to a new habitat. This is further supported by the fact that the rhinoceros is a generalized feeder which will take almost anything available (Goddard, 1968; 1970 Mukinya, 1973; Hall Martin et al. 1982; and Waweru, 1985).

Those plants which had very high preference rating values are the plants which are common in the dung and rare in the field , meaning that the rhinoceros have to search for them. Low value are a result of the plant being very common in the field and rare in the dung. This implies that the rhinoceros might be

ignoring them when feeding. The preference of some species by the rhinoceros might be due to their chemical composition or nutritional value.
Those plants with high nutritional value will be selected while those with low values will be ignored.

It was observed that the amount of grasses recorded in the faecal analysis of rhinoceros dung was high. Hall- Martin *et al*. (1982) made the same observation while studying rhinoceros in the Addo Elephant National Park. They also noted that the direct observation technique usually underestimates the amount of grass taken by the rhinoceros. This explains why past studies using the direct observation technique have always supported the fact that the rhinoceros is entirely a browser (Schenkel and Schenkel, 1969; Goddard, 1968; 1970; and Mukinya, 1973). This belief might have led to a bias such that when a rhinoceros feeds on the ground, in the absence of any woody vegetation, no records are taken. It is also very difficult to differentiate grass bitten off by a rhinoceros from that bitten off by other herbivores.

Studies on the rhinoceros diet in Nairobi National Park indicates that grasses comprised about 19% of the total diet (Waweru, 1985). The percentages of grasses recorded in the rhinoceros diet in this study, 12.6% and 12.3% during the wet and dry seasons respectively in LNNP, and 7.6% and 7.4 for wet and dry seasons, respectively for SRGR, supports the fact that the rhinoceros feeds on grass.

Using the Kolmogrov-Smirnov test it was shown that there was no significant difference between the diet for rhinoceros during the wet and dry seasons in both SRGR and LNNP. This can be attributed to the fact that vegetation in LNNP was largely woody evergreen type and fires and deciduousness are absent. As a result of this there are no drastic fluctuations in the food and quantity as would be expected in other areas like the Tsavo (Goddard, 1970), Masai Mara (Mukinya, 1973) and Ngorongoro (Goddard, 1969).

In case of SRGR the vegetation is almost the same throughout the year. Rainfall is very erratic and cannot be relied on as a factor which can cause much variation in the food availability and quantity. Most of the plants identified in the dung were woody type and mainly drought adopted. Annual herbs are rare and do not comprise a major component of the rhonoceros diet in SRGR. The dietary quality was not analysed and therefore it is difficult to comment on the effects of the seasonal changes on it for both study areas.

CHAPTER 6

SPATIAL DISTRIBUTION

6.1: INTRODUCTION

The main objective of this part of the study was to determine the pattern of movement after release, and the home range sizes once the translocated rhinoceroses settled down. The distribution of home ranges was related to vegetation distribution and water distribution. In addition to home ranges the results were expected to give information on the effects of different vegetation composition and structure on the distribution of translocated rhinos.

The black rhinoceros is a solitary (Ritchie, 1963, Goddard, 1969; 1970), and non territorial animal (Schenkel and Schenkel, 1969; Hamilton and King, 1969; Mukinya, 1973; and Waweru, 1985). It is known to be attached to its home range unless moved by man (Ritchie, 1963). The size of the individual home range is dependent on food and water availability and therefore translocation from one habitat to another may have effects on the home range size.

6.2: METHODS

6.2.1: Individual Identification

Visual identification technique was employed when searching for rhinceroses. A four-wheel drive vehicle and a pair of 9 x 50 binoculars was used (Goddard 1970; Mukinya 1973; Waweru 1985). Once sighted the rhinoceros was closely observed and the animals' ears studied/scrutinized and notching pattern identified. At capture time, each rhinoceros was marked using a unique pattern (Fig. 3.2). This pattern was designed to be used for all rhinoceroses translocated within in Kenya.

Another feature which was used in identification was the foot print measurements. All rhinoceroses translocated to Nakuru had their foot prints measured. For each foot print 5 measurements were taken, the length, width of the foot, and length of each of the three toes. The result was 20 records per animal. These were recorded on a notebook and once foot prints were sighted on roads, watering points or bare ground the measurements were taken and later counterchecked with the records to confirm the individual.

6.2.2: Locations

A field map was made by plotting 1 km square grids on a 1:50,000 scale map of LNNP. Each side of the 1 km square grid was subdivided into 10 equal subdivisions. Each major 1 km line was numbered using two ordinates. The subdivision were supposed to give the third ordinate. This was done for both the northings and eastings. The field map was reduced to fit an A4 size paper for ease of carrying it around. The location of a rhino was recorded by six ordinates the first three eastings and the last three Northings (Waweru, 1985). The rhino number and location code were recorded on a field notebook. In case of foot prints, the measurements were recorded and later counterchecked in the chart in the camp.

6.2.3: Movement patterns

Immediately after release the movement of the rhinceroses were monitored by recording their sightings/prints using the field map. Whenever a rhinoceros was located, the date, location and direction of movement were plotted on a field map. Whenever possible the rhinoceros tracks were followed and also plotted on a field map. Latter the movement patterns of an individual rhinoceros or a group of rhinoceroses whose plottings clustered was/were plotted together to give the general movement pattern.

6.2.4: Home Ranges

Six months after release the rhinoceroses were dispersed and individual movement were concentrated in specific areas. Records of these locations were plotted on maps for each individual. The most peripheral points were joined and area of an individual and their sizes were expressed in sq.km. Data were collected during the wet (March-May) and dry (August-October) seasons, to check for seasonal variation in home range sizes.

6.3: RESULTS

6.3.1: Movement Patterns After Release.

Figure 6.1 shows that all the rhinoceros translocated to LNNP were released at the same site located in the Southern part of the Park. After release the rhinoceros were observed to run into the forested areas except for female 2 (youngest in the group), which settled in the area around the release site for about two weeks. For the first few days the movement was not systematic. However three main movement directions had been identified through the plotting of the locations. One was eastwards across the Makalia river, this population settled along the Nderit river, and in parts of the Tarchonanthus bushland and Euphorbia forest.

The other route was northwards, these rhinoceroses finally settled in the dense Acacia woodland, area west of Baboon cliff and went as far as the presidential pavilion. The third route was along the Naishi river valley, some settled in the Naishi region, others in the Nganyoi area, and some in the area North of the Olive-Teclea forest. However it should be noted that during the early days after

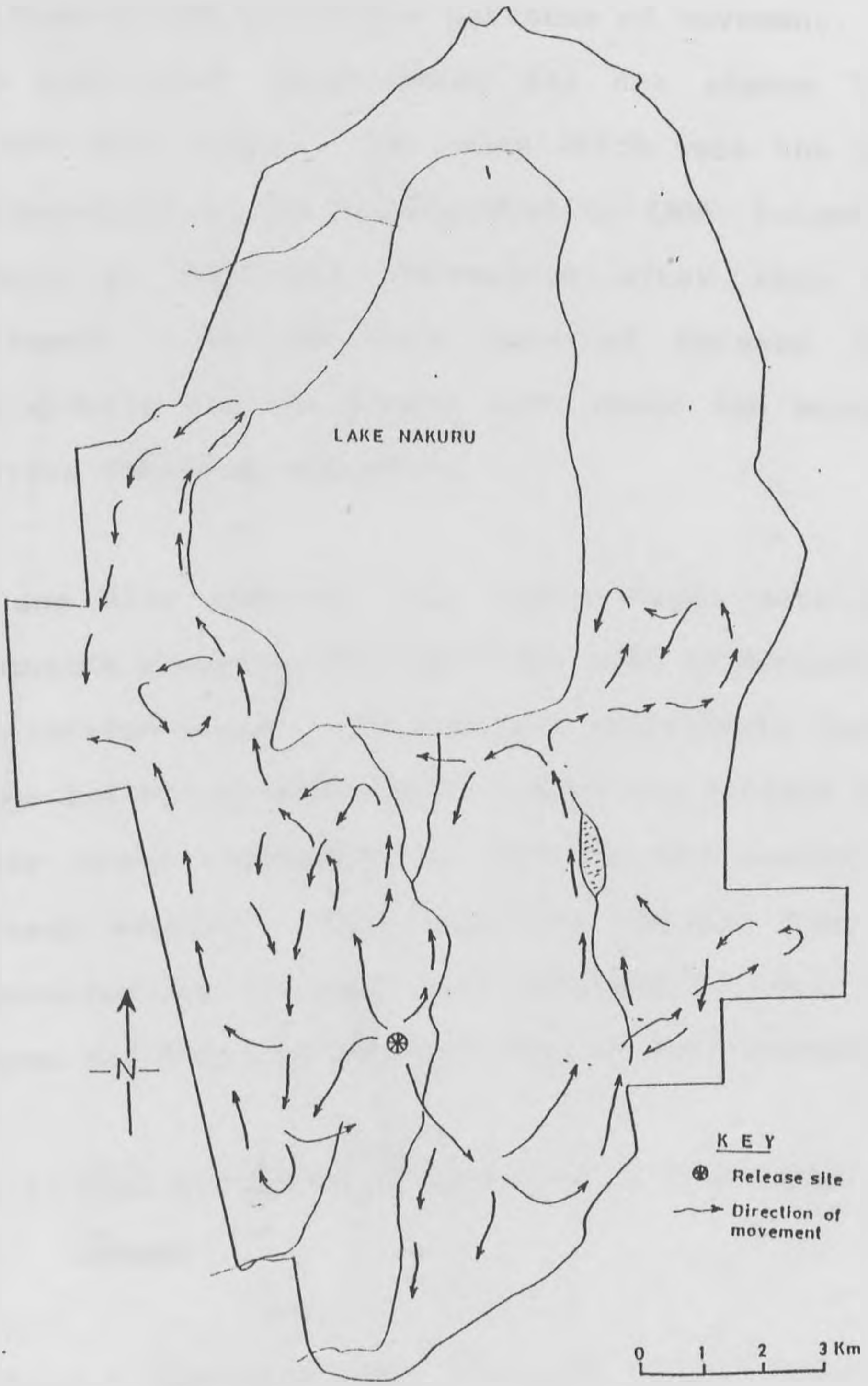

Fig 6.1: RHINO MOVEMENT AFTER RELEASE

release, the movement was very random and only came to stabilize after sometime. After six months regular movement patterns were recorded with individual rhinoceros showing unique patterns of movement. The two indigenous rhinoceroses did not change their former home ranges. Two males which were the first rhinoceroses to be translocated to LNNP joined the female at different occassions after they were released. Matings were observed between these individuals but the female home range and movement pattern remained unchanged.

It was also observed that before final settlement dominance played a very important role in determining who settled where. The dominant individuals (mainly large and strong rhinoceros) pushed the juniors from their areas regardless of whether the junior had already settled. This behaviour implies that the rhinoceros are not very much attached to their home ranges and they can easily forego it when necessary.

6.3.2: Size and Seasonal Variation of Individual Home Ranges.

Table 6.1 indicates that the total black rhinoceros population in LNNP was 19 individuals. Data on

Table 6.1: Individual Home Range Sizes (± SE) and Seasonal Variation for Black Rhinoceros in LNNP.

Sex and Identification Number	Wet season* Area in sq.km	Dry season* Area in sq.km
M1	9.4	11.9
M2	7.3	8.1
M3	5.1	9.1
M4	11.2	15.7
M5	8.5	11.4
M6	5.9	11.5
M7	6.4	9.2
M8	5.6	9.9
M9	7.3	12.6
M10	8.4	14.7
M11	4.8	9.6
F1	6.7	15.3
F2	5.2	6.9
F3	6.5	14.6
F4	9.7	11.8
F5	12.5	20.2
F6	9.1	20.6
F7	8.5	18.5
F8	9.4	13.9
MEANS	WET	DRY
Males	7.3 ± 2.0	11.2 ± 2.4
Females	8.4 ± 2.3	15.2 ± 4.6

* -- Wet season --- February to May.

Dry season -- August to December.

spatial distribution collected for these individuals indicated that the males had a mean home range size of 7.3 ± 2.0 sq km and 11.2 ± 2.4 sq km during the wet and dry season, respectively. The females had had 8.4 ± 2.3 and 15.2 ± 4.6 sq km during the wet and dry seasons respectively. The student's "t" test showed that during the wet season, the females had significantly larger home ranges than the males ($t = 4.2$, $df=17$, $P < 0.001$). The males showed significantly larger home ranges during the dry season compared to the wet season ($t = 4.6$, $df = 20$, $P < 0.001$).

It was also noted that the females had significantly larger home range sizes during the dry season than the wet season ($t=12.3$, $df=14$, $P < 0.001$). This implies that for both seasons the females occupied larger home ranges than the males. The data also indicates that there was significant variation in home range sizes between individual rhinceroses.

