SADC REGIONAL PROGRAMME FOR RHINO CONSERVATION

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ASSESSMENT OF BIOLOGICAL AND HUMAN FACTORS LIMITING THE WEST KUNENE RHINO POPULATION

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The Programme is funded by the Italian Ministry of Foreign Affairs, Directorate General for Development Cooperation (Project AID 5064).

The Programme is contracted to CESVI and implemented through a regional consortium which comprises:

- The Secretariat of the Southern Africa Development Community (SADC)
- IUCN-ROSA (The World Conservation Union - Regional Office for Southern Africa)
- The IUCN African Rhino Specialist Group
- WWF-SARPO - (World Wide Fund for Nature - Southern Africa Regional Programme Office)
- CESVI (Cooperazione e Sviluppo)

The ***Programme goal*** is to contribute to maintain viable and well distributed metapopulations of Southern African rhino taxa as flagship species for biodiversity conservation within the SADC region.

The ***Programme objective*** is to implement a pragmatic regional rhino strategy within the SADC region following the acquisition of sound information on, firstly, the constraints and opportunities for rhino conservation within each range state and secondly, the constraints and opportunities for rhino metapopulation management at the regional level.

DISCLAIMER

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EXECUTIVE SUMMARY

A: Reconciling objectives of biological management for black rhino and community based natural resource management

1. Once widely distributed across sub-Saharan Africa the black rhinoceros (*Diceros bicornis*) has suffered a dramatic decline in numbers due to demand for their horns. From an estimated population of 65,000 in 1970 numbers dropped by more than 96% to a population of less than 2,500 by 1992. The escalating poaching in the last thirty years paralleled the dramatic increases in the price of horn in far eastern and North African markets. Although numbers are currently recovering in most populations, the incentives to illegal hunters from poaching continues to outweigh the risk of detection. However, the number of unprotected populations has diminished.

2. The continued recovery of the black rhinoceros requires regional cooperation in subspecies metapopulation management, conservation and security. Due to the precarious state of the black rhino in the SADC region this requires an initial focus of achieving a minimum population increase of 5% per annum over the next ten years. The goal beyond this is enhancing overall biodiversity, ensuring economic sustainability, and stimulating local community conservation awareness and involvement in the protection and wise use of the black rhino.

3. Community-based natural resource management (CBNRM) programmes have the objective of protecting and improving local livelihoods, wildlife resources, and the ecological conditions on which they depend. The hypothesis runs that through improved local control over resource management communities are empowered, and if viable enterprises are linked to the biodiversity of an area, generating benefits for a community, these stakeholders will act to counter any threat to the resource. Over the last two decades conservation agencies have incorporated these principles to address the dwindling populations of African wildlife outside state-protected areas on agro-pastoral communal lands.

4. This report describes the ecological and human-induced constraints on a population of black rhino from a region of Southern Africa. It was completed at the request of the MET and the SADC Regional Rhino Programme to act as a case study for understanding interactions of rural livelihoods, ecotourism, and biological management in a free ranging population of black rhino. In addition, the report aims to comment on the application of a proposed protocol for mitigating human effects through limiting access, and to develop a standardised methodology for the further analysis of ecological and rhino population data.

B: The black rhino in North-Western Namibia

1. The Kunene Region, which is an area of approximately 70,000 km^2, in the north west of Namibia is home to a key population of desert-dwelling black rhinos, recognised by the African Rhino Specialist Group (AfRSG) as a Key 1 Population. In 1970 the population stood at approximately 300 animals. Poaching and a heavy drought in the early eighties reduced the population to approximately 60 animals in 1982. Appropriate conservation measures introduced at this time have since led to a steady increase in rhino numbers.

2. Focusing on the charismatic megafauna a community-based conservation approach was balanced by intensive field operations and strong law enforcement carried out by both government and non-governmental organisations. These measures greatly reduced poaching and contributed to wider biodiversity conservation objectives. More recently empowerment of the surrounding communities, through conservancy development, has diversified stakeholder participation in wildlife monitoring and increased development options for tourism enterprises.

3. The rhino now range over an area of approximately 20,000 km^2, a small part of which falls in Erongo Region. The range covers mainly arid, uninhabited country between the Skeleton Coast Park and the communal farming areas to the east. In 1997 the estimated human population of Kunene Region was 64,000. Around 6,000 people live close to the rhino range, dispersed in small villages and at natural water points occurring on the periphery of the rhino range.

4. The mean rhino density is estimated at 0.02 km^2, the lowest recorded in Africa, and ranges from 0.007 – 0.046 km^2 across eight sub-populations. The density, breeding performance and ranging patterns of black rhino in Kunene are influenced by the variable geology and its impact on soil development, the vegetation types and access to water. This is compounded further by the very low rainfall (<150mm per annum), which is unreliable and patchily distributed. Further influences come from human-induced disturbance (HID), chance events, and demographic effects in small sub-populations.

C: Ecological constraints on the black rhino in North-Western Namibia

1. Ecological studies and reports were reviewed to assess the historical impact of rainfall, browse availability and HID on the black rhino. Twenty years of monitoring data was used to assess past and present performance of the population. Performance for the whole population was analysed using the following parameters: calving interval; calves born per adult female; and, annual growth rates.

2. Using a geographic information system (GIS) this study both examined the ranging patterns of females to identify ecological factors that are limiting spatial movement and fecundity, and also mapped conservancies to investigate how land use, primarily ecotourism, might further impact the black rhino. The analysis involved plotting rhino home ranges using Minimum Convex Polygons (MCPs) to determine ecozones for the comparison of population performance indicators across a revised system of ecozones for the area. Density was then compared across the range area using a 2x2 km grid and density values were assigned to each ecozone. A course habitat map of the area was used to assess terrestrial habitat characteristics associated with each ecozone. Data was analysed using a general linear model.

3. A spatial modelling framework was designed to further classify terrestrial habitats based on the predicted ecological needs of black rhinos. This used a GIS modelling approach, based on a Digital Elevation Model, LANDSAT 7 satellite images and aerial photos. The results will be used to predict suitable sites for the reintroduction of rhino in the historical range and prioritise these sites in terms of habitat suitability and further examine patch occupancy, carrying capacity and landscape connectivity patterns in the current range area.

4. Annual growth rates steadily declined as the population grew over the last 15 years. The population growth rate currently stands at 3.27% per annum over the last five years. Growth rates for the last ten years are only 2.73% per annum. Three years of good rainfall have contributed to pushing growth above 5% in the last two years. However, the historical impact of poor rainfall, and increased competition for browse, compounded by the escalating numbers of other wildlife species highlights the need to consider manipulation of the population in areas where growth is below 5% or likely to be heavily impacted by the onset of drier conditions.

5. Differences in the availability of surface water, geology, topography and forage led to variations in the density of black rhino. The highest densities of black rhino were associated with the mountainous basalt areas of the range. Population performance in two of these optimum habitats (zones 3 and 6) was significantly different. In the area with higher poaching and off-take, zone 3, performance indicators suggest density-dependent factors limit growth and health of the population. Differences between female calving intervals were significant across each ecozone. This suggests that in sites where female home range is increased relative to the availability of resources recruitment rates are reduced. Comparing zones 3 and 6, the ratio of males to females is 0.67 and 1.18 respectively, indicating that density-dependent factors as well as a male bias could have major implications on future performance. This would be amplified should there be a drought in the region, resulting in a dramatic decline in breeding performance.

D: Human-induced disturbance on black rhino in Kunene and Erongo regions

1. Human-induced disturbance (HID) occurs when the impact of an animal's response to human presence causes an overall decrease in fertility or increase in mortality. HID is defined as any activity that constitutes a stimulus sufficient to disrupt the normal activities and/or distribution of a species relative to the situation in the absence of that activity. The level of threat caused by HID is related to the amount of alternative habitat available and chance for habituation of a species.

2. The black rhino in North-western Namibia are particularly vulnerable to HID due to the observed ecological stress on the population. Also, current conservancy legislation falls short of resolving the shortcomings of the present land tenure regime, by which land remains unequally distributed between settler and indigenous farmers, and tenure within the communal areas remains insecure. This results in no means of regulating access rights of farmers and visitors to the area. HID in this area includes: tourism activities, such as trips using 4x4 vehicles or aeroplanes; monitoring of wildlife by MET rangers, conservancies and NGO’s; and, local activities, mainly on the periphery of the range, including livestock grazing and consumptive use of wildlife resources.

3. A study was undertaken to investigate the relationship between black rhino spoor counts and an independent direct measure of density of rhino to test the potential of developing an index for black rhino in this region. The level of sampling effort required for collection of accurate and precise spoor count data was also determined. The study aims to assist with the development of a complimentary monitoring technique, allowing the involvement of all stakeholders, notably conservancies, without increasing levels of human disturbance.

E: Recommendations

1. Fecundity was limited by the availability of surface water and forage, and decreases in black rhino population growth rates were related to these key ecological factors. The short term goal for management of the Kunene population is to ensure that proposed conservancy land use must take account of these spatial factors. This will allow the allocation of land to ensure the successful recovery of black rhinos continues, and maximise benefits to communities beyond only small "pockets" of benefit in the communities or conservancies in areas where population performance remains good.

2. Regulating access to the Kunene range area, and finding acceptable levels of tolerance for rhinos, are key priorities. This requires a programme be implemented to give input on rhino ecological and security needs at the local level during the ongoing conservancy management planning process. This also needs to be done at the regional level, through the MET's Directorate of Tourism's North-west Tourism Plan and the Directorate of Parks and Wildlife's proposed feasibility study for strengthening conservancy land tenure rights through the proclamation of a multi-use IUCN Category VI Protected Area in the northwest.

3. Key follow-up activities and research in support of these programmes should involve the following:
    - the hosting of a workshop to devolve the findings of this study to traditional authorities and conservancy bodies to ensure regional by-in of biological management goals for the Kunene population of black rhino;
    - a broader survey of community perceptions towards rhino and future management is conducted to support the future drafting of a Kunene management plan for black rhino;
    - this management plan should consider the design and development of mechanisms to regulate access into the rhino area, tourism concession areas and registered conservancies as part of a broader land use plan;
    - a study to quantify tourism impacts on rhino would need to be conducted to mitigate some of the problems associated with access, without removing opportunities for development; and,
    - to better understand stocking levels the continued ground truthing of Ecological Land Units (ELU's), as part of the habitat assessment, to refine the first draft of the habitat suitability model.

4. When considering that this study indicates density-dependent factors currently limit growth in the optimal habitat (Zone 6) a translocation programme is recommended as an intervention strategy with a view to determining acceptable levels of off-take that maximise optimal growth. **To do this the removal of at least ten animals from areas with the highest density of animals, e.g. the mountains area of the Palmwag concession - revised zone 6, is strongly advised.** Monitoring the population response to this off-take will allow for the development of an adaptive management regime sensitive to the fluctuations in the resource base and the prevailing environmental conditions. Managing the densities of other browsers and habitat management should also be considered.

5. This population of black rhino is one of four remaining unreconstructed populations of black rhino left in the world. The reintroduction of animals from other metapopulations in the country into areas of the northwest experiencing poor breeding is not advised so as to

maintain the genetic and economic value of this unique population. Monitoring the population response levels to the good rains over the last two years in these poor breeding areas (e.g. zones 1, 4 and 8) and regulating access rights are seen as priorities.