Figures 6.2 a-i, shows that the home ranges were concentrated in the southern part of the Park. However some rhinoceros settled in the western and eastern sides of the lake. The figures indicate a very high degree of overlap between individual home

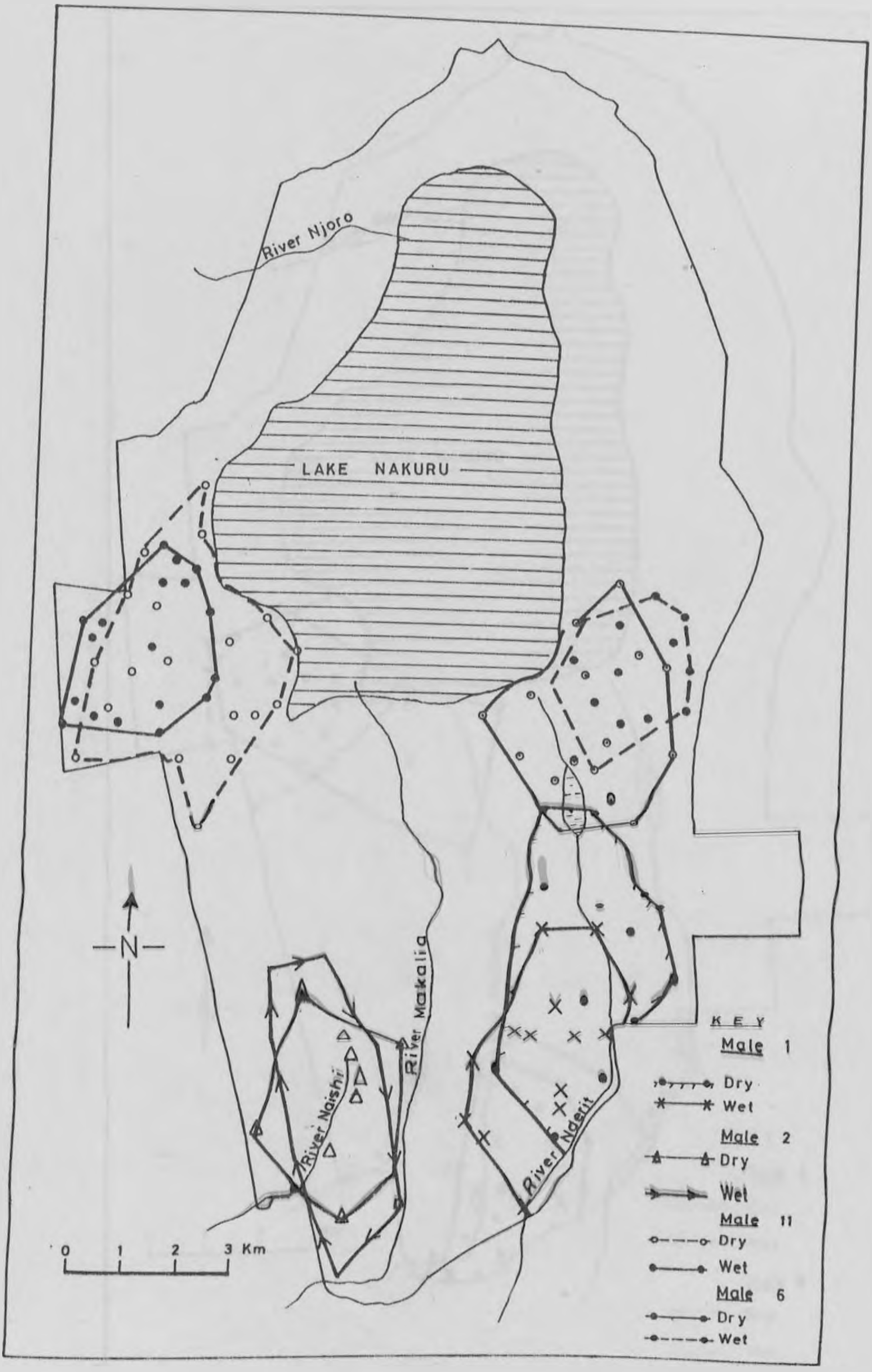

Figure 6.2a: Males 1, 2, 6 and 11

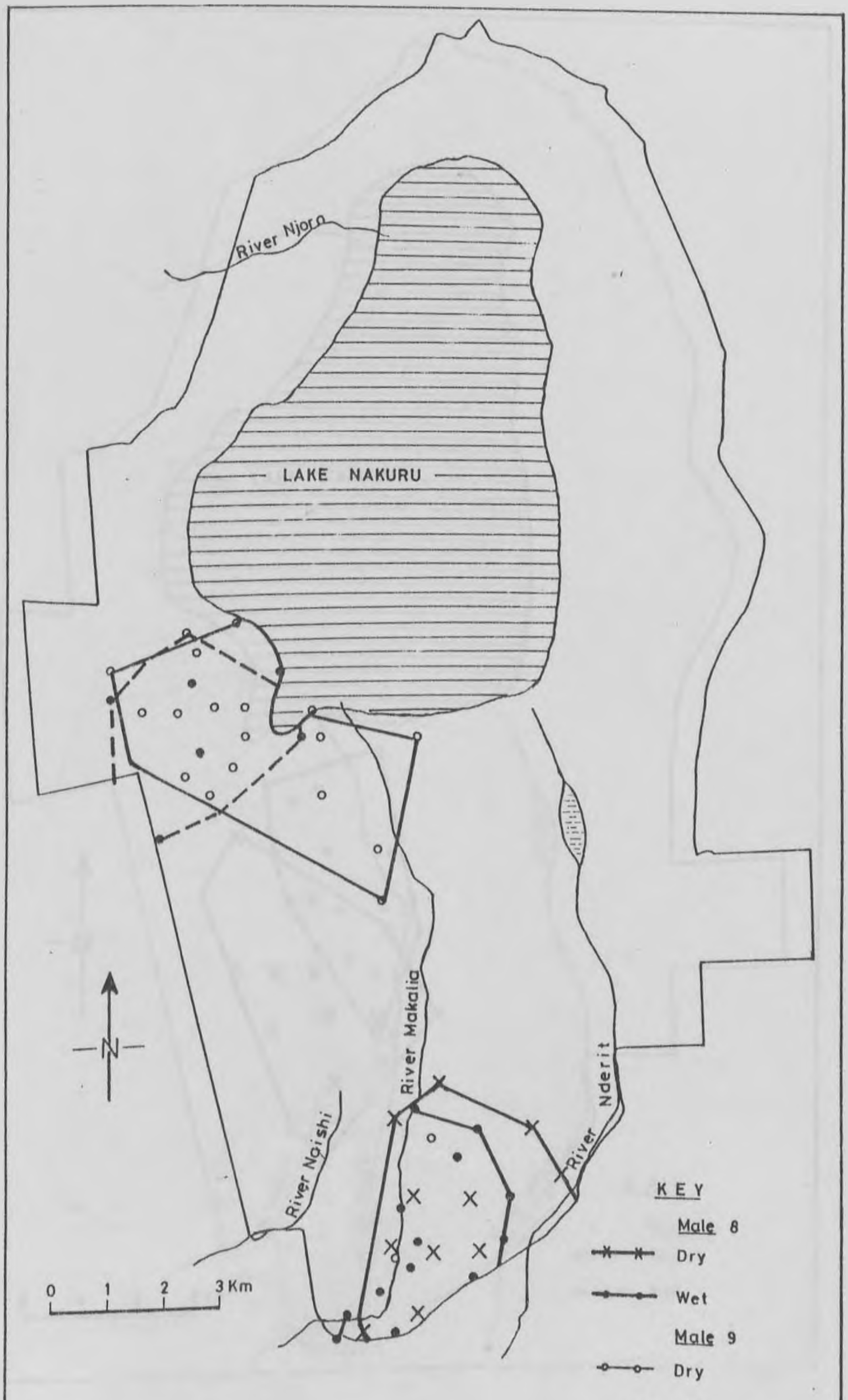

Figure 6.2b: Males 8 and 9

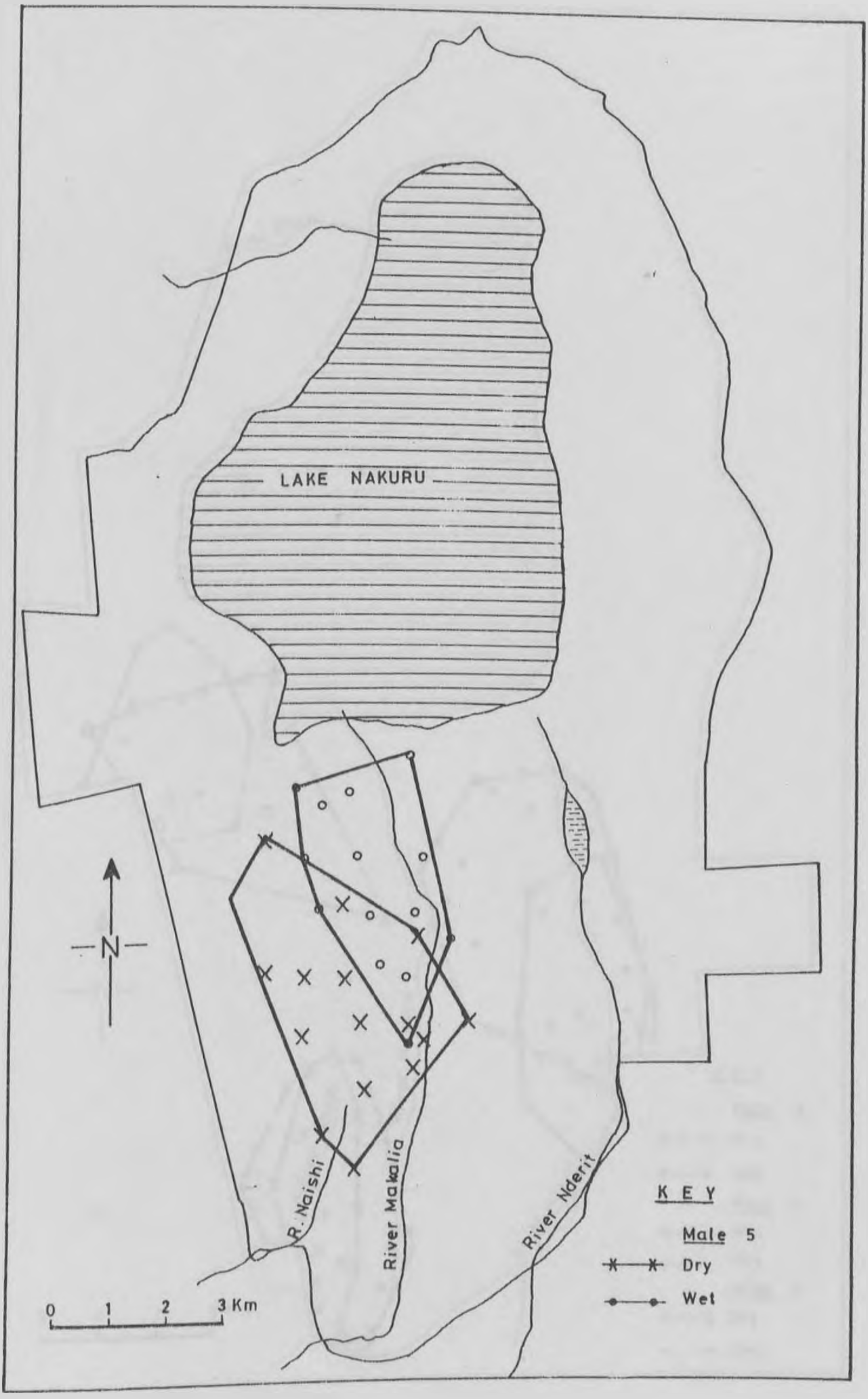

Figure 6.2c: Male 5

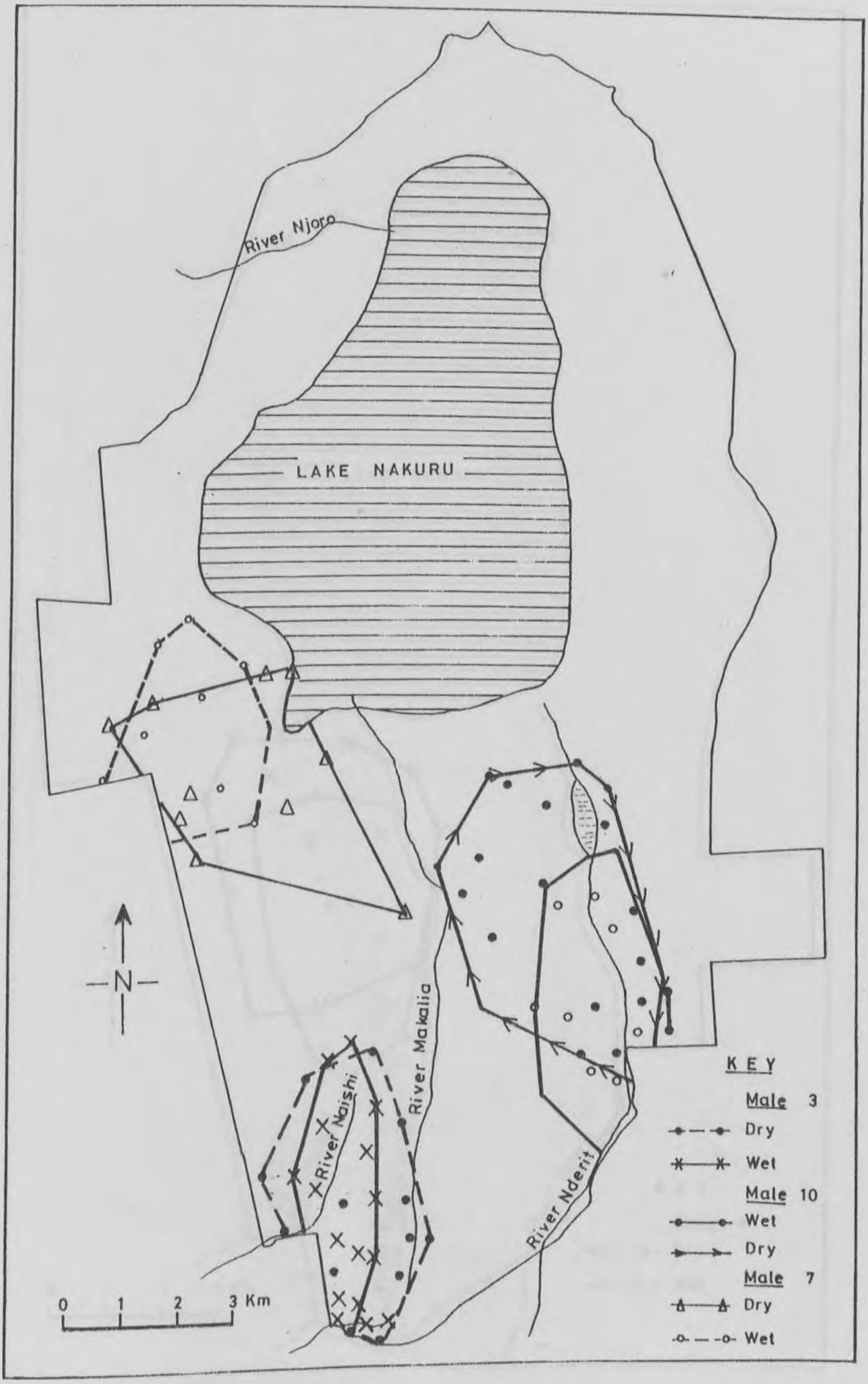

Figure 6 2d: Males 3, 7 and 10

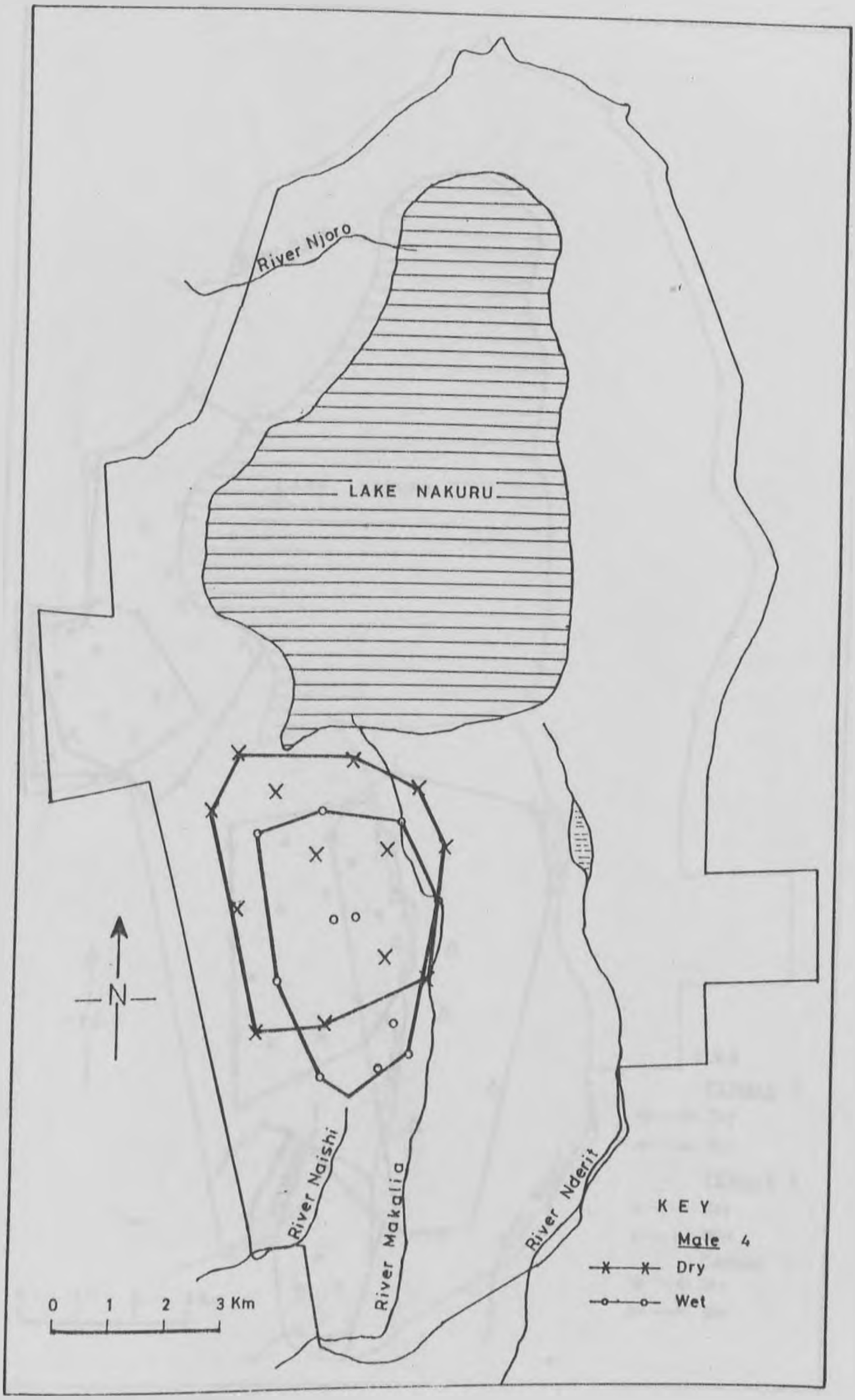

Figure 6.2e. Male 4

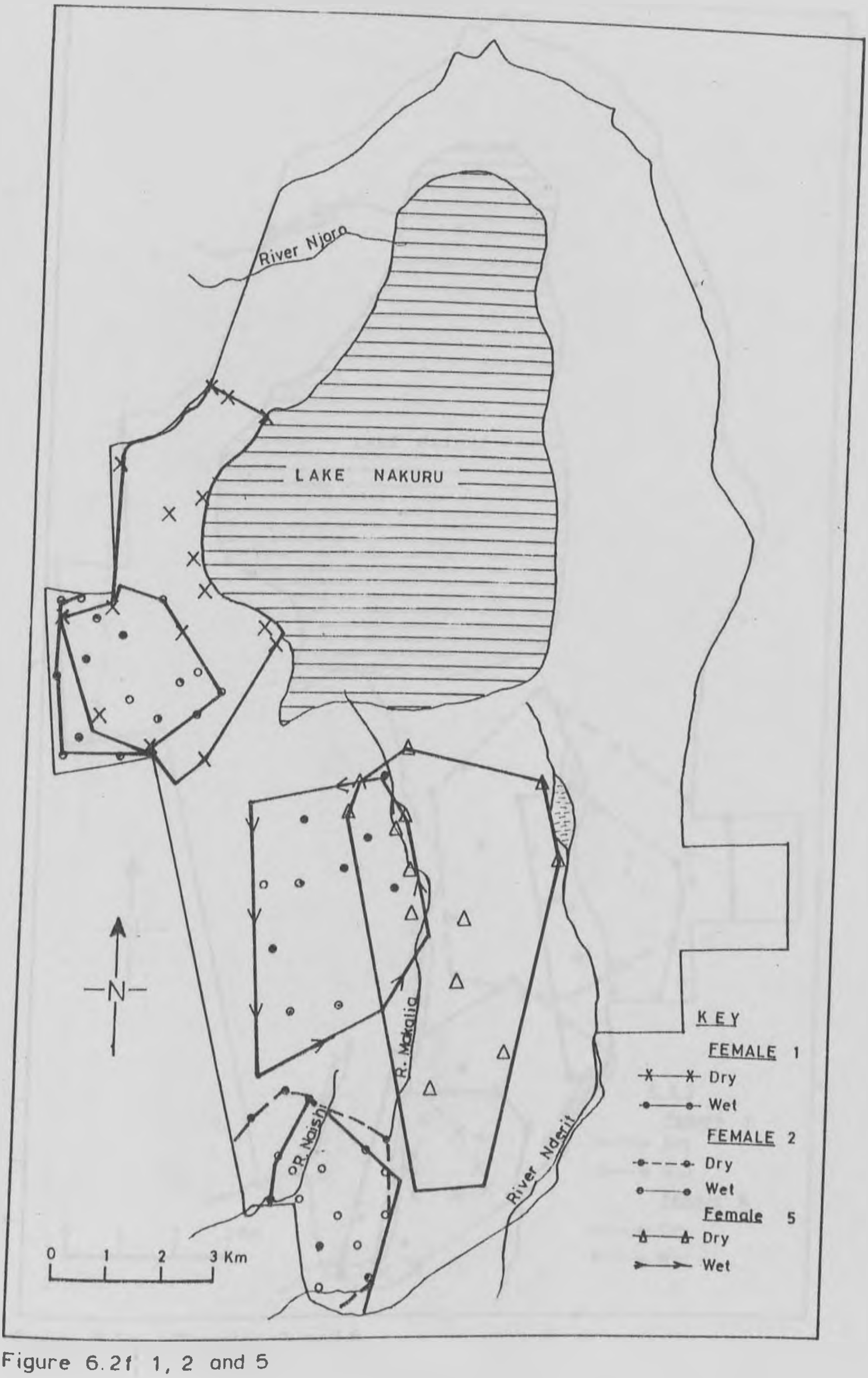

Figure 6.2f 1, 2 and 5

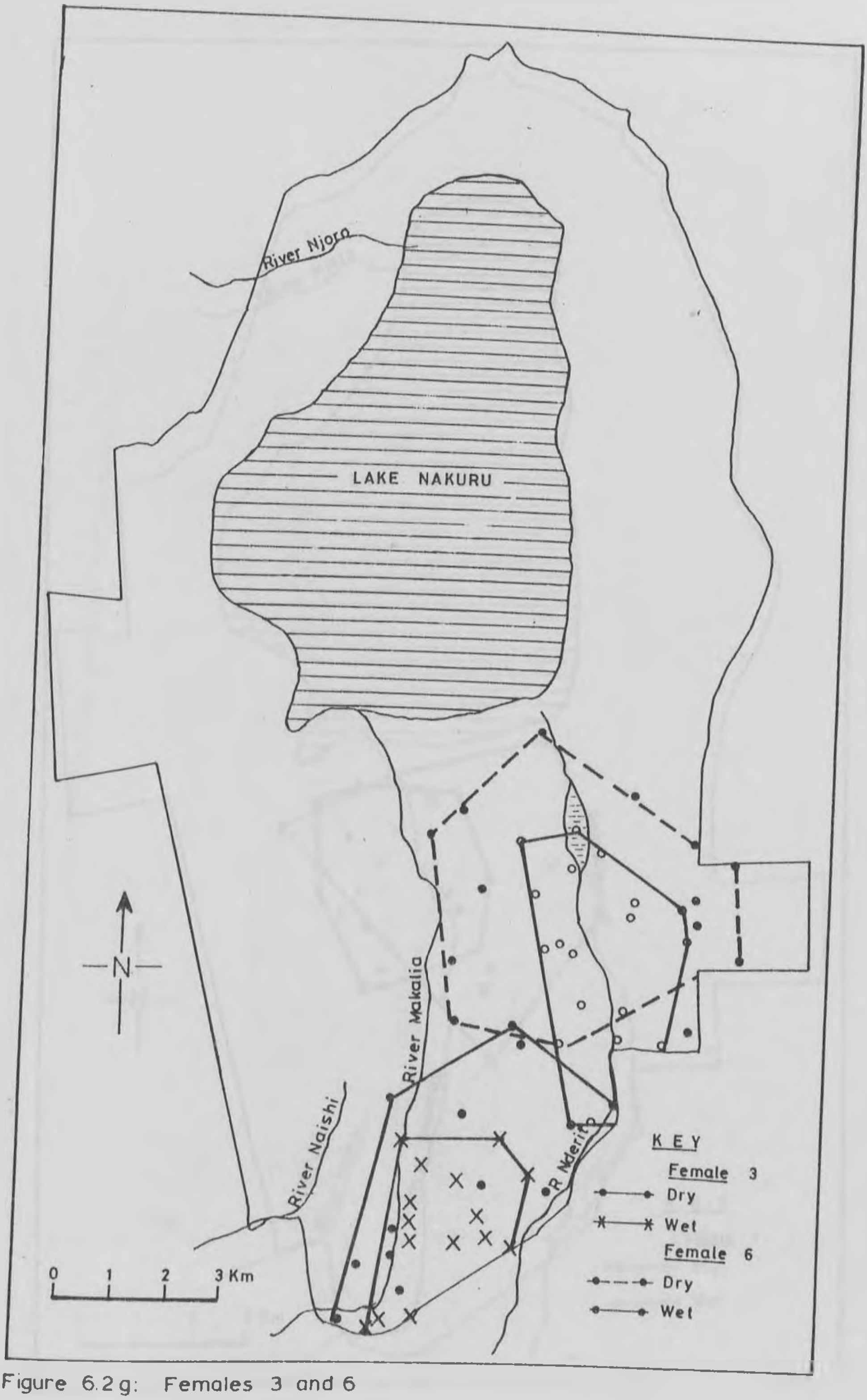

Figure 6.2g: Females 3 and 6

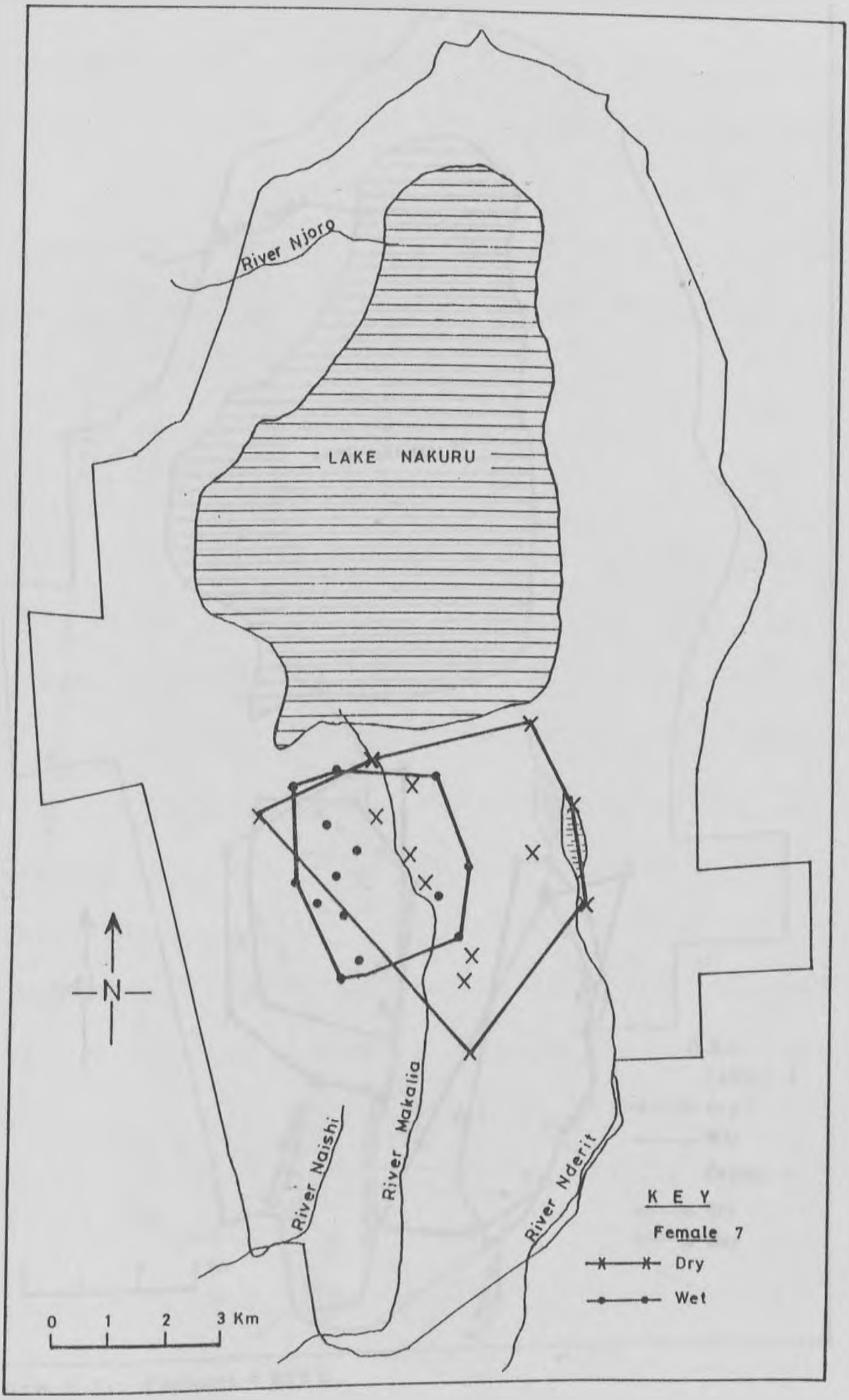

Figure 6.2h: Female 7

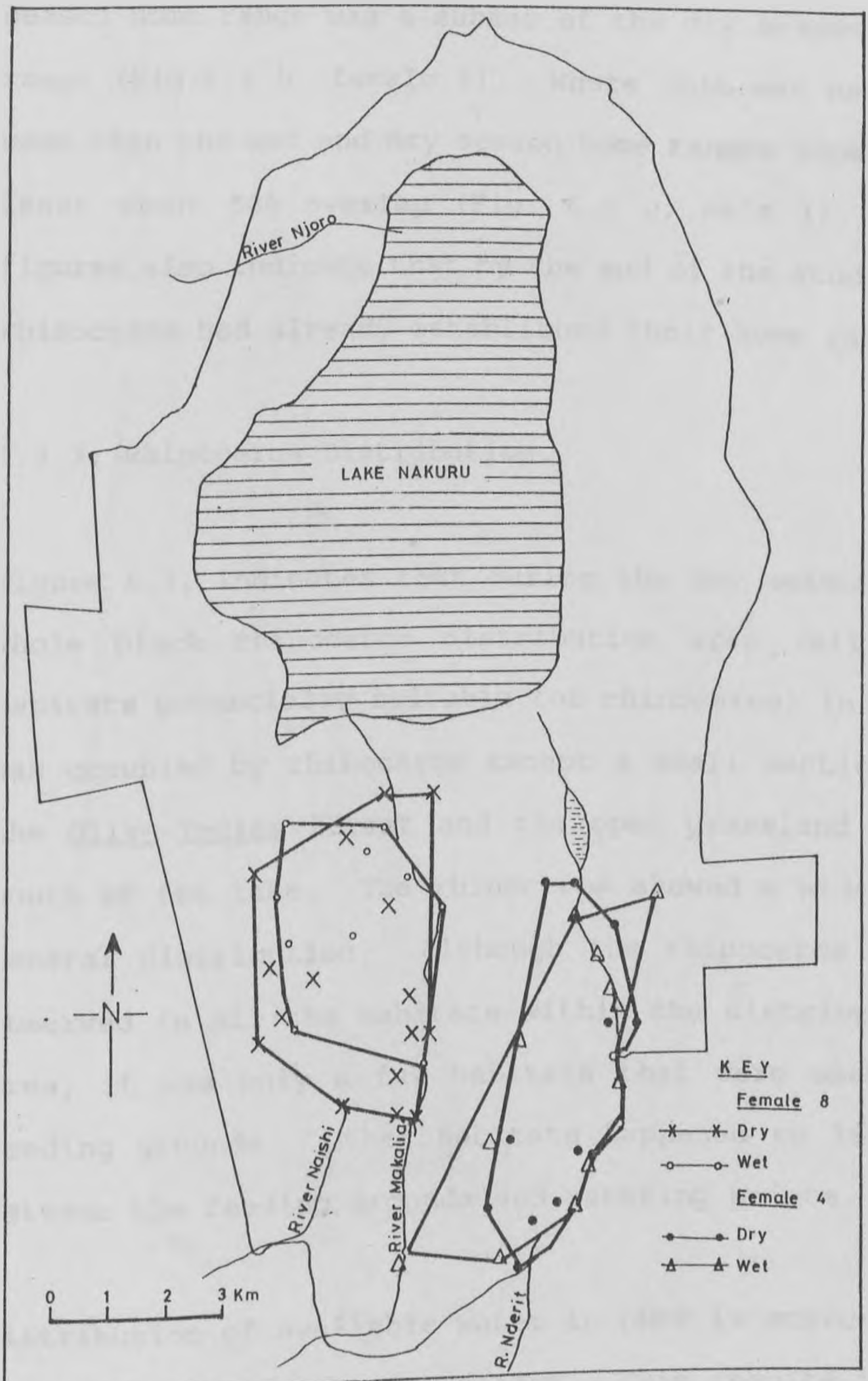

Figure 6.2i: Females 4 and 8

ranges both for males and females. Some individuals had as much as 100% overlap. In most cases the wet season home range was a subset of the dry season home range (Fig.6.2 h, female 1). Where this was not the case then the wet and dry season home ranges showed at least about 50% overlap (Fig. 6.2 c, male 1). The figures also indicate that by the end of the study the rhinoceros had already established their home ranges.

6.3.3: Rhinoceros Distribution.

Figure 6.3, indicates that during the dry season the whole black rhinoceros distribution area (all the habitats potentially suitable for rhinoceros) in LNNP was occupied by rhinoceros except a small section of the Olive-Teclea forest and the open grassland area south of the lake. The rhinoceros showed a wide and general distribution. Although the rhinoceros were observed in all the habitats within the distribution area, it was only a few habitats that were used as feeding grounds. Other habitats happened to lie in between the feeding grounds and watering points.

Distribution of available water in LNNP is scarce especially during the dry season. This results in intensive utilization of the few watering points

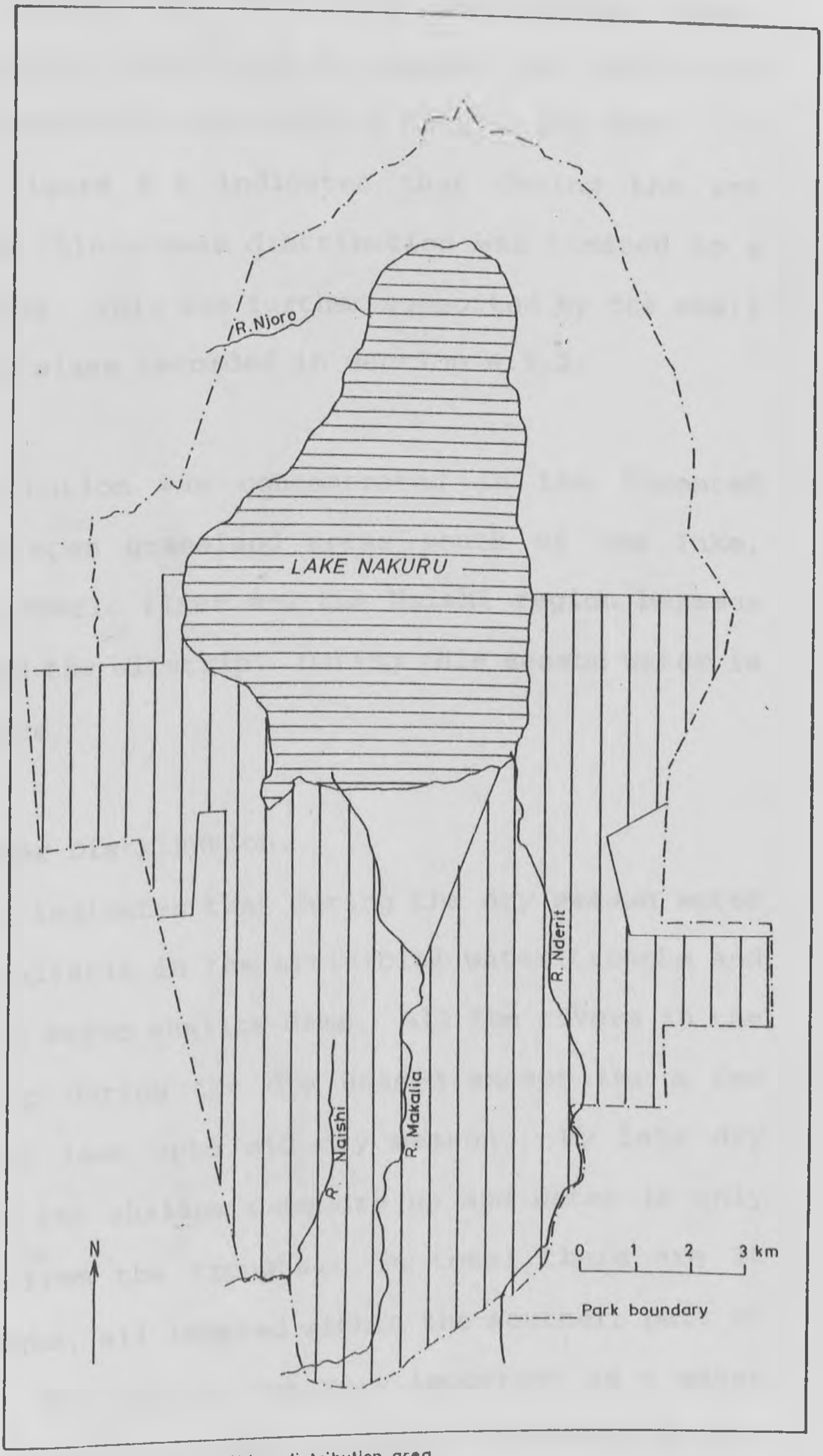

Fig 6.3 Dry season Rhino distribution area

during this season. However no rhinoceros was observed outside the rhinoceros distribution area. Therefore even during the dry season the rhinoceros range is limited to the southern part of the Park. In contrast figure 6.4 indicates that during the wet season the rhinceroses distribution was limited to a smaller area. This was further supported by the small home range sizes recorded in section 6.3.2.

The distribution was concentrated in the forested areas and open grassland areas south of the lake, along the Nderit river and the Naishi region between Nganyoi and the airstrip. During this season water is in abundance.

6.3.4: Water Distribution.

Figure 6.5 indicates that during the dry season water is only available in the artificial water troughs and some of the major shallow dams. All the rivers in the park dry up during the dry season except for a few pools which last upto mid dry season. By late dry season all the shallow dams dry up and water is only available from the troughs. In total there are 10 Water troughs, all located within the southern part of the Park. The lake is not very important as a water source because of its salinity which increases as the