6. Any implemented translocation programme should be conducted with the full involvement of communal conservancies. Prior to considering sites for reintroduction guidelines or protocol need to be developed to prioritise allocation - e.g. to those areas identified from studies of: habitat suitability; historical distribution; and, where communities are willing to invest in rhino management through local institutes.

7. Future protocol for monitoring of this population should build on the existing programme implemented by the NGO Save the Rhino Trust (SRT), who acts as a support service to the MET and conservancies in the area. The relationship between spoor frequency on roads and true density suggests this method has potential as a repeatable, objective and inexpensive supplementary monitoring technique in this arid environment. This could be implemented by conservancies as part of their ongoing fixed route monitoring programme and allow involvement of all stakeholders in monitoring, without increasing levels of disturbance.

8. In conservancies where direct monitoring of rhino will take place, or tourism involving rhino tracking, training should be provided by SRT and once completed monitoring activities could be undertaken by the conservancy. The goal for any further training and research activities should be to develop a code of practice for viewing rhino that is adopted by tour operators and includes self-policing by the private sector in partnership with communities.

9. Though well developed the strengthening of community ties within the programme should be considered to allow formal participation of traditional leaders and registered conservancies in the management of black rhino in the region. In the last year the development of the MET's Rhino Technical Advisory Committee (RTAG) is seen as a positive step in this direction. Co-opting conservancy and community input on this committee will go a long way to the recognition of the community's stake in the survival of the black rhino in the region.

CHAPTER 1: INTRODUCTION TO BLACK RHINO CONSERVATION IN AFRICA

1.1 GENERAL INTRODUCTION

Long gestation periods for black rhinos (*Diceros bicornis*) stretch the critical periods influencing offspring survival (i.e. late pregnancy, early lactation and weaning) across different periods of the year, so no strong selective pressures favour any particular time for reproduction (Hitchins and Anderson, 1983). Although this makes the species extremely susceptible to over hunting, characteristics such as late age of first breeding and age-dependent fecundity, have also allowed populations of the black rhinoceros to recover from near extinction when successful conservation measures have been implemented.

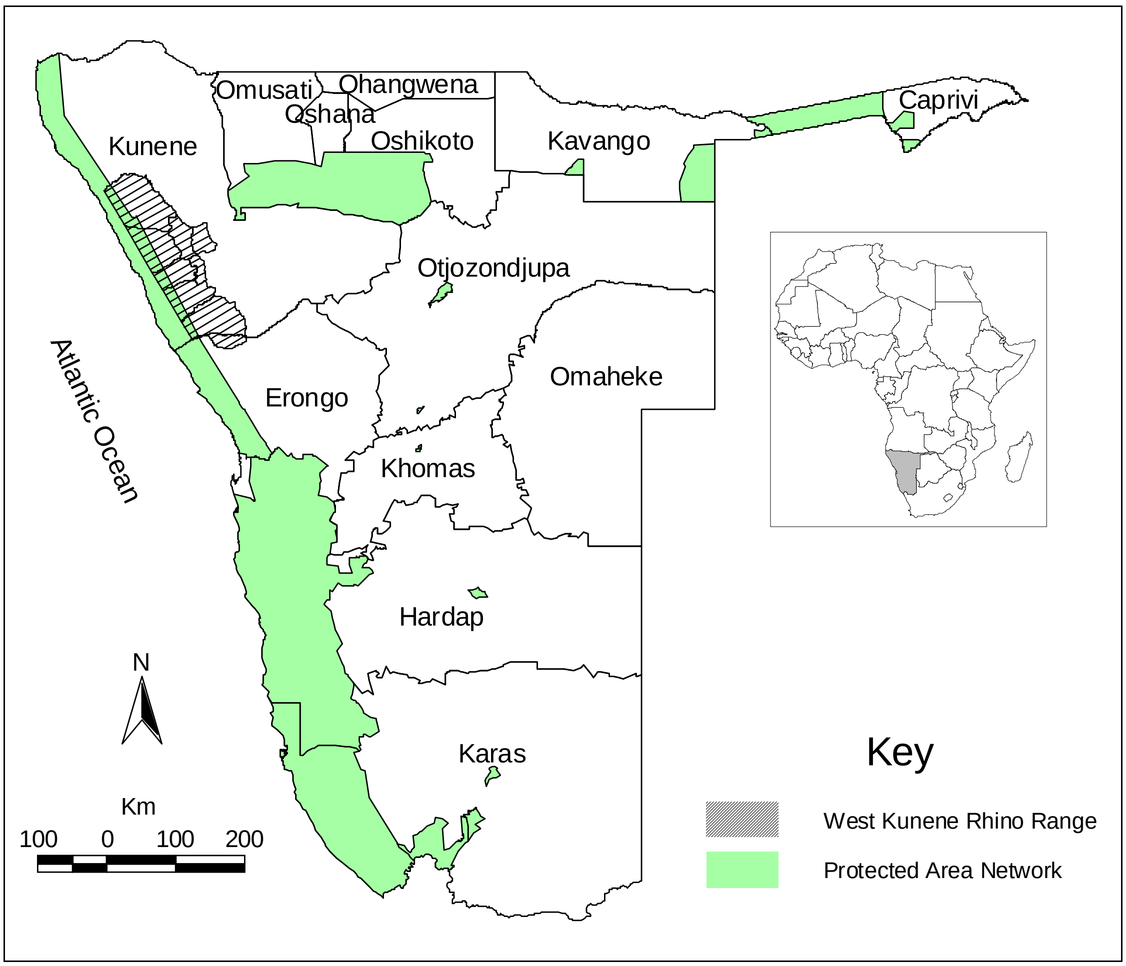


Figure 1. Map of Namibia indicating its position in southern Africa and the locality of the West Kunene Rhino Range (modified from Mendelson *et al.* 2002).

In the arid North-western communal lands of Namibia the desert-dwelling black rhino (*D. b. bicornis*) are typical of a population that have been poached to near extinction and are now showing a recovery in numbers following the successful implementation of appropriate conservation measures. Focusing on the charismatic megafauna, a community-based conservation approach in the early 1980's was balanced by intensive field operations and strong law enforcement carried out by both government and non-governmental organisations. These measures greatly reduced poaching and contributed to wider biodiversity conservation objectives.

Over these last 20 years Namibia's Community-Based Natural Resource Management (CBNRM) programme has provided an innovative means for communities to be actively involved in and directly benefit from wildlife management. Over the same period black rhino numbers in the northwest have more than doubled. Subsequently, recent growth rates have declined and are now below the minimum 5% target in some areas. As more rural communities register conservancies and develop land use plans, there is a need to reconcile aspects of biological meta-population management with development goals for communities.

This report describes the ecological and human-induced constraints on the population of black rhino in North-western Namibia and uses a geographic information system (GIS) to analyse ecological and black rhino population data collected there. This chapter provides an introduction to black rhino conservation in Africa, including the development of community-based conservation approaches in the region. It goes on to review studies on human-induced disturbance (HID) on the biological management of wildlife species. The chapter finishes by describing the history of black rhino conservation in Namibia, where the research took place, and by listing the aims of this report and its overall structure.

1.2 CONTINENTAL TRENDS IN BLACK RHINO NUMBERS

1.2.1 Decline and status of the black rhino

The black rhinoceros was once widely distributed across sub-Saharan Africa. However, from as early as the later half of the 19th century, accounts from hunters travelling in southern Africa detailed the gradual decline and localised extinction of the species in southern Africa (Selous, 1881). In the last thirty years this decline has increased to catastrophic proportions, with numbers plummeting by over 95%, from an estimated population of 65,000 in 1970 to less than 2,500 in 1992 (Emslie & Brooks, 1999).

The early decline in the numbers of the black rhinoceros was attributable mainly to the conversion of suitable habitat for agricultural use, often at the hand of western hunters. In more recent years the single most influential factor in the decline has been poaching for rhino horn, principally for Far Eastern medicines (Leader-Williams, 1992; 't Sas-Rolfes, 1995; Martin & Vigne, 1997). The listing of all extant rhinoceros species on Appendix I of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) in 1977, and the establishment of strong conservation measures in Kenya, Zimbabwe, Namibia and South Africa have been ineffective in preventing the further decline of many black rhinoceros populations across Africa. The incentives to illegal hunters from poaching continue to outweigh the risk of detection, although the number of unprotected populations is diminishing (Leader-Williams, 1992). With this in mind, though numbers are currently increasing, it is expected that the southern African region will experience increased illegal hunting with growing economic pressures, drought and as populations elsewhere are exterminated.

1.2.2 Conservation strategy

Rhino conservation strategies are designed and implemented within national committees to meet the needs of both national and regional meta-population goals. Collaboration at the regional level is facilitated through the IUCN SSC African Rhino Specialist Group (AfRSG) and sub-committees such as the Rhino Management Group, the Rhino and Elephant Security Group and the South African Development Community rhino programme. Continued growth of all populations of rhino species is dependent on regional cooperation in subspecies metapopulation management, conservation and security. Due to the precarious state of the black rhino in the SADC region this requires an initial focus on achieving a minimum population increase of 5% per annum over the next ten years. Goals for the next decade are:

- Development of strategies within departments and agencies that will lead to self-sufficiency.
- Conservation efforts focusing on Key and Important rhino populations.
- Increased regional co-operation.
- Active local community and private sector participation, as well as increasing incentives for these sectors to conserve rhino.
- A more culturally-sensitive dialogue between the consumers of rhino horn and the conservation community, and an evaluation of the potential benefits of opening a limited trade in rhino horn.

(Emslie & Brooks, 1999)

The goal beyond this is enhancing overall biodiversity, ensuring economic sustainability, and stimulating local community conservation awareness and involvement in the protection and wise use of the black rhino.

1.3 ECOLOGICAL CONSTRAINTS ON THE BLACK RHINO

Studies indicate that the onset and timing of reproduction in the black rhinoceros is a response to the prevailing ecological circumstances, notably nutrient availability. The wide variety of habitats in which black rhinos still occur, and the variety of plant species utilised, is a reflection of their adaptability. However, only a small proportion of the browse species and biomass available makes up their diet. The highest densities of black rhinos occur in scrub-bush and open woodland habitats (Goddard 1968, 1970; Hitchins, 1969; Schenkel & Schenkel-Hulliger, 1969; Joubert & Eloff 1971; Mukinya, 1973, 1977; Frame, 1980; Loutit *et al.*, 1987; Brett *et al.*, 1989; Kiwia, 1989a; Oloo *et al.*, 1993; Emslie & Adcock, 1994).

The seasonal changes in diet can also result in a seasonal shift in habitat utilisation, with riverine habitat being favoured during the dry season (Emslie & Adcock, 1994). Variations in the home range size of female black rhino, as a measure of spatial movement, appear to be related to food and water requirements (Klingel & Klingel, 1966; Goddard, 1967b; Hitchins, 1969; Frame, 1980; Conway & Goodman, 1989; Kiwia, 1989b; Emslie & Adcock, 1994), with male home range being governed primarily by social pressures (Owen-Smith, 1992; Adcock, 1994).

In more arid rangelands, such as those seen in North-western Namibia, climatic conditions, elevation, substrate and drainage have a direct effect on height, canopy cover and the composition of woody species (Coughenour & Ellis, 1993). The population of desert-dwelling black rhino in Kunene and Erongo regions of North-western Namibia is one of the most extreme cases of arid land adaptation. Because breeding is only achieved when females achieve 80% of their mature body weight (Georgiades, 1985), it is fair to assume the inter-calf interval will also depend on females retaining a similar proportion of their expected body weight. This indicates that environmental stochasticity would be expected to be the influential factor in the dictating the demography, reproductive success and size of home range for this population.

1.4 A SUMMARY OF COMMUNITY-BASED NATURAL RESOURCE MANAGEMENT (CBNRM)

1.4.1 Introduction

Historical approaches to conservation, such as the gazetting and management of protected areas, have been instrumental in protecting some of what remains of Africa's natural habitats and the continents biological diversity. However, this conservation approach was largely a strategy to protect biological resources of the continent's natural heritage, or for recreational purposes of the then colonial governments. Though there is recognition that protected areas contributed to the human welfare and the security of its neighbours the exclusive nature of this approach to management, and the imposed values, meant that there were considerable costs in living with wildlife for the poor communities that bordered these areas. These came in three forms:

- direct costs, such as stock losses, damage to gardens and threats to humans from wildlife such as elephants and predators;
- preventing local populations from utilising resources within 'protected' areas; and,
- exclusion from the management of these areas, ignoring traditional knowledge, practices, rights and responsibilities regarding management of their environment.

The result was the alienation of communities from conservation efforts and intense conflicts between conservationists and local residents (Western & Wright, 1994; Ghimire & Pimbert, 1997; Fabricius *et al.*, 2001).

1.4.2 The emergence of CBNRM in Africa

The emergence of community-based resource management is a shift away from the 'traditional' approaches to the conservation of natural habitats, by attempting to integrate both development and conservation goals and moving away from top-down regulation and enforcement. This type of conservation is based on the idea that programmes are only valid and sustainable when they have the dual objective of protecting and improving both local livelihoods and ecological conditions. The following factors have influenced the recognition of local agendas in the conservation of wildlife resources in southern Africa:

- the pressure to promote development by utilising wildlife in rural areas;
- a need to diversify the economy in these areas away from agriculture-based systems;
- a lack of local resources for law enforcement and the desire to conserve wildlife outside protected areas;
- an increase in pressure from communities and subversive action;
- the pressure for land reform;
- the desire of conservation agencies to acquire new areas for conservation; and
- political expediency and recognition by governments that rural voters are important.

(Fabricius *et al.*, 2001)

1.4.3 The emergence of CBNRM in Namibia

Communities bear costs of living with wildlife. Therefore, incentives could play a key role for a community deciding if the economic benefits from wildlife utilisation are greater than from competing land use options that exclude wildlife. The emergence of CBNRM in Namibia is one such example where governance and trade-offs associated with incentives have been central to the programme. CBNRM programmes in Namibia followed the lead of private landholders who received limited custodial rights to manage and use 'huntable' wildlife on their land in 1974. The incentives associated with this resulted in increased wildlife stocks on freehold farming areas of Namibia (Barnes & de Jager, 1996). In 1996, a legislative amendment granted conditional rights over specific wildlife resources and tourism to a community institute, called a conservancy. These new institutions were to be managed by committees, elected by the community. Community game guards and field officers would undertake wildlife monitoring activities in the conservancy and benefits, in the form of revenue from hunting, joint ventures with tour operators, live sale of game, and meat from annual quotas would accrue to the community to be distributed under an agreed plan.

As of January 2002 15 conservancies have been registered, nine of these fall in North-western Namibia where a further 11 are emerging (Figure 2). Low human density and a unique, scenic landscape provide realistic options for some communities in the Kunene and Erongo regions of northwest Namibia to benefit from an increasing tourism market. Some difficulties associated with common property resource management do result from the semi-arid landscape. Conservancies, as social units, fail to match the ecological parameters of the regions. This has resulted in a conflict of ownership over these resources and their effective management. However, there is no reason why these conservancies cannot form the building blocks for co-operative management across larger groupings of institutions (Jones, 2001).

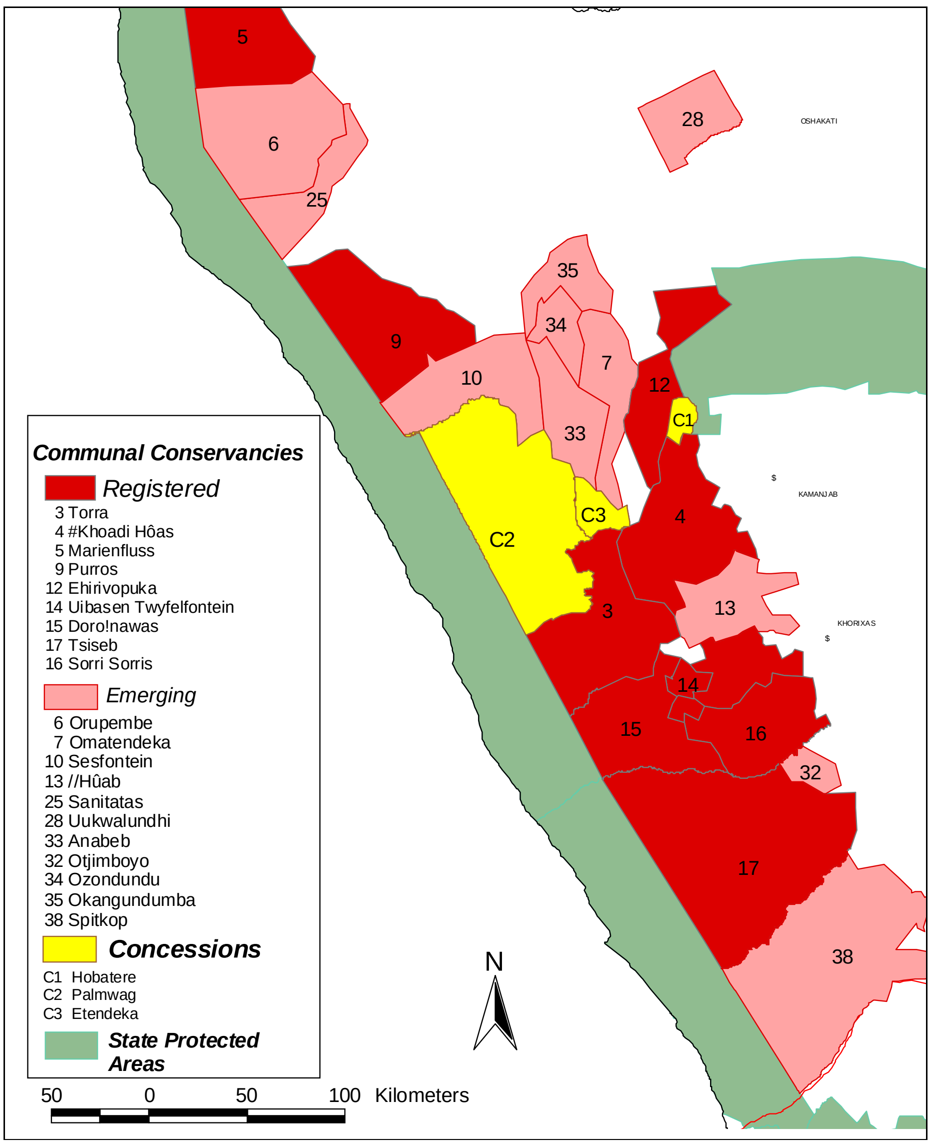


Figure 2. Map of North-western Namibia indicating registered and emerging conservancies (modified from Mendelson *et al.* 2002).

Namibia's conservancy programme faces many challenges in meeting its goals of devolving greater rights and authority over wildlife from government to rural communities and enabling these communities to benefit from the sustainable use of wildlife. These include:

- whether the limited rights of conservancies provide strong enough incentives for sustainable resource use;
- the lack of group land tenure undermines the ability of the conservancy institution to enforce zoning of areas for wildlife and controlling tourism;
- a lack of confidence that MET will devolve further rights that give communities the freedom to make their own decisions;
- a growing gap between the limited rights conservancies have to deal with problem animals and the expectation of conservancy members that such problems will be effectively managed by the institution;
- a need to fully integrate conservancies into government's overall decentralisation policy to ensure integrated land use planning and avoid duplication; and,
- to develop macro-economic policies that give more recognition to wildlife and the tourism sector as efficient and productive forms of land use and, with appropriate incentives, see the removal of subsidies on other forms of land use.

(MET, 2002)

1.5 A REVIEW OF HUMAN-INDUCED-DISTURBANCE (HID)

1.5.1 Introduction

Human activities are acknowledged as a conservation concern where HID is implicated in the decline of a population. This occurs when the impact of an animal's response to human presence causes an overall decrease in fertility or increase in mortality. The level of threat caused by HID is related to the amount of alternative habitat available and if the tolerance of a species can be increased with habituation. Black rhino in the Kunene and Erongo regions of North-western Namibia are vulnerable to HID as they occur at low density in an arid environment.

This section briefly reviews the biological and political considerations of disturbance impacts on mammals in the context of ensuring maximum benefit from all wildlife species, without leading to potential declines in biological diversity. This formed part of a collaborative study between the SRT research section and the University of Cape Town investigating alternative means of monitoring black rhino that might lesson the impact of HID.

1.5.2 What constitutes disturbance?

HID has been defined as any activity that constitutes a stimulus sufficient to disrupt the normal activities and/or distribution of a species relative to the situation in the absence of that activity (Fox & Madsen, 1997). From a conservation perspective, disturbance of wildlife is a concern when it impacts upon survival or fertility and hence causes a population to decline (Gill *et al.*, 2001).

If animals avoid areas in response to human presence this is equivalent to actual loss or degradation of this habitat (Gill & Sutherland, 2000). Displacement of animals from their preferred habitat to less profitable environments can have important consequences on individual survival and fecundity and lead to decreases in overall population size due to site abandonment and lower levels of resource availability (Duschesne *et al.*, 2000). If there is suitable habitat with sufficient resources nearby disturbance may be avoided by movement to alternate sites. By contrast, animals with no suitable habitat nearby will be forced to remain despite the disturbance, regardless of whether or not this will affect survival or reproductive success (Gill *et al.,* 2001).

1.5.3 Disturbance effects

The immediate effects of disturbance can be seen in the response of a species to human presence (Hill, *et al.*, 1997). Many species of wild ungulates have been shown to exhibit behavioural and physiological responses to human disturbance (Duschesne *et al.*, 2000). Reactions include increased vigilance time, seeking dense cover within home ranges and taking flight, causing increased movement in an enlarged home range (Recarte *et al.*, 1998). Cows and calves in the breeding season have been found to be the most easily disturbed demographic group in a number of species (Wolfe *et al.*, 2000). Under high levels of disturbance, some species were found to become nocturnal and wary, leave preferred areas and expend more energy as a result of increased stress and movements (Tuttyens and MacDonald, 2000). Chronically high levels of stress can result in cessation of reproduction, cardiovascular and gastrointestinal disease and damage to the immune system. (Fowler, 1999).

1.5.4 Disturbance impacts

Disturbance impacts occur at a population level, where populations are caused to decline due to a reduction in breeding success or an increase in mortality (Hill *et al.*, 1997). Southern elephant seals on Gough Island have shown a decline due to a reduction in pup production linked to disturbance by helicopter flights (Bester *et al.*, 2001). Female elk that were subjected to HID during the calving period had a decline in reproductive success (Phillips & Alldredge, 2000). Distribution and population dynamics of gorillas in Bwindi Impenetrable National Park, Uganda are affected by human disturbance in the form of agricultural encroachment, pitsawing, hunting and gold mining (McNeilage *et al.*, 2001).