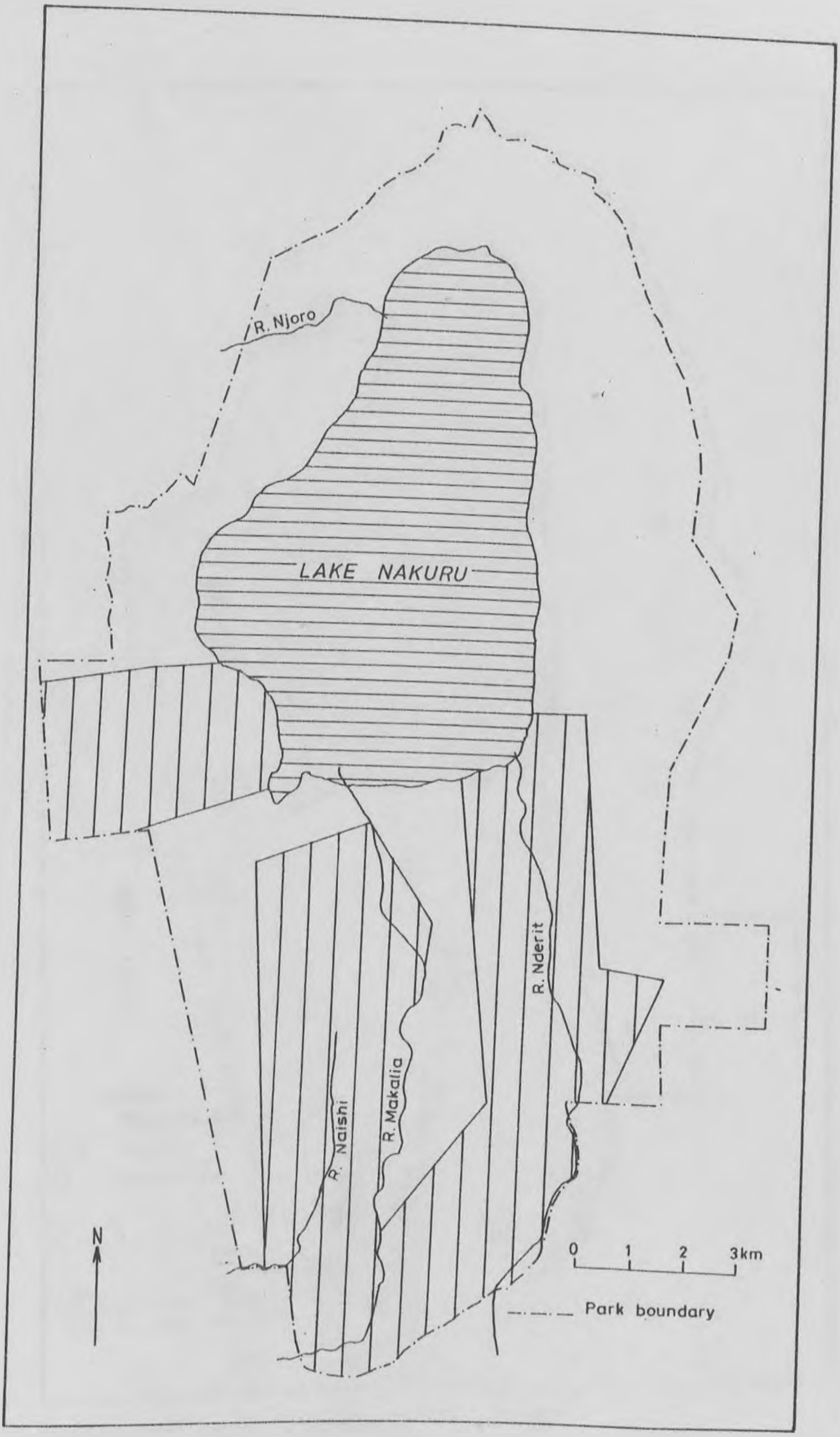

Fig 6.4: Wet season Rhino distribution area

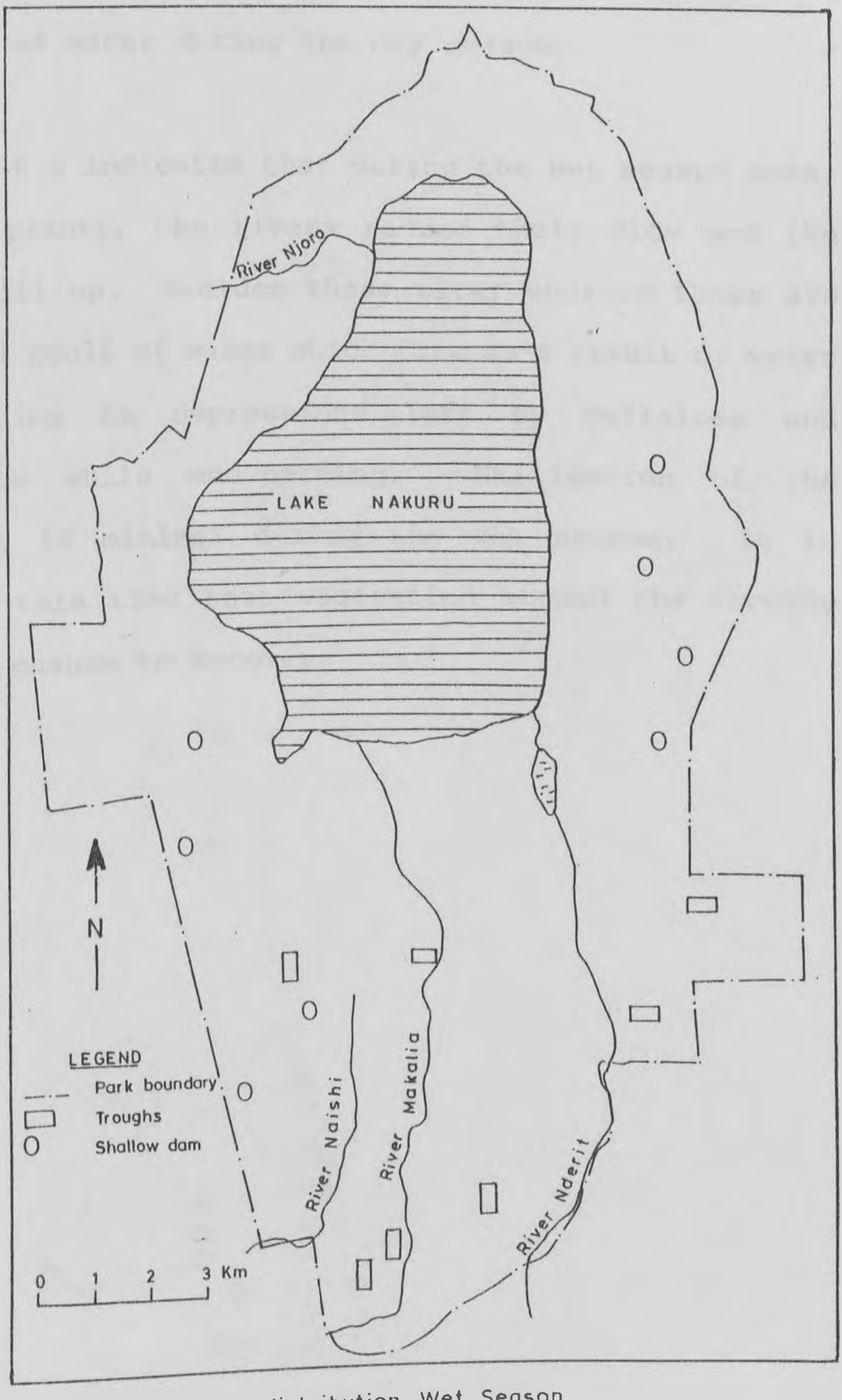

Figure 6.5: Water distribution Wet Season

dry season progresses. Besides the troughs there are about five springs which play an important role as a source of water during the dry season.

Figure 6.6 indicates that during the wet season water is in plenty, the rivers resume their flow and the dams fill up. Besides these water sources there are several pools of water which form as a result of water collecting in depressions left by buffaloes and warthogs while mud-bathing. Utilisation of the troughs is minimal during the wet season. It is during this time that vegetation around the troughs gets a chance to recover.

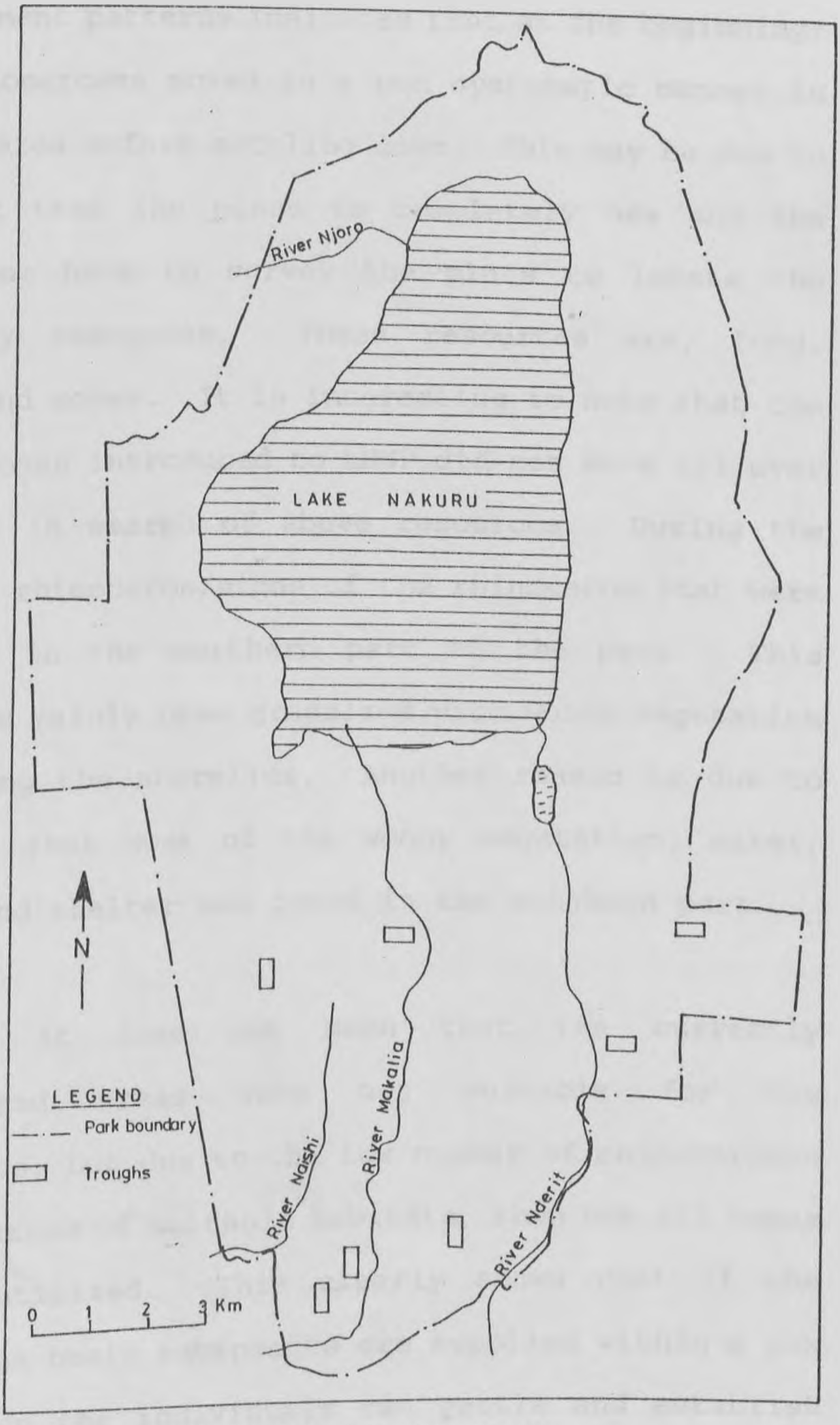

Figure 6.6: Water distribution Dry Season

6.4: DISCUSSION.

The movement patterns indicates that at the beginning, the rhinoceroses moved in a non systematic manner in the new area before settling down. This may be due to the fact that the place is completely new and the rhinoceros have to survey the place to locate the necessary resources. These resources are, food, water, and cover. It is interesting to note that the rhinoceroses introduced to LNNP did not move all over the park in search of above resources. During the study no rhinoceros/signs of the rhinoceros that were recorded in the northern part of the park. This region is mainly open grassland with woody vegetation only along the shoreline. Another reason is due to the fact that most of the woody vegetation, water, browse and shelter was found in the southern part.

However, it does not mean that the currently uninhabited areas were not suitable for the rhinoceros, but due to the low number of rhinoceroses and an excess of suitable habitats, then not all areas can be utilized. This clearly shows that if the rhinoceros basic equipments are supplied within a new area, then the individuals can settle and establish their home ranges very easily.

The results also indicated that in LNNP the dominant males were observed to push young individuals from their areas. This implies that the black rhinoceroses are not strongly attached to their home ranges and they do not even defend it. This further confirms the fact that black rhinoceros are not territorial (Schenkel and Schenkel, 1969, Goddard, 1970, Waweru, 1985).

Home range sizes differ from one area to the other. Mean size of 2.8 sq km and 4.8 sq km for males and females respectively were recorded in Nairobi National Park (Waweru, 1985). Goddard (1968) reported 15.80 sq km and 15.02 sq km for males and females respectively in the Ngorongoro and 22.02 sq km for males and 17.08 sq km for females in Tsavo. Results of this study have given mean home range sizes of 7.3 ± 2.0 sq km for males and 8.4 ± 2.8 sq km for females during the wet season, while during the dry season the mean sizes are 11.2 ± 2.4 sq km and 15.2 ± 4.6 sq km for males and females respectively. The above observations indicates that the home range size in rhinoceros is dependent on the vegetation of the given area and the availability of water.

Studies in Nairobi National Park showed that the distribution of the black rhinoceros was affected by disturbance (Waweru, 1985), this was not observed in LNNP. The rhinoceros distribution area in LNNP is least disturbed. The number of visitors in this area is relatively low compared with the lake shore. Cover is readily available in LNNP so is food supply.

Therefore the distribution and size of the home ranges is dependent on the water availability. Goddard (1968) reported larger home ranges for rhinoceros living in drier areas. This explains why larger home ranges were recorded in LNNP during the dry season.

All the rivers draining into the lake have become seasonal as a result of land use activities upstream and in the catchment areas. The lake is alkaline and as the dry season progresses the water becomes more and more unsuitable for drinking. By this time the animals are dependent on the five springs around the lake for drinking water. However introduction of the black rhinoceros was preceded by a water development phase during which 10 cemented water troughs were constructed (Rhino Rescue files). Water for these troughs is obtained from six boreholes drilled for this purpose. The location of these troughs which are the main sources for drinking water during the dry season, might have contributed to the current distribution of rhinoceros in LNNP.

In addition several shallow dams were developed and provide water for a short period during the dry season. These are very important during the wet season. Trampling around the troughs during the dry season indicates that water supply is inadequate and more should be added. The location of water points should be such that they are randomly distributed all over the park.

In addition the animals will be more evenly distributed around the park. Since LNNP has plenty of rhinoceros' browse plants all over the park, new troughs sites should be dependent on the habitat distribution. This will result in a more even distribution of herbivores in the park and ease the current overstocking in the southern part of the park.

The observed overlapping in home ranges of different rhinceroses indicate that, rhinoceroses can tolerate each other and share the available resources without any aggression. This can result in a small area holding high densities of rhinceroses. Goddard (1967a) recorded a density of about 9 rhinoceroses/sq km.

Observations at SRGR indicates a density of 1.63 sq km. These figures are very unrealistic because it is known that no single area of above size (1km2) that can naturally provide adequate resources. Therefore the home range size will depend on the distribution of the basic resource requirements. Going by the above argument, it is clear that for this to be possible, the species (*Diceros bicornis*) must possess a high degree of individual tolerance. This is a big advantage to the species because it can thrive in very high densities.

The home range sizes in LNNP compares well with results from Lerai forest on the floor of the Ngorongoro crater (Goddard, 1967a). The only problem in LNNP is availability of water. With water scarcity the home range sizes are slightly higher than expected for woody vegetation (Goddard, 1967a; Mukinya, 1973; Waweru, 1985). The vegetation in LNNP can provide browse material throughout the year just like a woodland swamp. This implies that LNNP can support a high density of rhinoceros.

CHAPTER 7

DEVELOPMENTS ASSOCIATED TO RHINO TRANSLOCATION IN LNNP

7.1 INTRODUCTION

In 1985 the Kenya Government in conjuction with the Kenya Rhino Rescue Steering Committee in an endeavour to save the few remaining black rhinoceros, proposed the establishment of special black rhinoceros sanctauries. The areas ear-marked for this were, Lake Nakuru, Tsavo, Aberdare, and Nairobi National Parks. The LNNP was to be developed as the first sanctuary. Following this a development plan was prepared detailing all the pre-requisite developemnt activities.

The most important aspect was enhancement of security before the rhinoceroses were translocated to LNNP. This called for the provision of a reliable fence all around the park boundary. The park is sorrounded by agricultural land and urban settlement (Northern part). As a result of this the park was fenced using chain link all around in 1976 except for a small portion on the western side where the boundary runs along a cliff. The fence was not well maintained and required major repairs in many places. In addition it was not effective in deterring human beings from entering the park and animals moving out into the farms. To overcome this problem the fence had to be reinforced with solar fence.