The presence of tourists and vehicles has been shown to impact on a number of different species. Tourist visits on elephant back in Chitwan Park in Nepal were found to disrupt the behaviour of Asian rhinos leading to a reduction in feeding time and increased vigilance behaviour (Lott & McCoy, 1995). Bighorn sheep were found to be disturbed by helicopters carrying tourists in the Grand Canyon (Stockwell *et al.*, 1991). With an increasing interest in ecotourism as a source of valuable income in developing countries there is an urgent need for common criteria which can be used to evaluate the importance of disturbance impacts to resolve conflicts of interest between wildlife conservation and human activities (Hill *et al.*, 1997). Establishing appropriate tolerance levels should be the priority when seeking to mitigate levels of disturbance. For example, Asian rhinos were found to be able to tolerate tourist visits when the distance between tourists and rhinos was restricted (Lott & McCoy, 1995). Also, a successfully breeding population of rhino occurring in the open grasslands of the Nairobi National Park in Kenya have both high levels of tourism traffic on the ground, and are exposed to continuous overhead traffic from the nearby international airport.

1.6 CONSERVATION OF THE BLACK RHINO IN NAMIBIA

1.6.1 Introduction

The Republic of Namibia is the driest country south of the Sahel. Although, 824,000 km^2, no perennial rivers flow within its borders (Seely, 1998). Some 14% of Namibia's surface area is designated as formal conservation areas (Figure 1), administered by government through the Ministry of Environment and Tourism (MET). Sparse and erratic rainfall patterns have a strong influence on the regions flora and fauna, with rainfall declining as you move east to west across the country (Figure 3). This also defines the livelihood strategies of Namibia's some 1.7 million people. The majority of these people are concentrated north of Etosha

National Park and in the far north eastern Kavango and Caprivi regions (Figure 1 and 3). Much or Namibia's biodiversity still exists outside formal conservation areas on communal land in Kunene and Erongo regions of the northwest. This includes a population of desert-dwelling black rhinos, recognised by the AfRSG as a Key 1 Population. These rhino represent the only desert ecotype population of black rhino and one of the few remaining populations' worldwide which has survived on land that has no formal conservation status.

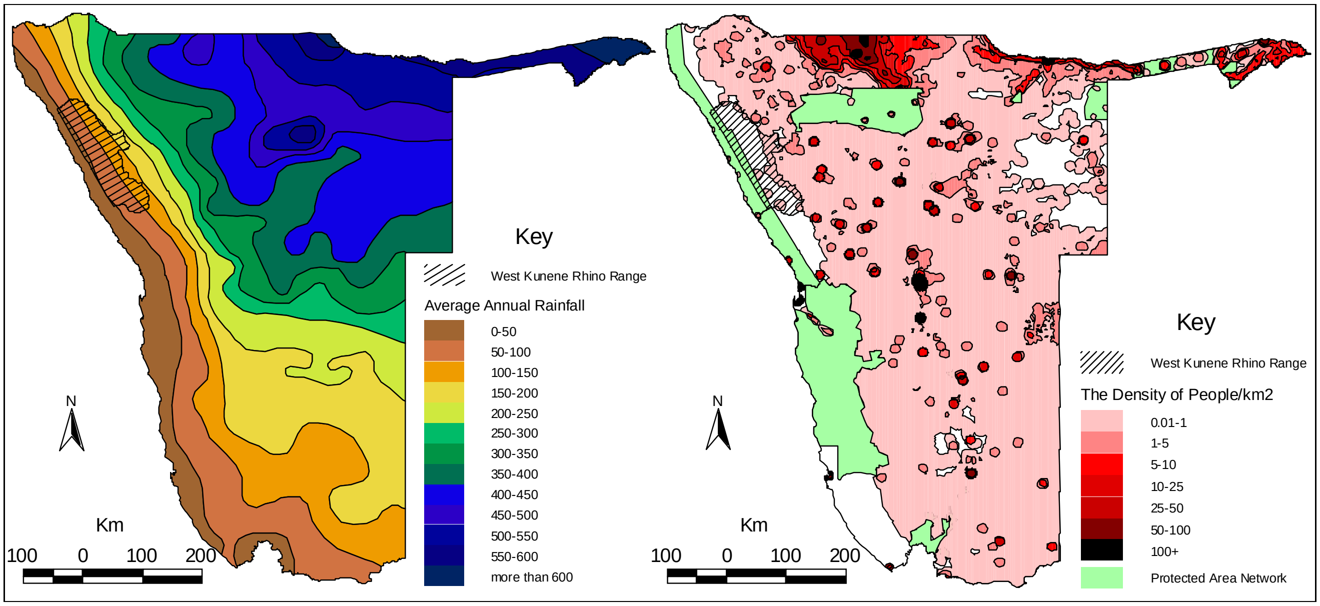


Figure 3. Mean rainfall gradient and population concentration across Namibia (modified from Mendelson *et al.* 2002).

1.6.2 Historical summary of black rhino conservation in Namibia

Active conservation of the black rhinoceros started in the mid-1960s, with the initiation of a project to translocate all splinter groups into Etosha National Park. Most of these were from freehold and communal farming areas bordering the northern, southern and eastern limits of the range area seen today (Figure 1). The project was highly successful and between 1968 and 1973 56 rhino were moved into Etosha (Joubert, 1971). However, conservation did not fall under its own directorate until the Nature Conservation Ordinance (No.4 of 1975). Under this ordinance both the black and white rhinoceros were designated specially protected species. This is administered through the Directorate of Parks and Wildlife of the now MET.

Namibia holds almost a third of all the black rhinos remaining in Africa, and is the stronghold of the south-western subspecies (*D.b.bicornis*). The Etosha National Park population is the biggest single population of any subspecies. One of the greatest strengths of Namibia's black rhino conservation programme is a diverse stakeholding in management. This includes: the state in the protected area network; the commercial farming sector, with rhino being managed under the MET custodianship scheme; and, the management by conservancies and NGO's of black rhino, both on communal and privately owned farms.

1.6.3 Conservation strategy

The current conservation strategy (MET, 2001) succeeds four previous plans or strategies for black rhino conservation in Namibia (MET 1997). This process of strategic planning has been associated with notable success in terms of protecting rhino populations and increasing rhino numbers, particularly that achieved as a result of translocation of rhinos and development of new populations.

The long-term conservation plan for Namibia's black rhinoceros populations is:

- To significantly increase the range area for *D.b.bicornis* in Namibia.
- To manage the black rhino metapopulation in an active and adaptive manner to achieve sustained and unrestricted growth.
- To minimise losses of black rhino due to illegal killing, and human disturbance.
- To ensure support (political and public) and incentives for black rhino conservation are in place and fostered.
- To secure coordination and collaboration for management of black rhinos by all stakeholders.
- To ensure that an enabling policy and legislative framework is in place and implemented.

(MET, 2001)

The Rhino Management Committee (RMC) is the decision making body on conservation of rhino in the Namibia. A Rhino Technical Advisory Group (RTAG), Chaired by the Rhino co-ordinator, overseas the implementation of the National Management Plan and makes recommendations to the RMC. The rhino custodianship manager and two representatives from the Directorate of Parks and Wildlife Management are permanent members of the RTAG. The RTAG co-opts other members from various sectors and stakeholders (government, private, NGO and community representation) to provide specialist input as and when required.

1.7 OBJECTIVES

The density, breeding performance and ranging patterns of black rhino in Kunene and Erongo regions are influenced by the variable geology and its impact on soil development, the vegetation types and access to water. This is compounded further by the very low (<150mm per annum), unreliable and patchily distributed rainfall (Hearn *et. al.*, 2000). Further influences come from HID, chance events, and demographic effects in small sub-populations. Therefore, this report has the following objectives:

- Review all available historical information and documented evidence on the past numbers and distribution of black rhinos in the West Kunene Rhino Range, Namibia.
- Conduct an analysis of data to quantify the spatial and temporal factors that affect the performance of sub-populations within the defined zones across the rhino range areas, and make a grid-based analysis of the key biological attributes of the rhino range.
- Use this analysis to develop a revised system of subdivision of population areas and derive updated estimates of ecological carrying capacity and density for black rhinos in each population zone.
- Make an evaluation of human-induced disturbance and impacts on rhino distribution, movements and interactions in the different population zones, and examine options for mitigating human effects through limiting access to vulnerable areas by use of control points.
- Define methodologies for future monitoring of the West Kunene rhino population, with emphasis on population performance indicators and key ecological indicators necessary for use in management decision-making.

CHAPTER 2: RECONCILING BIOLOGICAL MANAGEMENT AND CBNRM: THE DESERT-DWELLING BLACK RHINO OF NORTH-WESTERN NAMIBIA.

2.1 INTRODUCTION

This chapter provides an overview of rhino conservation measures in the region and begins by describing the Kunene rhino range that is home to the desert-dwelling black rhino. Second, a historical review details the previous performance of the black rhino and factors impacting distribution and growth. The final section discusses the types of HID occurring in the region.

2.2 DESCRIPTION OF THE KUNENE RANGE AREA

2.2.1 Location and climate

The study was carried out in North-western Namibia, namely Kunene and Erongo regions (between 12^{o} 00' and 14^{o} 45' E/18^{o} 45' and 22^{o} 40' S) (Figure 4). The climate is arid with an east-west rainfall gradient ranging from 150mm to 30mm.

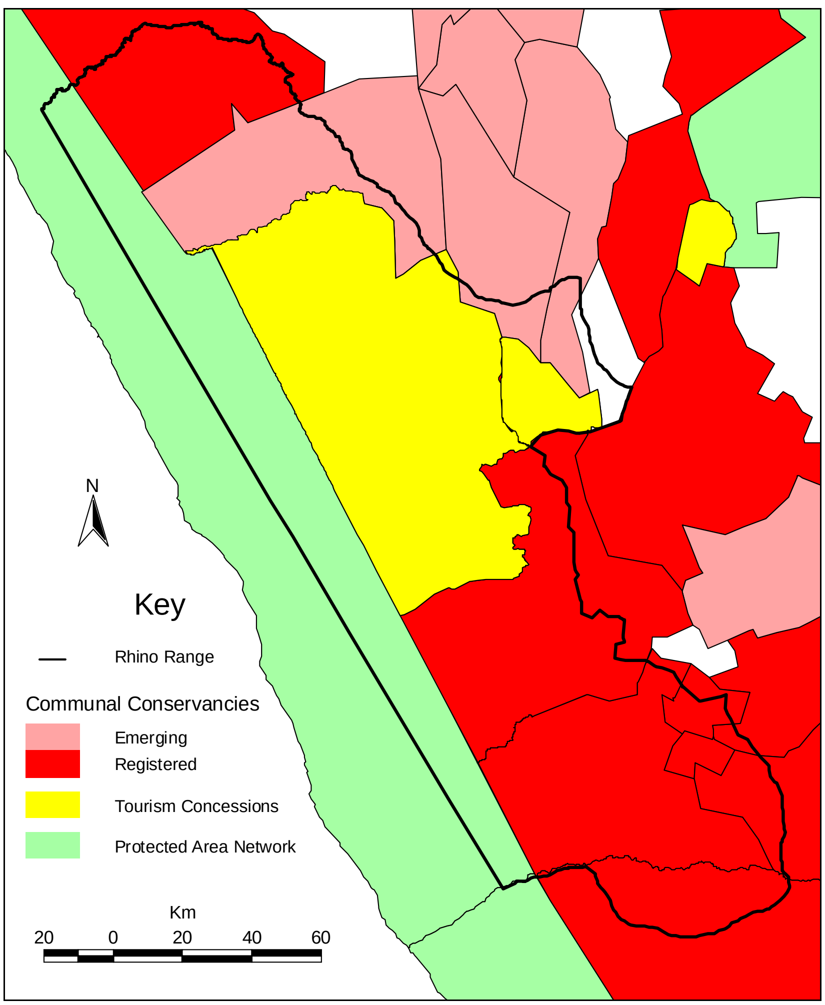


Figure 4. Land use bordering and falling on the Kunene rhino range (modified from Mendelson *et al.* 2002).