Introduction of the rhinoceros implied an increase in personnel and therefore development of associated infraastructure. This involved the development of both permanent and temporary structures.

Water is very important for the survival of any animal species. The LNNP is known to have a problem in respect to fresh water availability. The lake water is highly alkaline and unfit for animal consumption. The rivers entering the park are all seasonal. Therefore water development was a pre-requisite in developing LNNP as a rhinoceros sanctuary. As a result of the above, when the rhino rescue steering committee was established, it had the following tasks.

- to create the necessary infrastructure needed for a rhinoceros sanctuary.
- to develop the support facilities necessary for a sizeable rhinoceros population.
- to implement the efficient translocation of between 30-40 rhinoceros.

All the objectives have been achieved and have been observed to have differing effects on the ecology and animals of LNNP. Major development activities observed to have direct or indirect effects on the rhinoceros ecology is dealt with in this chapter.

7.2 METHODS.

Most of the information presented in this section was obtained from the park files and monthly reports available at the park headquarters. Where the information was not clear, on the spot checks were conducted for further confirmation. In addition information was continously recorded during the study period.

7.3 RESULTS.

7.3.1 Water development.

As indicated in figure 7.1 there are four major rivers that drain into the lake. These are Njoro, Makalia, Nderit and Naishi. Except for the Njoro all the others are seasonal, flowing during the rains only. The amount of water reaching the lake via Njoro has been highly reduced due to off take upstream and agricultural activities in the catchment area. As a

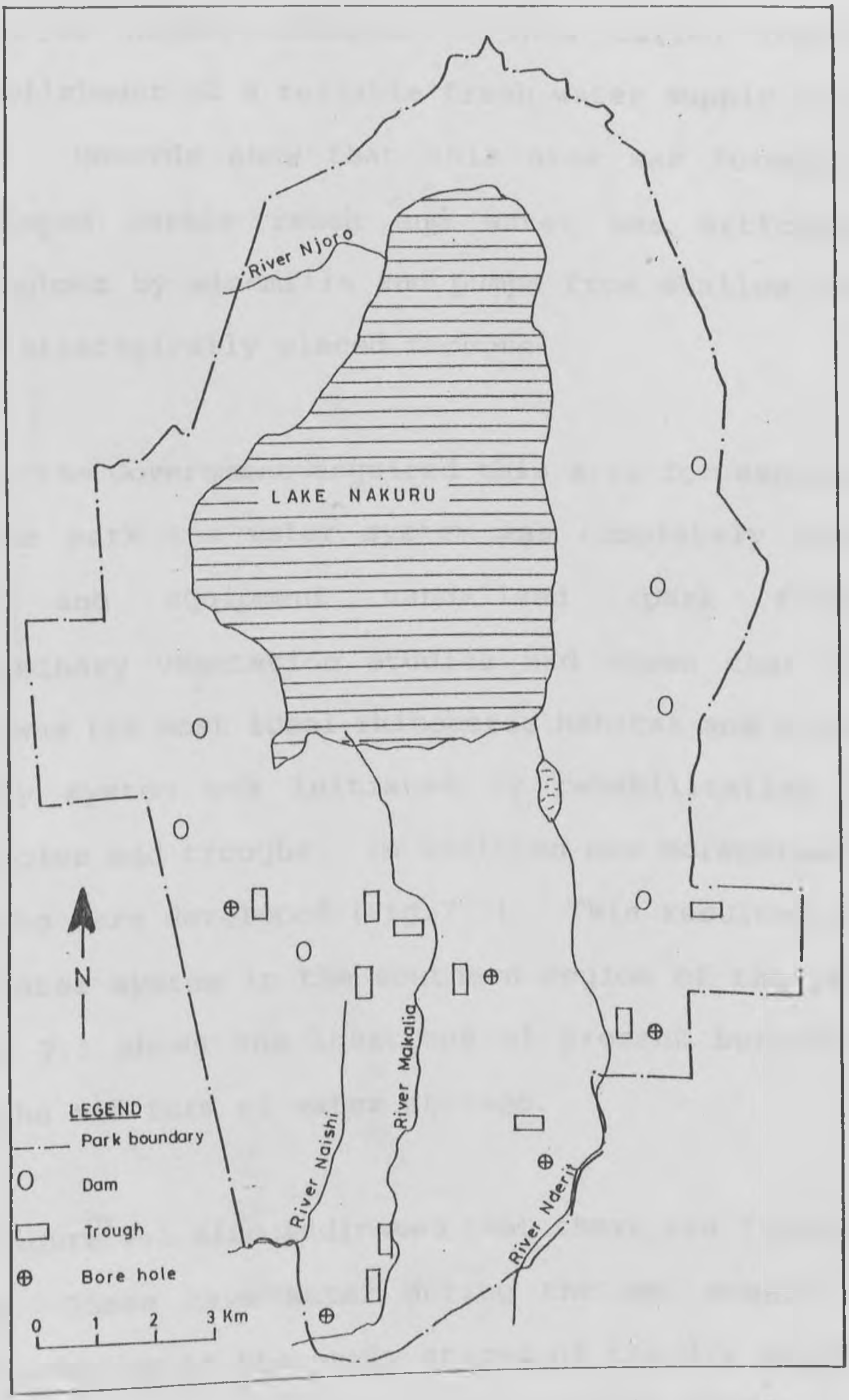

Figure 7.1 Distribution of bore holes and drinking troughs

result of the above factors these rivers have been ruled out as potential sources of water for animals in LNNP. The only other source of water is the lake which is highly alkaline. This called for the establishment of a reliable fresh water supply in the park. Records show that this area was formerly a developed cattle ranch and water was articulated throughout by windmills and pumps from shallow wells into strategically placed troughs.

After the Government acquired this area for expansion of the park the water system was completely broken down and equipment vandalised (park files). Preliminary vegetation studies had shown that this area was the most ideal rhinoceros habitat and a water supply system was initiated by rehabilitating old boreholes and troughs. In addition new boreholes and troughs were developed (Fig.7.1). This resulted in a new water system in the southern region of the park. Table 7.1 shows the locations of present boreholes, troughs and form of water storage.

The figure 7.1 also indicates that there are 7 shallow dams. These have water during the wet season and mostly dry up in the early stages of the dry season.

Table 7.1: Borehole Location and form of water storage

Borehole	Location	No. of troughs	Storage
A	Soysambu	1	Tank
B	Nderit	1	Tank
C	Nderit Swamp	1	None
D	Nganyoi	5	Tank
E	West of Nasoit	1	None
F	Lake Nakuru lodge	1	Tank

Except for the Nganyoi borehole with a permanent lister engine all the others are served by a mobile engine and water is pumped on specific days.

7.3.2: Infrastructure

Translocation of rhinoceros to LNNP called for enhanced security and an efficient administrative programme. To implement this several infrastructure developments had to be carried out before the rhinoceros were released to LNNP.

a. Roads.

In the past, most of the tourist activities had been concentrated around the lake shore resulting in the roads serving the area getting more attention in terms of maintenance. The southern part road network was neglected and had to be developed. This involved the grading of existing roads, construction of bridges (where necessary) and establishing of survaillance tracks. Figure 7.2 shows that a total of 3 bridges and 54 kms survaillance tracks were constructed. In addition approximately 74 km boundary road was developed on the inside of the solar fence for maintenance purposes.

b. Fence.

The park was enclosed with a chain link fence in 1976 except for a small section on the western escarpment. This fence was not strong enough to prevent the rhinoceros from moving out and human beings from getting in. As a result of this the fence had to be rahabilitated and extended to cover the whole perimeter of the park. In order to enhance security a second solar powered fence was constructed on the inside parallel to the chain fence. It is only in a 1.5 km section between Nganyoi and Makalia falls where the two fences are merged.

The solar fence is approximately 74 km long. The fence is composed of 12 wire strands among which six are live and carry about 5000 volts. Figure 7.3 indicates that some parts of the park were left out by

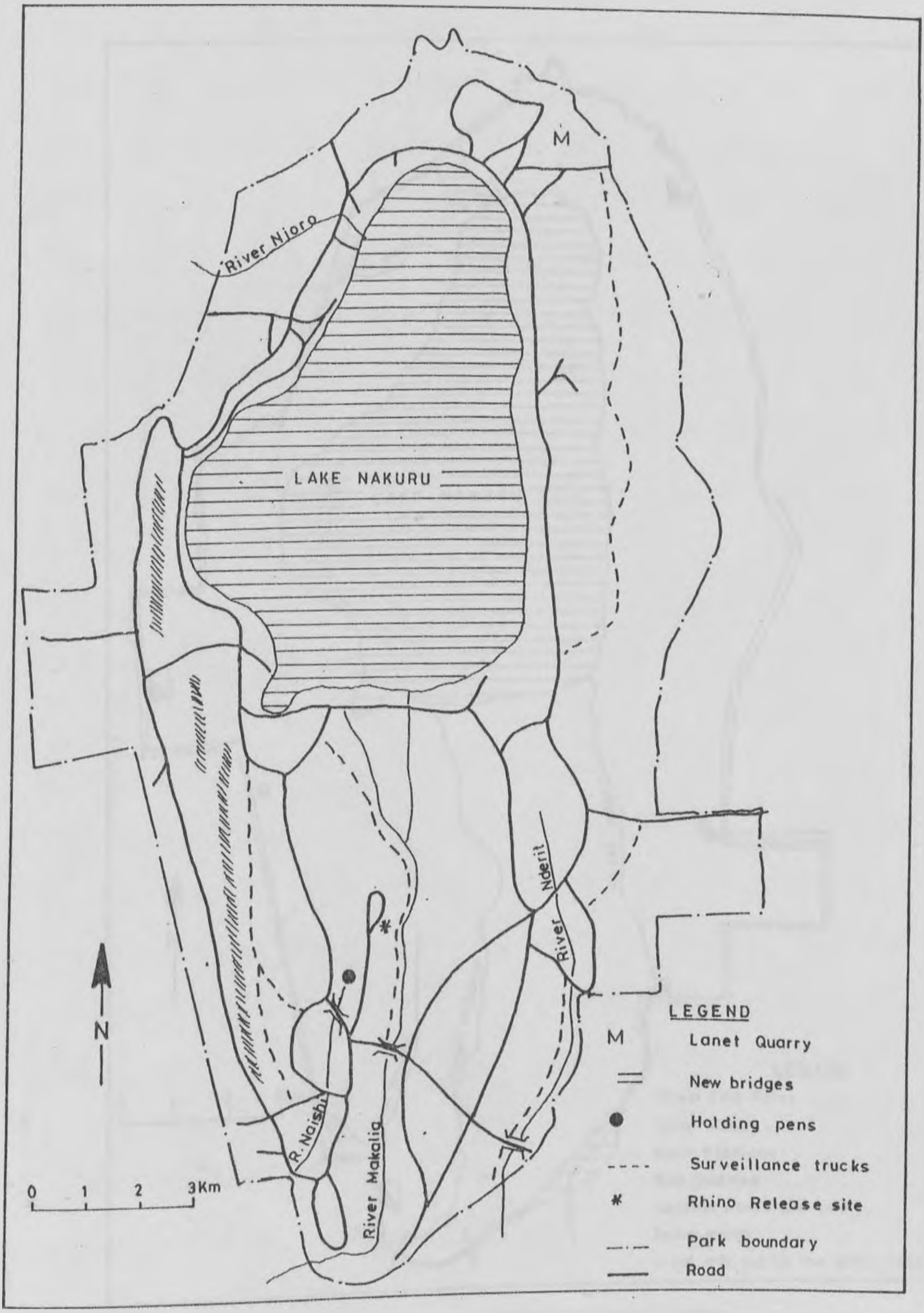

Figure 7.2 New infrastructure

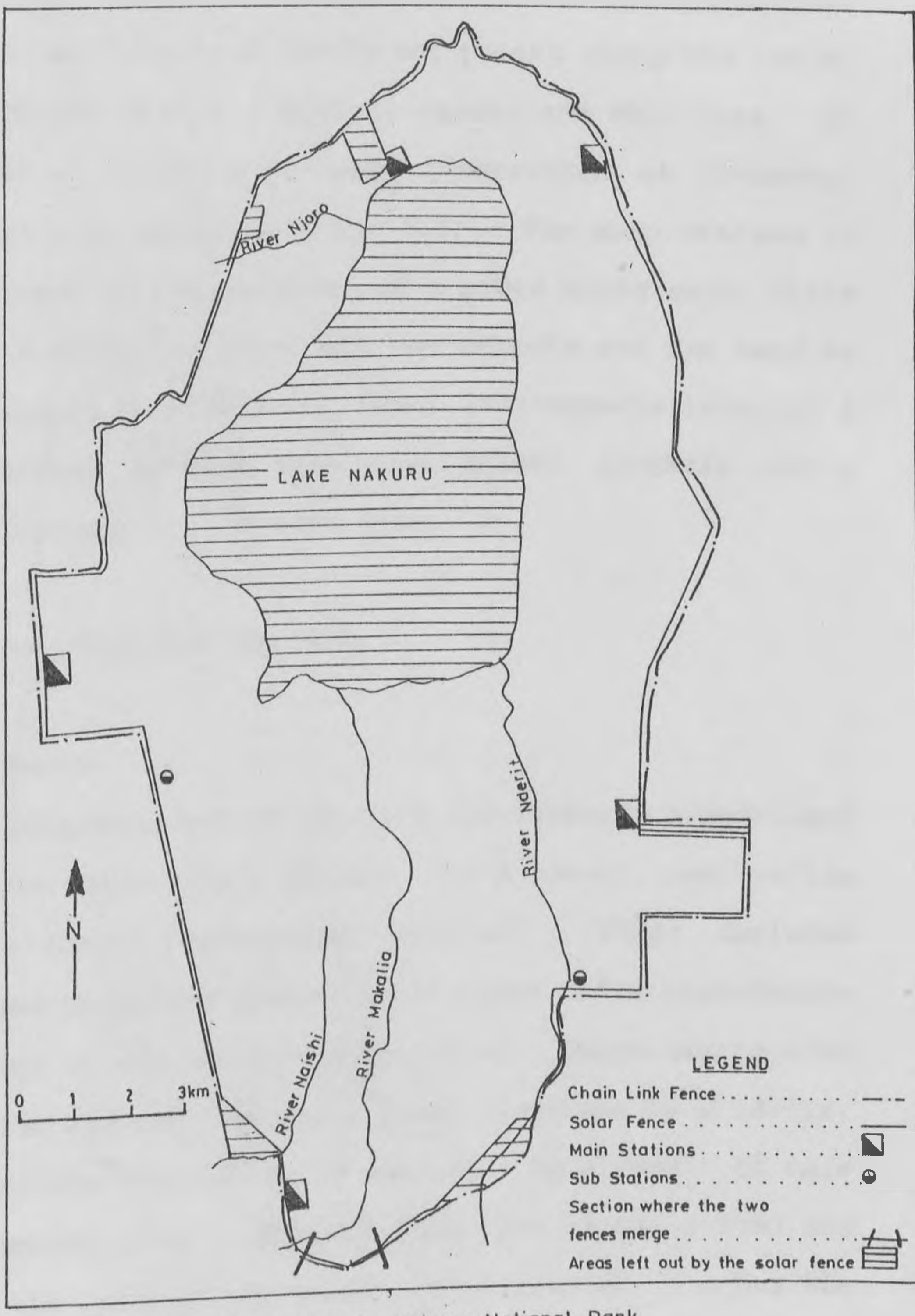

Figure 7.3: Solar fence in Lake Nakuru National Park

the solar fence although they are inside the chain fence. This was attributed to the nature of the terrain. The power is supplied to the fence from four stations located at different points along the fence. These are Nganyoi, Nderit, Lanet, and Main Gate. In addition substations were constructed at Soysambu, Pwani and Zakaria's (Fig. 7.3). The main station is composed of two unipots and a power house each, while the substations have only two unipots and are used by maintenance personnel. Other developments included a temporary release site near Naishi airstrip and a holding pen in the same area.

7.3.3: Cleaning The Park.

a. Relics

The southern part of the park was formerly a developed cattle ranch (Park files). As a result many relics from former development existed. These included unused telephone poles, fence posts and a considerabe amount of old broken fencing wire. These were a sore to the eye and the wires posed a hazard to wildlife, therefore they had to be removed. As a result of this "operation clean up" was carried out in early 1987 and all the unwanted material was collected. During the exercise 23 snares were collected.

b. Squatters.

After Mr. J. Long's ranch was bought by the Government for the extension of LNNP, some of the workers (25) of the former cattle ranch remained in the park as squatters. Their residential structures were located about half a kilometre east of the Lake Nakuru Lodge. A long legal tussle between the Park management and the squatters started in the mid seventies and did not end until late 1986, when the squatters were settled at Kiambogo Settlement Scheme which is about 20 km south of the park. The park authorities demolished these structures after settling of the squatters.

c. Lanet Quarry.

This quary had been inside the park and owned by the Lake Nakuru Ballast and Aggregate Limited (Fig. 7.2). It had been running without a permit until 1984 when a five year lease (Grant No.1E 38851) was given by the Government. However pressure from the park management and the Rhino Rescue Trust resulted in the closure of the quary in 1986.

7.3.4: Visitors.

Lake Nakuru National Park has been very popular with visitors since it's inception in the early 1960's.

During the early years (1961-1971) the major tourist attraction was birds, especially the pink coloured flamingoes which occur in great numbers. Visitors data was collected for 17 years from 1973 to 1989. Figure 7.4 indicates that there has been a steady increase in number of visitors over the years except on two years 1975 and 1979 when major decline in numbers was recorded. Major increases in visitors numbers was recorded in 1977, 1980, 1984 and 1987.

7.3.5: Herbivore Biomass.

Wildgame in LNNP was counted on several occasions in 1989. The data represented here is for the last census carried out in December 1989. counting was carried out on the ground using vehicles. The study area was divided into 12 survey blocks (Fig. 7.5). The counting started as early as 0600 hours and continued to about 0800 hours. Data was collected on species name, number, sex, and age. The total population for each species in the park was obtained by summing up all the numbers recorded for each species per block.

Table 7.2 indicates that there is a very high number of herbivores and very few carnivores. The number of waterbuck comprised 52.7% of the total biomass in the

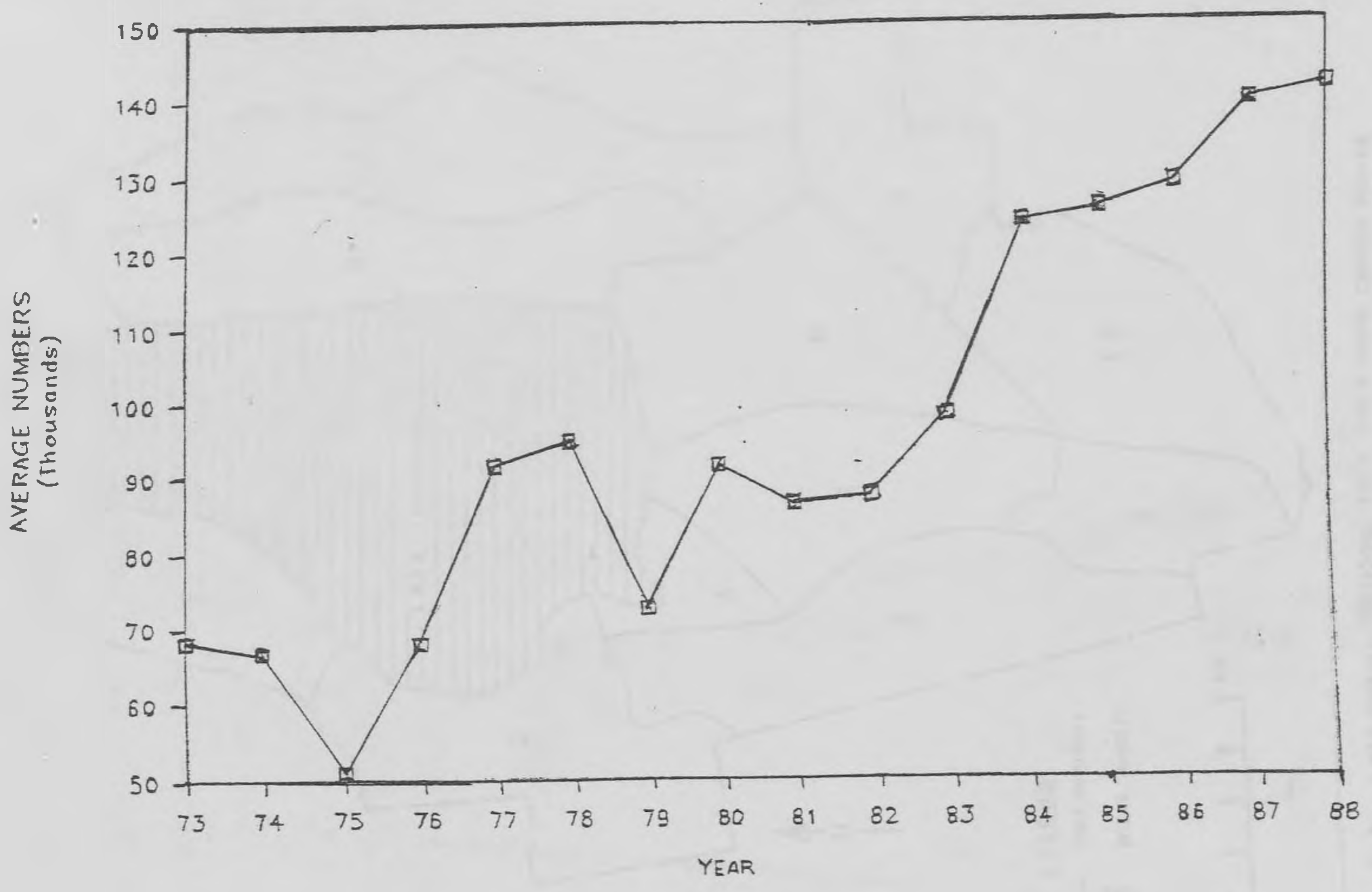

Fig. 7.4: VISITORS STATISTICS IN L.N.N.P

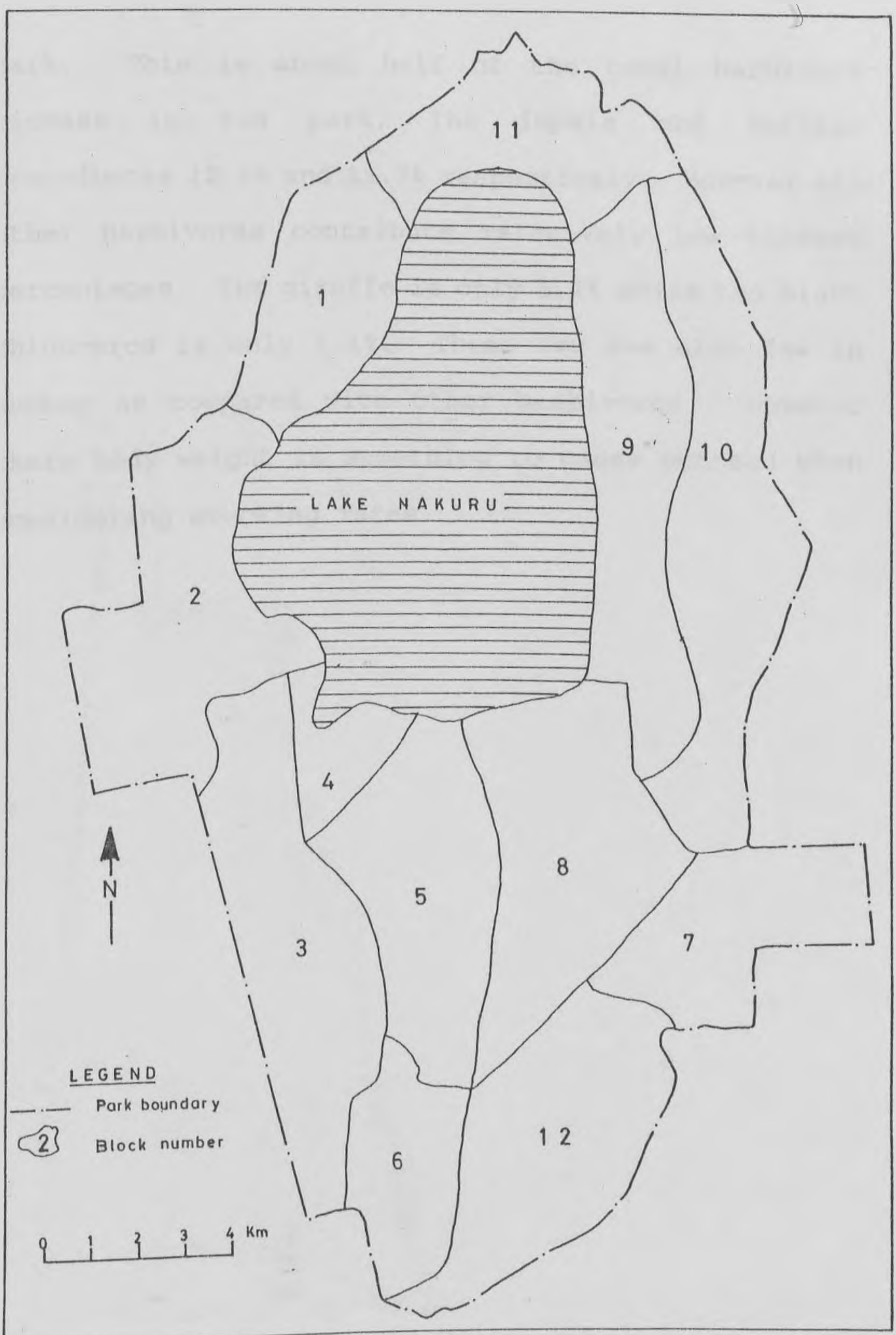

Figure 7.5: Lake Nakuru National Park Herbivore census blocks
Adopted from the Park files (1988)

park. This is about half of the total herbivore biomass in the park. The impala and buffalo contributes 12.9% and 12.7% respectively. However all other herbivores contribute relatively low biomass percentages. The giraffe is only 5.2% while the black rhinoceros is only 1.1%. These two are also few in number as compared with other herbivores. However there body weight is something to cause concern when considering stocking rates.

Table 7.2: Population Numbers and Stocking Rates for Herbivores in LNNP.

Species	Nc	Density *	AU/sq km	Biomass	%Biomass
Waterbuck	4649	31.9	11.2	5.1	52.7
Impala	4147	28.4	2.5	1.3	12.9
Warthog	1339	9.2	0.9	0.4	4.2
Buffalo	392	2.7	2.7	1.2	12.7
Thompson's Gazelle	1301	8.9	0.3	0.1	1.3
Grant's gazelle	589	4.0	0.4	0.2	1.7
Zebra	162	1.1	0.5	0.2	2.3
Eland	75	0.5	0.4	0.2	1.8
Giraffe	98	0.7	1.1	0.5	5.2
Reedbuck	70	0.5	0.04	0.02	0.2
Dikdik	24	0.2	?	?	?
Bushbuck	5	?	?	?	?
Hippo-potamous	35	0.2	0.8	0.4	3.7
Ostrich	4	?	?	?	?
Rhinoceros	19	0.1	0.2	0.1	1.1

Nc -- number counted.

* ---- The density calculations were based on the dry land area only (145.9 sq km).

The mean population weights (kg), animal units (IAU = 455kg) and biomass (Tonnes/sq km) are based on Coe et al, 1976; and Dorst and Dandelet, 1972.

7.4: DISCUSSION

Water development resulted in supplying clean drinking water to the animals mainly in the southern part of the Park. In the past water was only available in the Nderit, Makalia and Naishi rivers during the wet season. Therefore during the dry season the only water source was the lake. This might have contributed in the low number of wild game in the southern part of the park in the past (Kutilek, 1977; Kakuyo, 1980).

Today a very high number of herbivores are observed in the southern part. The waterbuck, impala, eland, thompson gazelle, grants gazelle have increased so are the warthogs. During the wet season the troughs are minimally used. This can be attributed to the fact that animals drink less during the wet season because most of the forage have high water content. In addition water is readily available in the rivers and pools. During the dry season the troughs are heavily used and trampling is very conspicous. During this period water is only available from the troughs hence all animals congregate there for drinking. This causes overgrazing in the areas around the troughs. The distribution of the troughs have caused overstocking in the southern part of the Park, especially during the dry season.