The area has three defined seasons: the wet season (March to May); the cold dry season (June to August); and, the hot dry season (September to February) (Viljoen, 1989a). Land is used communally and, therefore, common traditional rights of access prevail. Grazing strategies are opportunistic, largely determined by water availability and rainfall. This divides the Kunene rhino range area into three broad categories: seasonally used rangelands; emergency grazing rangelands; and, areas utilised purely by wildlife. The rhino range area overlaps the seasonally utilised rangelands in the mountains and the transitional zone where perennial vegetation in the linear oases of the ephemeral rivers guarantees forage during the dry season. These alluvial river deposits act as a reservoir for groundwater and support the bulk of the woody vegetation in an area where soil development is generally minimal. Recharge of these aquifers is dependent on local rainfall or natural downstream migration of water from the easterly areas of higher rainfall. Temperatures in the region are similarly variable, ranging from below zero to above 40°C.

To date 20 conservancies are proposed or have been registered in North-western Namibia, covering more than 50,000km^2. In Kunene alone this covers more than 35,000km^2. Two large tourism concession areas, one bordering the Skeleton Coast Park, also fall on the Kunene rhino range area, and cover a further 6,000km^2 (Figure 4).

2.2.2 Topography and geology

In the central parts of the study area, topography consists of a prominent high, volcanic plateau region of flat-topped mountains (Etendeka Group) with steep pediment slopes. In the far north and south, steep slopes are dominated by shists and marble lying in westward-vergent folds and faults. Various other aeolian sandstone formations, volcanic deposits and the Post-Karoo igneous Doros Complex are dispersed across the southern part of the study area. The southern limit is marked by The Brandberg massif, dominated by granite, with Konigstein peak (2573m) forming the highest mountain in Namibia (Diehl, 1990; Swart, 1992). To the west, gently undulating rocky and granite plains, with isolated rock outcrops, finally give way to the shifting dunes of the coastal desert.

2.2.3 Vegetation

The area falls in one of three floristic regions partly represented in Namibia, namely the Karoo-Namib regional centre of endemism (Maggs *et. al.*, 1998). The study area is further recognised as the Kaokoveld centre of plant diversity within this region and is classified as comprising predominantly of “mopane” savannah (Giess, 1971). From east to west along the climatic gradient the dominant vegetation and growth form goes from: *Commiphora* spp., *Colophospermum mopane*, *Euphorbia damarana* shrubland and dwarf shrubland; to *Calicorema capitata* with *Commiphora* spp. and dwarf shrubland; and, culminating in the exposed unvegetated plains where succulent species and dwarf shrubs are isolated in drainage lines.

2.2.4 Human population

Though the population of Kunene Region stands at 64,017, representing 4.5% of the total Namibian population (UNDP, 1997), most are centred around the major towns or more fertile lands to the east of the study area. Less than 10% live directly next to the eastern border of the range area where subsistence farmers utilise man-made and natural water points. Here, a wide variety of wildlife species range freely amongst farming settlements, including predators and elephants.

The economy of the Herero and Damara who dominate the area is mainly confined to semi-nomadic pastoralism or sedentary agriculture, although people’s sources of income/subsistence are extremely diverse. These include: pensions; waged employment with government services, wealthier farmers and the increasing number of tourism ventures in the area; and, selling products of local industry such as beer and handicrafts (Sullivan, 1999).

2.3 REVIEW OF PAST PERFORMANCE OF THE BLACK RHINO IN KUNENE

Historically the black rhino was once widely spread across the region occurring from the Kunene river in the north to the Erongo mountain range in the south (Figure 5). Hunting of rhino started in the late 1700's as the first explorers arrived in the area. In Charles John Andersson's accounts (1856) of his exploration from Walvis Bay in 1850 into central west Namibia, then known as Damaraland, he "single handed" shot up to 60 rhino. Then, distribution extended to the Swakop river, where rhino had been hunted by the residents of Roëbank, a missionary station set up in 1846 20kms south east of Walvis Bay. Inland, amongst the Erongo mountain range, a Dutchman residing at Richterfeldt, by the name of Hans Larsen, had shot nine rhinos in one day and described the area had, "literally teemed with rhinoceroses" on his arrival in the late 1840's. By the 1900's the impact of hunting for ivory and rhino horn was being felt in the area. One such documented slaughter between 1898 and 1908 resulted in 150-200 rhinos being shot in the region. By 1977 only 20 were thought to still exist north of the Hoanib river (Viljoen, 1982).

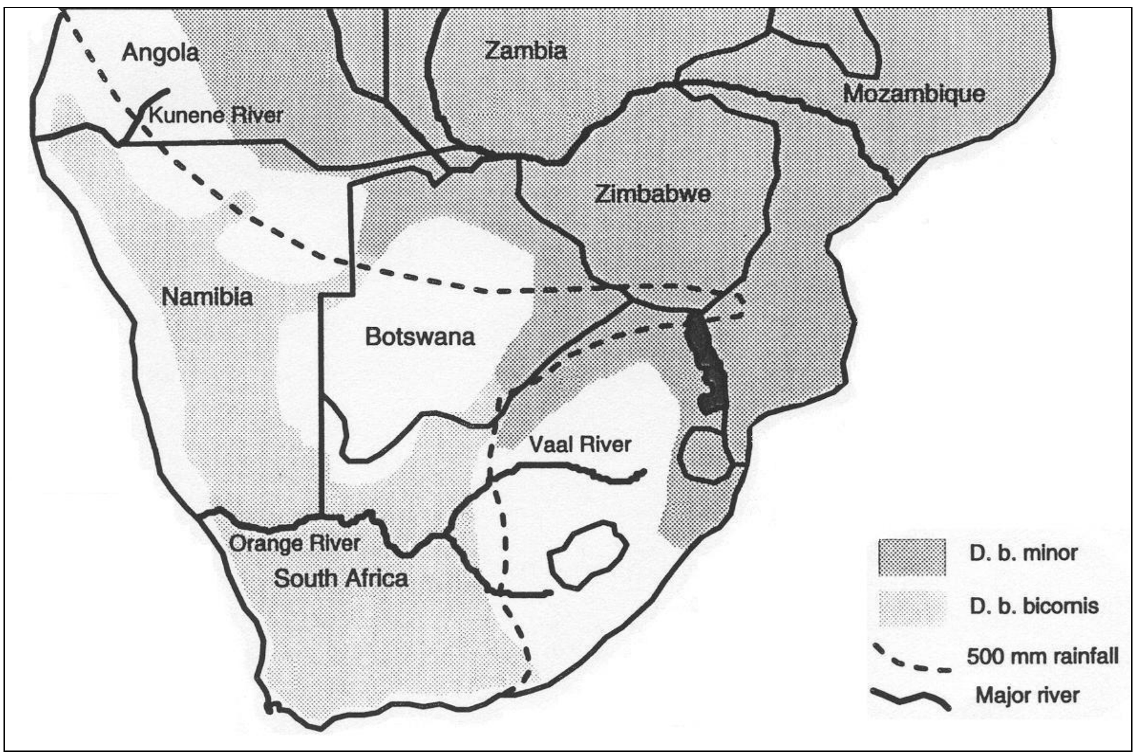


Figure 5. Former range of the *D.b.bicornis* in Southern Africa (after Hall-Martin & Knight, unpublished)

Accurate historical estimates for the number of rhino occurring in North-western Namibia were made difficult due to the broken country which they inhabit. As far back as the early 19th century up to the early 1970's these estimates are now known to be too low. Table 1 summarises some of these early estimates.

One of the first approximations of rhino numbers in the Kunene and Erongo regions, by Captain G.C.Shortridge during 1922 and 1923, produced an estimate of only 150 rhinos in what is now western Kunene Region. By 1988 data on known rhino individuals allowed the first accurate figures to be established. At this point, prior to the onslaught on rhino in the 1970's there were thought to be approximately 300 rhino still surviving in what is now Kunene Region. By 1982 this figure had fallen to 60. The situation had not been assisted by the drought of the early eighties and the issuing of 2,000 to 3,000 .303 rifles along with over 200 000 rounds of ammunition by the then South African government to cattle herders in the area to protect themselves against the South West Africa People's Organisation (SWAPO) "Terrorists". By 1981 poaching had left what had been healthy populations of rhino and elephant almost extinct from central and western Kaokoland (Owen-Smith, 1970).

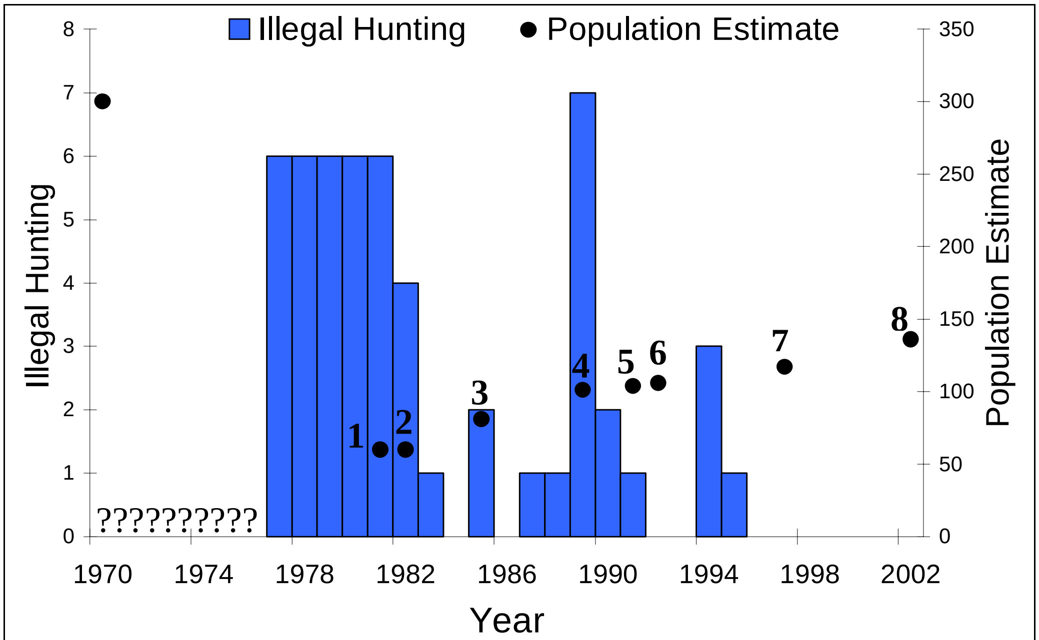
Table 1. Summary of the past estimates of black rhino numbers in the northwest

Estimate	Year	Area	Source
150	1922 – 1923	Ugab river to the Kunene	Shortridge, 1934
50	1923		Manning
150	1970	Kaokoland	Owen-Smith, 1970
30	1975	Kaokoland	Joubert & Mostert, 1975
20	1977	Kaokoland	Viljoen, 1982
300	1970	Kaokoland and Damaraland	Loutit, 1988
60	1982	Kaokoland and Damaraland	Loutit, 1988

The poaching had gradually moved south from the Kunene river and was mainly being orchestrated by traders moving through the area, many believed to be Portuguese refugees, and those in the surrounding towns. These were well organised operators who also gave weapons and ammunition to local villagers to carry out the specific poaching of rhino and elephant. These groups included members of the South African Government, including the South African Defence Force (SADF). Speculation also links the South African Government with forces from the Union for the Total Independence of Angola (UNITA), who would pay the SADF for arms with ivory and rhino horn. The increased poaching tracked the then escalating international price for rhino horn, where in Japan alone from 1975 – 1980 the price increased by more than four times due to improved livelihoods in the Far East and therefore greater demand for horn .

The beginning of the 1980's saw the initiation of some of the key conservation efforts in the region that turned around the rapid decline in the numbers of rhino. Figure 6 tracks these changes with the illegal hunting activity. In 1981 the appointment of a warden in Khorixas, Chris Eyre, by the then Directorate of Nature Conservation led to some key convictions of known poaching gangs. The field operations of the Endangered Wildlife Trust and the Namibian Wildlife Trust started the first extensive monitoring programme at this time. Data collection was led by Blythe Loutit south of the Ugab River and by Garth Owen-Smith and Duncan Gilchrist north of the Springbok river and into Kaokoland. Data was collated into the first identikit files by Ruth Gilchrist. Local involvement in the monitoring programme followed with the initiation of the community game guard scheme and by the mid-eighties specific rhino monitoring patrols, made up of community members, led by teams from Save the Rhino Trust (SRT).

The majority of rhino sightings in the early eighties were still chance sightings acquired while driving or walking in the area. Patrols only started going further west of the junction of the Achab and Uniab rivers in 1985. By the mid-eighties the method used today to locate rhino, by using local knowledge to track fresh spoor from where a rhino drank the night before, began to be used extensively across the area and increased the accuracy of population estimates. This method proved to be more efficient and cost effective than flying or vehicle based patrols. Armed patrols by the MET's Wildlife Protection Services started at this time and strong law enforcement from MET staff in the area, notably Rudi Loutit and Tommy Hall, led to further key convictions in the area. However, towards the end of the eighties the poaching trend picked up and resulted in a hotly debated crisis management tool, the dehorning in 1989 and 1991 of two specific sub-populations that were most at risk. The gamble is now recognised to have paid off, with no dehorned animals being poached and one of the areas, zone 3, where they were dehorned now has the best breeding performance and population health in terms of the sex ratio in both sub-adult and calf age groups. However, concerns about breeding in another area where dehorning was carried out, zone 1, force home the fact that many factors are impacting on population health and recruitment in the northwest, especially in such arid conditions. This is taken up later in the report.



- **Conservation Actions:**

1. First GRN conservation official based in Khorixas; **2.** Traditional leaders support, NGO monitoring activities initiated community game guards appointed; **3.** Intensive monitoring by SRT teams – more accurate population estimates; **4&5.** Dehorning operations and APU (armed) operating in the area; **6.** 1st Rhino Census; **7.** Community participation formalised through Conservancy Legislation & 2nd Rhino Census; and, **8.** 3rd Rhino Census.

Figure 6. Population estimate over time, in relation to illegal hunting and conservation actions.

The desert-dwelling black rhinoceros of North-western Namibia are typical of a population that have been poached to near extinction and are now showing a recovery in numbers following the successful implementation of appropriate conservation measures (Figure 6). This rhino conservation project has brought five sectors together; whose combined forces have brought the illegal hunting of rhino to an end in Kunene and Erongo regions. These include: the local inhabitants; MET; second tier Damara Government; and, the private sector and non-governmental organisations. The development of a community-based conservation approach in the early 1980's was balanced by intensive field operations and strong law enforcement carried out by both Government and non governmental organisations.

Monitoring efforts have increased steadily over the years and the first complete census of the entire range area, involving CGG, MET and SRT, was carried out in 1992. This was repeated five years later. It was at this point that a condition score, using criteria outlined in Reuter &

Horspool (1996) and further developed by Reuter & Adcock (1998), were also given to each rhino sighted during and subsequent to the census.

Since 1992 only two instances of illegal hunting have been recorded in the northwest, one in 1994 when three rhino were poached, and the other in 1995 when a single animal was poached. In both cases the culprits were caught and put on trial. A total of 15 rhino have been translocated from the population since 1989. Table 2 summarises the details of these operations.

Table 2. Details of translocations out of the northwest from 1989 to the present day.

Number moved	Year	Area	Destination	NOTES
3	1989	Etendeka	Waterberg	Bull, female and subadult
7	1989	Old farms	Waterberg	Majority sub adults, 1 cow and calf
1	1991	Wereldsend	Hardap	Sam (male) Walked east. Picked up near Uis
1	1991	Old farms (poachers ccamp)	Hardap	Young female
1	1991	Khowarib plains	Hardap	Male, moved east from the current range
1	2000	Ombonde river	Etosha	Male, breakout form western Etosha
1	2000	Klip river	Etosha	Male, went walking east and picked up near Kamanjab on a freehold farm

SRT presently maintains continuous surveillance patrols on the population of desert-dwelling black rhinos in the northwest. Additional surveillance of the area is carried out by the MET's Wildlife Protection Services, conservancy field-staff and community game guards from the surrounding villages. These patrols have several functions. These include: obtaining long-term data on individual rhinos, their movement patterns and population performance; the deterrence and detection of poaching; and, the deterrence of other illegal activities in the area.

2.4 HID IN NORTH-WESTERN NAMIBIA

2.4.1 Causes of disturbance

The Kunene and Erongo regions are accessed by tour operators, guides and independent travellers (usually in 4 x 4 all terrain vehicles). Visitors enjoy exploring the surroundings and looking for wildlife. The sighting of 'desert-dwelling rhino' is one of the highlights of a visit to this area and their presence is a major draw, along with various other unique aspects of the region's landscape and people. Tourist lodges provide excursions in 4 x 4 vehicles, which offer the chance to view black rhino and desert elephant. Several companies advertise flights in this region, primarily up the Huab River. Operators also advertise flights along the Uniab and Ugab Rivers, although these appear less popular.

Presence of livestock species can affect wildlife, both directly through their presence and indirectly through competition for food and water resources. Communal grazing on farms in semi-arid savanna in South Africa was found to substantially change the composition and structure of woody plant communities. These changes reduced the availability of natural resources (Higgins *et al.*, 1999). The presence of cattle have been found to have a negative impact on rhino distribution in Masai Mara in Kenya, rhino being displaced from suitable habitat when cattle, with herders, were present (Walpole *et al.*, 2003). The exploitation of the land resource by livestock farmers in the Kunene and Erongo regions is opportunistic, dependent on rainfall/water and pasture availability. The periodic droughts in this area make competition with livestock for food and water a particular problem for wildlife (Joubert & Eloff, 1971). The death in October 1992 of a rhino in the Ugab River, in the southern range, is believed to be linked to drought, compounded by the influx of cattle as conditions worsened for the surrounding pastoral farming communities.

Consumptive utilisation of wildlife forms another form of potential HID. Registered conservancies are given user rights over huntable game, (e.g. oryx, kudu, springbok) and rights for:

- the capture and sale of game;
- trophy hunting;
- own-use hunting; and,
- the right to apply for permits for the use of protected and specially protected game.

2.4.2 Impacts of disturbance on the Kunene black rhino population

Black rhino are not at present directly affected by harvesting or trophy hunting. However, the black rhino and elephant in the Kunene and Erongo regions experienced high levels of poaching during the 1970s and 1980s. A major factor influencing the level of response of a species to disturbance is the risk of mortality associated with human activities. Thus, species that have been hunted by humans show more aversion to HID caused by hunting (Fox & Madsen, 1997; Perrin & D'Inzillo Carranza, 2000).

In the arid environment of North-western Namibia, where resources are scarce, there is no alternative habitat for individuals which have abandoned their home ranges due to disturbance. Studies by Berger and Cunningham (1995) showed that interactions between humans and this black rhino population resulted in flight by rhinos in 33% of encounters with males, 58% of encounters with solitary females and 59% of encounters with females with calves (n = 150). After detecting human presence rhinos were recorded moving up to 40 km.

CHAPTER 3: METHODOLOGY

3.1 GEOGRAPHIC INFORMATION SYSTEMS

3.1.1 Introduction

A GIS typically developed as computer software designed to capture, store, update, analyse and display all forms of data that are recorded according to geographic location (Johnston, 1998). Information can consist of spatially explicit locational data, as well the single entity having its own attributes. A GIS allows the representation of data in two forms; raster-based, where information is grid or pixel based and with an individual data value; or vector-based, where information is portrayed as points, lines and polygons. Both forms of data can be converted to allow analysis of multiple map layers.

Though developed initially for geographers GIS's are now being more widely used by conservation biologists. Smith and Kasiki (2000) sites the increased availability of satellite data as a contributing factor and various studies are sited where a GIS has been used. These include: studies on spatial factors impacting Elk (*Cervus elaphus*) calving; to find how burning affected the amount of suitable black-tailed jackrabbit (*Lepus californicus*); and, habitat preference of orchid species However, the resolution of data has meant that uses of GIS have been often restricted to studies of larger land mammals, including elephants. Walpole *et al.* (2003) successfully uses a GIS in the spatial analysis of factors predicting the distribution of black rhino in Kenya's Masai Mara ecosystem.

3.1.2 Habitat characteristics and rhino density

Data imported into the GIS and used in this analysis came from various sources. Vegetation and topographic classification of the northwest is available through the Namibia Atlas Project (Mendelson *et al.* 2002) and is accessible at the following website: http://www.dea.met.gov.na/data/Atlas/Atlas_web.htm. These data were imported into ArcView (ESRI), with the spatial analysis tool extension, to analyse the attributes within home ranges of individual rhino. Rhino density across the Kunene range area was calculated using a script (Smith, 2002) designed to count the number of home range polygons overlapping a 2x2km vector grid of the study site.

Water point data were recorded in the field using a GPS (Global Positing System) receiver (Garmin GPS 45,12 and Etrex venture models) during censuses of the Kunene rhino range area in 1997 and subsequent patrols. Data on seasonal water points were collected in the census started in 2002. Spatial data was imported into SPSS (Version 11.0) to perform analysis on attributes assigned to the 2x2km vector grid of rhino presence, habitat type and mean distance to water. This allows future comparison with other wildlife data derived from annual censuses which are recorded at a similar resolution. The Kolmogorov-smirnov test was used to determine if variables were normally distributed or not and the appropriate parametric or non-paratmetric tests used.

3.2 HOME RANGE AND DISTRIBUTION AREA

3.2.1 Revising the system of subdivision of the population areas

The varied topography of the northwest, its changing geology and other natural barriers impact the distribution of rhino and carrying capacity across the range. This results in variations in "sub-population" density of rhino. Therefore, in a widely dispersed population such as Kunene's, independent analysis of these sup-populations allows for a better understanding of how these ecological conditions impact population performance (Hearn, 2001). From the inception of the Kunene black rhino monitoring project in the beginning of the eighties, black rhino Ecozones have been used to assist with patrol planning and the implementation of the five yearly census. Previously, theses zones have been used to compare performance across the range area. However, these did not accurately reflect the ecological conditions.