This can only be alleviated by water troughs being evenly distributed in the park. The shallow dams have water only for a short while and for this reason they are only in use during the period just after the rains. If these dams were supplied with borehole water, it would ease the overcrowding around the troughs.

The cleaning of the park was a very important exercise because in the past impalas and buffaloes had been observed with snares. One buffalo died in early 1987 as a result of being caught in a snare (Park files).

This would have been a serious threat to the rhinoceros which were to be introduced into the park. Unused fencing poles and telephone poles would have been an eye sore to visitors in the park. This would remind them of the fact that they were in a former ranch, while the park was supposed to be in the most wild state.

Squatters had tobe moved out of the park and quarry activities stopped inside the park boundaries. Human settlement and industrial activities are not permitted in conservation areas because of the effects they would have on the vegetation and animals being conserved.

The drop in visitors numbers in 1975 and 1979 can be attributed to major events that took place in the country by then, the murder of J M Kariuki in 1975 (Weekly Review March 1975) and the death of the first President of Kenya in late 1978 (Daily Nation 23rd August 1978). This decline in visitors numbers was general for all the national parks in the whole country by then. However the introduction of rothchild's giraffe into LNNP in 1977 might have caused the increase in visitors numbers so is the 1987 introduction of the rhinoceros.

The 1984 increase can be attributed to the increased number of people visiting the park in connection with the rhinoceros project. The herbivore population in LNNP have been increasing since the inception of the park (park files). Censuses conducted in 1988 and 1989 indicated that the population of most of the herbivores have increased, especially in the southern part of the park.

This can be attributed to the fact that there is increased security and enhanced water supply. The solar fence all around the park closes all migration and dispersal routes for animals in the park. With the current rate of increase, soon the population may overshoot the potential carrying capacity of the park unless population control measures are taken. An example is in 1987 when the lake dried up and the hippos were observed to move all the way to the fence but could not move out since further movement was barred by the fence (park files). Past records indicated that whenever the lake dried up, the hippos used to temporary migrate to L. Naivasha via L. Elementaita and return to L. Nakuru when conditions returned to normal, using the same route (Jerkins per.comm.).

These hippos are believed to have come from L. Naivasha using the same route. The movement of plains game between the Delamere Ranch and the Park has been cut off. For many years the thompson gazzelle and the grants gazzelle used to move freely between the Park and the Ranch. This have resulted in the distribution of these animals extending to most of the southern part of the park and as far as the lake shore region and beyond.

CHAPTER 8

8.0: GENERAL DISCUSSION CONCLUSSIONS AND RECOMMENDATIONS

8.1: GENERAL DISCUSSION

Past records of rhinoceros populations in Africa have indicated a downward trend until mid 1980s when some countries started serious campaigns to save the remaining few individuals. In 1970 Africa had about 65,000 rhinoceros (Western and Vigne, 1985). Today the population is lower than 3500 inidviduals (Gakahu, 1991). Some countries which had rhinoceros by 1980, today have none left. However it is only those countries with effective antipoaching squads that have substantial rhinoceros populations (> 100) remaining. These countries are Zimbambwe, South Africa, Namibia, Kenya, and Tanzania.

The populations remaining by 1984 were in fragmented small populations (Cumming, 1987). This prompted the need to establish breeding herds, and could only be achieved by the establishment of special rhinoceros sanctuaries in the respective countries. The objectives for these sanctuaries were to provide breeding areas. Therefore all rhinoceros in fragmented populations would be captured and concentrated in these sanctuaries where security and breeding would be enhanced. If well managed these sanctuaries would provide rhinoceros for reintroduction to the former range.

Kenya adopted this policy in 1985 and by 1987 the first rhinoceros sanctuary, LNNP, was ready. However instead of getting rhinoceros from the fragmented populations, rhinoceros were obtained from a privately owned ranch, Solio Ranch Game Reserve (SRGR) which was overstocked with rhinoceros Jerkins 1985. It is worthy noting that most of the rhinoceros remaining in Kenya by 1986 were in private ranches and a few in protected areas. Among the populations SRGR had the highest density. There was an urgent need to reduce the population to a level which the ranch could comfortably support. A total of 17 rhinoceroses were successively translocated to LNNP.

The LNNP was selected as the first sanctuary because of it's vegetation, small size, closeness to Nakuru town, accessibility, and its abundance and variety of bird life and herbivores which makes it a unique park. In addition the park had only one species of browsers, the rothchild's giraffe translocated to the park in 1977 (Kakuyo,1980). Before 1977 the park had no browsers (Kutilek, 1972) and this had resulted in an increase in woody vegetation which have grown very tall. Vegetation studies indicated that some species had attained more than 20 m height and are unavailable to both the giraffe and the rhinoceros. This is common in the dense and open Acacia woodland, Olive - Teclea forest and the Euphorbia candelabrum forest.

Vegetation studies indicated that there were more browse material in LNNP as opposed to SRGR the browse plants had been subjected to browsers for a long time while in LNNP the browsers had only been introduced recently (Kutilek, 1972; Kakuyo, 1980). However the height of the browse plant limits the amount of browse that is readily available to the rhinoceros. Whereas in SRGR most of the browse is readily available to the rhinoceros. Browse material above 2.5 m is considered unavailable to the rhinoceros (Waweru, 1985).

The suggested potential carrying capacity of 203 rhinoceros in LNNP can be considered to be on the higher side. This can only be achieved in the absence of other browsers and assuming the climatic conditions do not change. The proposed pioneer population of 40 rhinoceros is a reasonable number but the sex ratio should be such that the females are more than the males. This is because LNNP is supposed to be a breeding ground. The population should be managed at 100 individuals and any excess should be translocated to other areas.

The capture exercise was a success. Out of 18 rhinoceros captured, 17 were successfully translocated to LNNP and one died at capture. This gives a mortality rate of 5.6% for the whole LNNP translocation. The death was attributed to an overdose, the rhinoceros was a subadult but an adult dose dart had been used (Rotcher, pers. comm.) This mortality rate however compares favourably with wildlife losses related to immobilising techniques. Orr and Moore - Gilbert (1964) reported a mortality rate of 5.9%, Harthon and Bligh (1965) a 2.0% loss rate and Short and Spinage (1967) recorded a mortality rate between 9-29%. Rhinoceros are very difficult to age in the field due to the habitat they live in and therefore the risk of overdosing is high.

During the LNNP translocation there were no capture related deaths after the translocation. McCulloch and Achard (1969) reported deaths of rhinoceros immediately after capture and also after release all attributed to capture and management of the capture rhinoceros. None of these was reported in the LNNP translocation. The rhinoceros were transported to the holding pens immediately after capture. In the holding pens they were crate trained for 7-14 days after which they were transported in crates to LNNP. The rhinoceros were not sedated during transportation. The time between darting and revival is very important. During the SRGR capture the rhinoceros were transported to the holding pens in an immobilised condition and revived in the holding pens. However the Game Capture Unit (GCU) have modified the procedure and now the rhinoceros is revived immediately after capture and walked into a crate. Once in the crate the crate is loaded onto a lorry and transported to the new release site (GCU files).

There was a bias in the sex ratio of rhinoceros translocated to LNNP. More males than females were translocated. This can be attributed to the fact that a private donor was giving the rhinoceros and he had an upper hand in deciding on what animal was to be captured. In other cases he had developed some fondness to some individuals which he could not let go. Therefore the GCU had no alternative other than to capture what was allowed by the donor, However this bias should be corrected by the translocation of more females to LNNP, from other areas.

Results on home range sizes and distribution of rhinoceros in LNNP indicate that the animals are very tolerant to each other and even share home ranges. The same has been observed elsewhere (Goddard, 1970; Waweru 1985). The size of the home ranges is dependent on water availability in LNNP. This explains why the home ranges in LNNP are larger in the dry season than in the wet season.

The development of the solar fence around the park has limited the distribution of the rhinoceros to within the park. Once the southern part is fully occupied, the rhinoceros will have no alternative other than move northwards. The surveillance tracks all over the park have made patrols more efficient and effective. This has been enhanced by the positioning of the fence maintenance stations along the fence.

Water supply in troughs and shallow dams have solved the water problem in LNNP, but the distribution of these watering points have caused overstocking in the southern part of the park. To overcome this more water points should be established in other parts of the park.

The strategy adopted by Kenya in 1984 to establish rhinoceros sanctauries has been successful. Today within Kenya there are total of 11 well protected rhinceros sanctuaries. Among these 6 are completely fenced, 3 are partially fenced and 2 are not fenced but security is enhanced. These 11 sanctuaries are holding about 75% of the total rhinoceros population in the country. The remaining 25% are found in non protected areas where their protection and survival cannot be assured. Within the last four years a total of 52 rhinoceros have been born in sanctuaries. The LNNP has recorded 3 calves within 3 years.

Therefore the capture and translocation of small fragmentary rhinoceros populations to safe sanctuaries has proved to be the best strategy as is the case with LNNP. However although the sanctauries offer a solution to the survival of the rhinoceros, caution should be taken due to the related management problem. The initial costs for development and actual translocation is very expensive and would require the collaboration of the government and all related conservation agencies. In addition not all areas can be developed into sanctuaries and this will call for proper preliminary studies to be carried out in these areas. Information on the past rhinoceros history, habitat suitability, communication, water available, security, infrastructure and disease should all be fully understood. The source for funds and the pioneering rhinoceros should be identified.

The issue of interbreeding is another serious risk which would face sanctauries unless measures are taken to interchange the breeding individuals between sanctauries. To overcome all the problems it will be very important for the concerned authorities to establish effective and efficient ecological monitoring programmes for the sanctuaries both private and Government owned. This will ensure that certain standards are maintained in the management of the sanctuaries for them to achieve the objectives they were initially set for.

8.2 CONCLUSIONS

The absence of browsers from a habitat results in the re-establishment of woody vegetation. This implies that browsing intensity in any given habitat will have an effect on the regeneration and establishment of woody vegetation in that habitat. Lake Nakuru National Park (LNNP) has a very high browse biomass density as compared to Solio Ranch Game Reserve

(SRGR). However most of the browse material is not readily available to the rhinoceros. The rhinoceros diet in LNNP comprised of a wider range of food plants than in SRGR. The rhinoceros is a generalised feeder, and will easily adopt to new food plants even when it had no prior exposure to the plants. The rhinoceroses were observed to feed on significant amounts of herbiceous plants besides feeding on woody vegetation.

Water availability is a significant factor in determining the home range size and distribution of rhinoceros translocated to a new area. The female home ranges were significantly larger than those of the males throughout the wet and dry seasons indicating that the females forage more widely than males in new habitat. The rhinoceros translocated to LNNP had very high percentage overlaps in home ranges for both sexes. Although rhinoceros have been recorded as non aggressive to one another, in LNNP a serious encounter was recorded implying that under certain circumstances there is serious fighting between individuals.

The fence has turned LNNP into a "terrestrial island" where free movement of animals is limited to within the park. The establishment of artificial watering points in the park have resulted in the increase pf herbivores in the southern part of the park. This puts alot of pressure on the herbiceous cover, especially on areas surrounding watering points.

The translocation exercise was successful and a population of 19 black rhinoceros were introduced to LNNP. This will provide these individuals with plenty of browse throughout the year resulting in a high breeeding rate. The small size of LNNP is an advantage because it will enhance successful copulation. Calves reported in LNNP are a sign of bright future for the rhinceros in Kenya and other areas.

The LNNP habitat can potentially support rhinoceros at a density of 1.4 sq km. However this will only be so if there is no competition for browse and productivity of the habitat remains constant. Since the purpose of setting up LNNP as a rhinoceros sanctuary was to start a breeding population, then the sex ratio which is biased now, should be adjusted such that the number of females is higher than that of the males. The habitat at LNNP can comfortably support 100 rhinoceros but the pioneering population should be about 40 individuals. Rhinoceros at LNNP should be maintained at a low density because high densities affect the recruitment rate in rhinoceros.

Ecological studies should be carried out before and after the commencement of any translocation exercise. This will enhance the understanding of the ecology of both the animal and its habitat. It is important to collect information on the individuals to be translocated before the actual exercise have started. Important information includes age, sex and body weight estimation, to enable the darting team prepare appropriate darts in advance. Time lag between capture and translocation exposes the rhinoceros to unnecessary stress and should be minimized.

8.3. RECOMMENDATIONS

The conservation of the rhinoceros should be dealt with at multispecies level, where other animals in the sanctuaries should be considered as equally important.

Preliminary studies should always be carried out prior to a capture exercise. Information on age, sex and body weight of the individuals to be translocated should be known in advance and the capture team will go for known individuals.

Ecological monitoring programmes should be established for all rhinoceros sanctuaries in the country. Trends on the vegetation and herbivore populations should be closely checked and where need be, control mechanisms should be used. For the rhinoceros, information on mating should be recorded and individuals involved well identified to help monitor the breeding individuals.

The future success of these rhinoceros in sanctuaries should depend mainly on proper security at all times. The personnel involved should be well trained and devoted to achieve this objective.

The sex ratio should be corrected such that the total population will be at least 30 females and 10 breeding males making a total of 40 rhinoceros.

The rothchild's giraffe should be studied and techniques for controlling the recruitment rates developed. This will check the giraffe population in the park.

SUGGESTED TOPICS FOR FURTHER RESEARCH.

1. Studies on the effects of fencing -" Terrestrial

Islands" - on the ecosystem

2. Studies on the effects of biased sex ratio on the breeding success of the rhinoceros.

3. Detailed studies on the importance of non-woody plants in rhinoceros diet.

4. Effects of park size on the ecology of translocated endangered animals with special reference to large herbivores.

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APPENDIX 1

WOODY VEGETATION : P.C.Q. DATA FORM

DATE : PLOT NO. SHEET NO.

POINT NO.	QT. NO.	HEIGHT CLASS(m)	SPECIES CODE	DISTANCE (cm)	STEM DIAM (cm)	HEIGHT (Km)	GROWTH UP SLOPE	WIDTH ALONG SLOPE	CROWN (m) DEPTH