The Minimum Convex Polygons (MCP) of an individual rhino was used to redraft the current Ecozones across the range area. Because the area covered by males is greatly influenced by prospective mates, as well as by access to resources (Adcock, 1994), only the home range of adult female rhinos was used. For the purposes of this study the core rhino area for each site was measured by plotting the peripheral points of all females of breeding age (greater than seven years of age).

3.2.3 Measuring home range

Using a GPS receiver the location of known rhinoceros sightings from 1997 were plotted on a map of the range area. This study used ten locations as the minimum necessary to measure an individual home range accurately (Conway and Goodman, 1989).

All data were then imported into ArcView (version 3.2) and analysed in the spatial movement extension. MCP's were used to calculate the distribution area for each site and home range (Schoener, 1981). Using this method, size is measured from the area of a polygon, which resulted from connecting the peripheral points of each individual female's sightings.

This method has several constraints. No measure of intensity of use is incorporated, excursions from a home range are not handled separately and by assuming that the home range has a convex shape, large areas that are never visited are incorporated into the home range resulting in a bias due to sample size (Anderson, 1982; Harris *et al.*, 1990; Worton, 1995). Various other methods that account for these constraints have been used to measure home range of the black rhinoceros (Loutit *et al.*, 1987; Brett *et al.*, 1989; Adcock, 1994; Berger, 1997), including those that can define core areas. However, due to a limited data set for all animals MCPs were chosen. This also allows the greatest comparison with other studies on the black rhinoceros (Goddard, 1967b; Hitchins, 1969; Mukinya, 1973; Frame, 1980; Kiwia, 1989b; Conway and Goodman, 1989). In a slight modification, where data were sufficient major excursions from the area were ignored.

3.3 POPULATION CHARATERISTICS

3.3.1 Identification methods

Monthly vehicle patrols, of up to three weeks duration, consisting of two trackers and a driver/photographer, have covered designated management zones of the West Kunene rhino range since the early 1980's. In the more inaccessible part of the range, camel patrols use the extensive game paths for patrols of up to 14 days. Water points were visited early in the morning to locate sets of footprints, which were tracked until the animal was located. Chance sightings of fresh sets of tracks were followed in the same fashion. Depending on the visibility, the identities of individual rhinoceros were confirmed from sex, horn size and shape, notches and marks on the margins of the pinnae of the ears (Goddard, 1967a; Mukinya, 1976; Brett et. al., 1989; Kiwia, 1989a).

3.3.2 Intercalving interval

Using updated records from the SRT rhino database (Brett, 1997) the structure of the population was determined using age classes after Hitchins (1970). Using these same data and historical data (Loutit unpublished data; Gilchrist unpublished data) records were analysed to determine the interval between breeding.

Due to the often inaccessible terrain patrol effort across the range area varies. This often meant females would not be sighted for long periods of time. Therefore, the calving intervals of three females were ignored due to these inconsistencies in patrol effort and the possibility that calves may have not been recorded.

3.3.3 Other performance indicators

Developing and fine tuning indicators of breeding success is central to avoiding populations overshooting ecological carrying capacity. This has been the topic of various discussions within the African Rhino Specialist Group (AfRSG). This project used the following criteria (developed by du Toit *et al.*, 2001) and presented at the 2002 AfRSG meeting.

Table 3. Classification of poor – excellent performance values for certain indicators (modified from du Toit, 2001).

Parameters	<Poor	Moderate	Good	Excellent
Percentage population growth per annum	<2.5%	2.5-5.0%	5.0-7.5%	>7.5%
Inter-calf interval (described above)	>3.5yrs	3.5-3.0yrs	3.0-2.5yrs	<2.5yrs
Age of the cow at first calving	>7.5yrs	7.5-7.0yrs	7.0-6.5yrs	<6.5yrs
Calf proportion as a percentage of the population: Calves (<1yr)			>8%	
0-3.5yrs			>28%	

3.4 ACCESS INTO THE RHINO RANGE

3.4.1 Distribution and use of entry points across Kunene

As the Kunene population falls on communal land many access points into the area exist with no way of controlling them. Vehicle access into the area is a growing problem, mainly due to vehicles leaving defined tracks To understand how these impact the population this study defined an entry point as one used by vehicles only. The location of these where recorded in the field using a GPS receiver. Level of use was characterised on the spot from the amount of visible vehicle tracks and, when available, from data collected at a few entry points by staff from the SRT. Appropriate control measures were prioritised in term of the impact of traffic on the distribution and breeding of the associated sub-population of black rhino.

3.5 DEVELOPING A HABITAT SUITABILITY MODEL

3.5.1 Introduction

Although free-ranging black rhinos continue to persist in the northwest, little is known about the spatial characteristics of this population. A spatial modelling framework was designed to classify terrestrial habitats based on the predicted ecological needs of black rhinos. In this study a GIS modelling approach, based on Digital Elevation Models, Landsat 7 satellite images and air photos were used. This preliminary model was refined using field assessment and a comparison with known rhino positional data. The model developed will test the hypothesis that rhino presence is determined by browse and water availability. Future fieldwork will be necessary to be able to predict optimal population expansion areas and prioritise new areas for rhino conservation. The model can also be used to examine patch occupancy, carrying capacity and landscape connectivity patterns.

3.5.2 Information derived from digital elevation model (DEM)

In arid rangelands, such as those seen in North-western Namibia, climatic conditions, elevation, substrate and drainage have a direct effect on height, canopy cover and the composition of woody species (Coughenour and Ellis, 1993). In Kunene, changes in the density and composition of woody species could be attributed to the changes in slope and aspect (Loutit *et al.*, 1987; Sullivan, 1998, 1999; Hearn *et al.*, 2000). This appears to be a result of differences in the moisture content of air coming off Namibia's westerly facing coastline, and air currents coming from the Namibian interior. To test this hypothesis, and if this whould have an impact on the presence and absence of rhino three variables were generated from the analysis of a DEM:

- continuous slope was reclassified into four initial categories (although exact slope classes were modified after field verification);
- elevation was reclassified into three classes; and,
- aspect was classified into three classes (although aspect cut-offs were also modified following field verification)

3.5.3 Ecological land units: unique combinations of DEM-based physical classes

Unique combinations of physical features were combined to form preliminary Ecological Land Units (ELU). This simple modelling approach can be used to stratify the region into ecologically meaningful and separable units. ELU's can be further stratified according to moisture regime (i.e. riverine, non-riverine), landform type (i.e. plains, hill slopes and valleys) and general soil type and overall vegetation community type. Each ELU or group of ELU's can be assigned a suitability ranking, based on habitat productivity for black rhinos. This was determined using a combination of field work and remote-sensing (satellite and air-photo) image analysis.

3.6 THE USE OF SPOOR AS A MONITORING TOOL

Spoor counts were made in two areas over a period of four months (August – November 2001) from the end of the cool dry season into the hot dry season. A network of four-wheel drive vehicle tracks was already present in the area and combinations of tracks in each site were selected to cover each areas varying topography. The soils consisted predominantly of lithosols and other weakly-developed, shallow soils of arid regions (Barnard, 1998) and form a soft substratum for spotting spoor. The habitat along the roads was defined as riverine, slopes or plains, based on topography and vegetation following classification of forage habitats in studies on the desert-dwelling elephants (after Viljoen, 1989). Roads were driven daily and checked for the presence of rhino spoor. Only one set of data was collected per day for an individual road. A vehicle was driven at 20 km h^{-1} along the roads with experienced local trackers scanning for spoor crossing the road. The date, time of day, road condition and number of observers was recorded for each road sample. Samples were only included in the analysis where the road condition was rated as "fresh" by the trackers, who were able to determine if a road had been driven since the previous day from the texture of the soil.

3.6.1 Detection of spoor

When spoor were detected they were assessed for age. Only spoor determined by trackers to have been made during the last 24 hrs were recorded. Trackers assisting with data collection were experienced in determining the age of spoor to this level of accuracy. Stander (1997) discusses the benefits of the use of skilled local trackers.

A GPS position was taken for the location of each set of spoor. Spoor were measured across the widest part of the hind foot - most of the weight is carried on the front feet, hence hind feet impressions are less likely to be distorted (Jewell *et al.*, 2001). Therefore, spoor of the same size recorded within 1 km was assessed carefully by trackers in terms of direction travelling and age, where they were assumed to belong to the same individual they were excluded from analysis to prevent autocorrelation. As individuals regularly use the same waterhole and have regular movement patterns within their home range (Joubert and Eloff, 1971) this assumption was felt to be justifiable.

3.6.2 Estimating density

This study used a separate data set from the study of home range across the entire range area. Only positional data from 1999 – 2001 was used to assess density in the study site. Black rhino are known to be sedentary in habit and occupy well-defined home ranges with very low dispersal rates in adult animals (Goddard, 1967b; Joubert and Eloff, 1971). Therefore, sightings data for the previous three years were considered sufficiently accurate to use in home range analysis.

The home range of each individual was calculated using the Minimum Convex Polygon (see details in section 3.3.2). This was based on 176 data points for 17 rhinos (males, mean = 10.0 ± 1.65 locations per individuals; females, mean = 10.7 ± 2.30). Not all known rhino in the study site had 10 sightings. However, these were still used in the analysis of density for this study. Two additional individuals were excluded from the analysis, as there were fewer than three data points for each. The area of overlap of each rhino's home range with the study site and percentage of this overlap of total home range area was calculated. The density calculation was taken as the total percentage of home range overlap with the study sites for all individuals combined, divided by the area of the study site.

To test the effect of water availability and habitat types on spoor distribution and rhino density, buffer zones consisting of the area within incremental 1.5 km distances were placed around all perennial water points in the study sites. The density of spoor detected on roads in each habitat type and rhino density calculated using minimum convex polygons was correlated for each buffer zone.

3.6.3 Sampling effort

Determining the level of sampling effort required to obtain accurate spoor count data was an important aspect of this study. The number and length of roads driven in each site were related to an index (penetration) of the size of the area. 'Penetration' is defined as the ratio of area (km^2) to total road length (km). The level of effort required to gather accurate and precise spoor count data was assessed using a bootstrap analysis programme. Road segments were selected at random using the random number generator in Excel (Microsoft Office '00) with replacement and increased progressively. Total distance and total number of spoor were recorded and used to calculate mean spoor frequency for each run (n=1000). The standard error, coefficient of variance, 95% confidence intervals and road penetration were calculated. Comparing total distance with mean spoor frequency and variance assessed the affect of distance driven. Penetration for each study site was assessed by comparing the area covered of each site, in terms of the ratio of total road length used with mean spoor frequency and 95% confidence intervals.

CHAPTER 4: RESULTS

4.1 INTRODUCTION

The following section describes the results of the analyses. First, key ecological constraints on the black rhino are outlined, followed by a brief section detailing the revised sub-division of the population areas. Section 4.2.4 describes the results of the analysis of rhino breeding performance using the revised sub-division of the area. Vehicle entry points into the black rhino range are mapped and levels of traffic assessed, followed by the presentation of the habitat suitability model. Finally, the use results of the spoor frequency study are presented.

4.2 THE KEY ECOLOGICAL CONSTRAINTS ON THE BLACK RHINO

4.2.1 Habitat preference

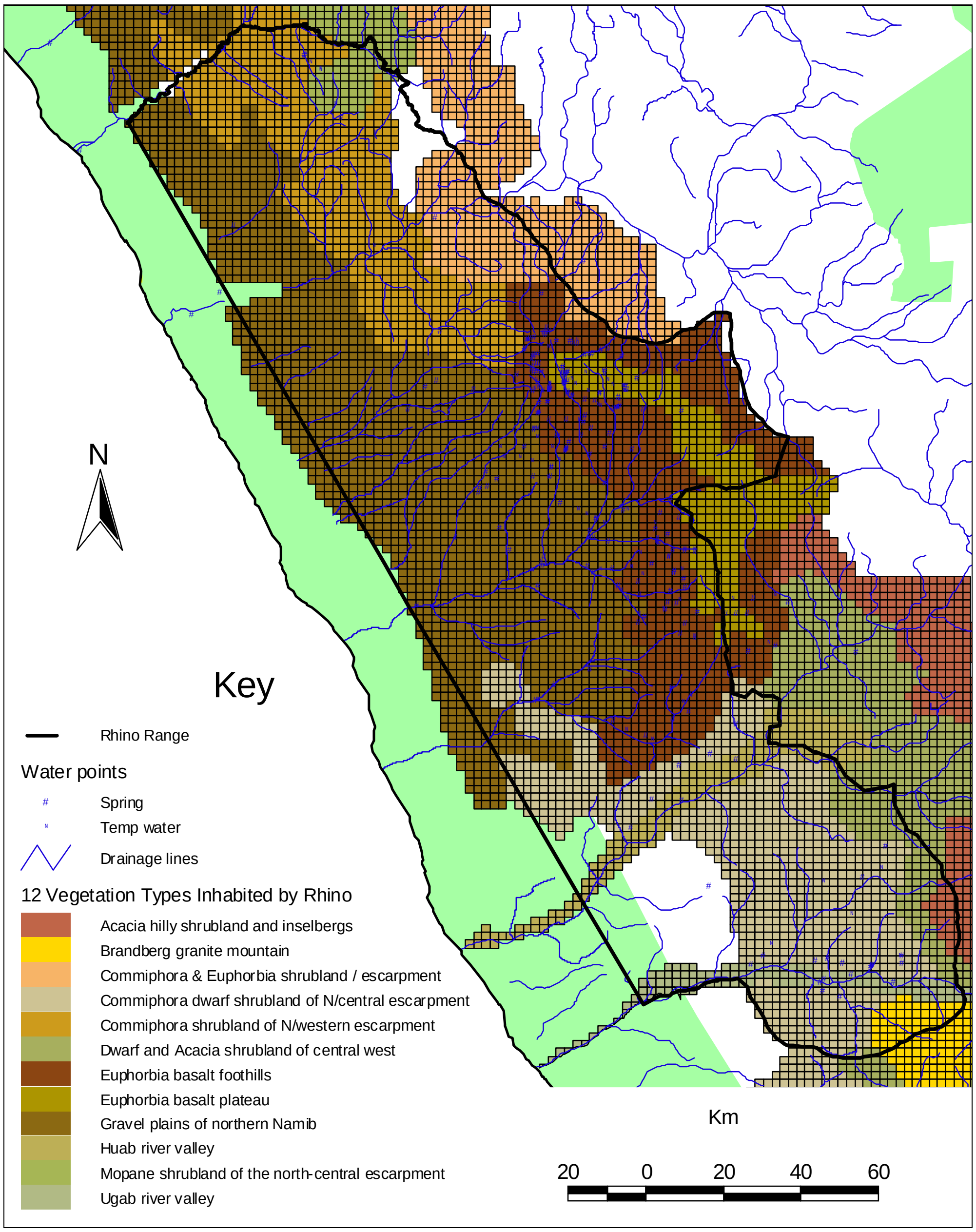


Figure 7. The 12 vegetation types inhabited by the black rhino in North-western Namibia, expressed as the major vegetation unit per 2x2km grid (modified from Mendelson *et al.* 2002).

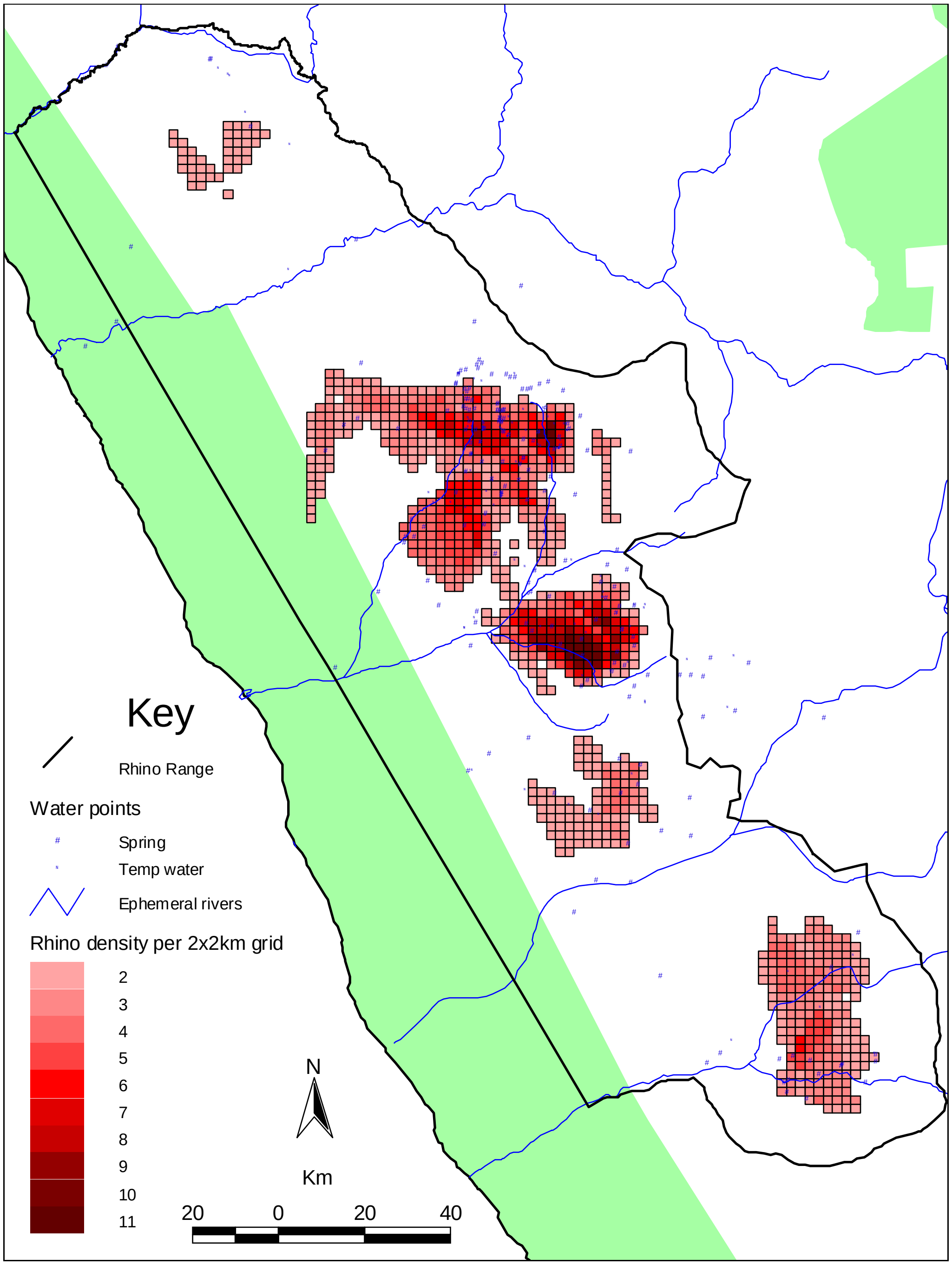


Figure 8. Rhino density across the Kunene range area, expressed as the count of home range polygons overlapping each 2x2km grid square. Excluded from the map are single overlapping polygons. However, these were used in the later analysis (modified from Mendelson *et al.* 2002).

Figures 7 and 8 were created using the GIS, to determine the factors influencing density and home range in the Kunene range area. Landform properties, in relation to the distribution patterns of individual rhino, were also analysed.

Rhino were found to occupy 6,312 km^2 of the Kunene range area, expressed as the count of 2x2km grid squares with one or more overlapping MCP's. Rhino occupied 12 different vegetation types (Figure 7), expressed as the major vegetation unit per 2x2km grid square with one or more overlapping MCP's. Density was highest in the basalt foothills of the range area (Figure 9).

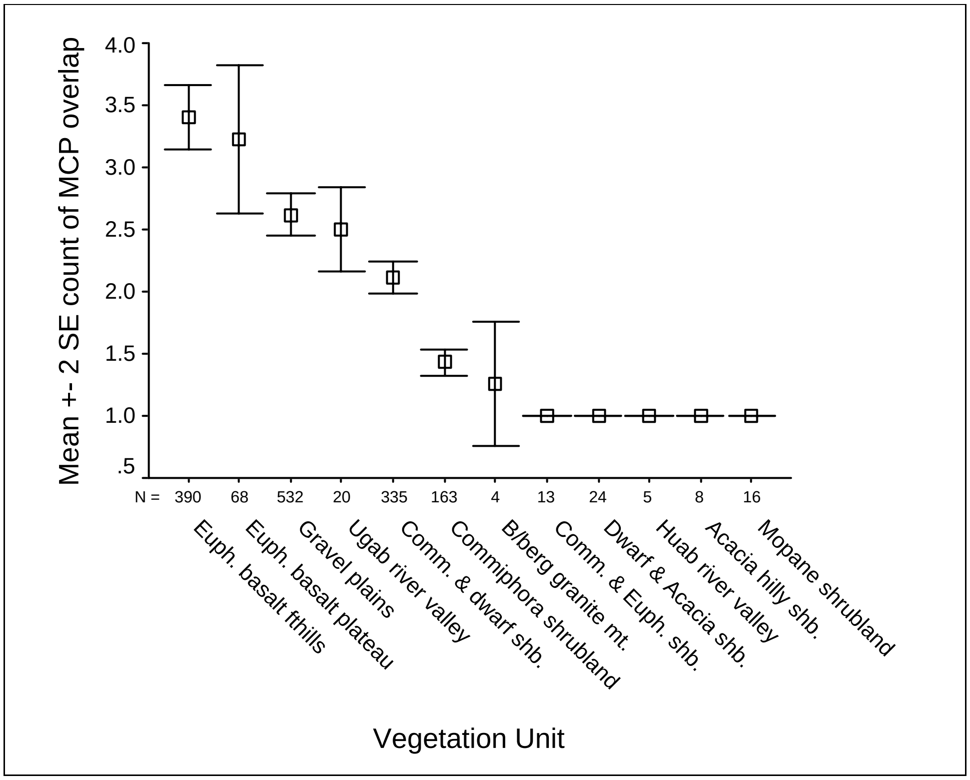


Figure 9. Rhino density per vegetation unit, expressed as the major vegetation unit per 2x2km grid square with one or more overlapping MCP's.

Figure 10 shows the rhino density, expressed as the mean MCP per 2x2km grid, decreases as the distance to permanent water is increased.

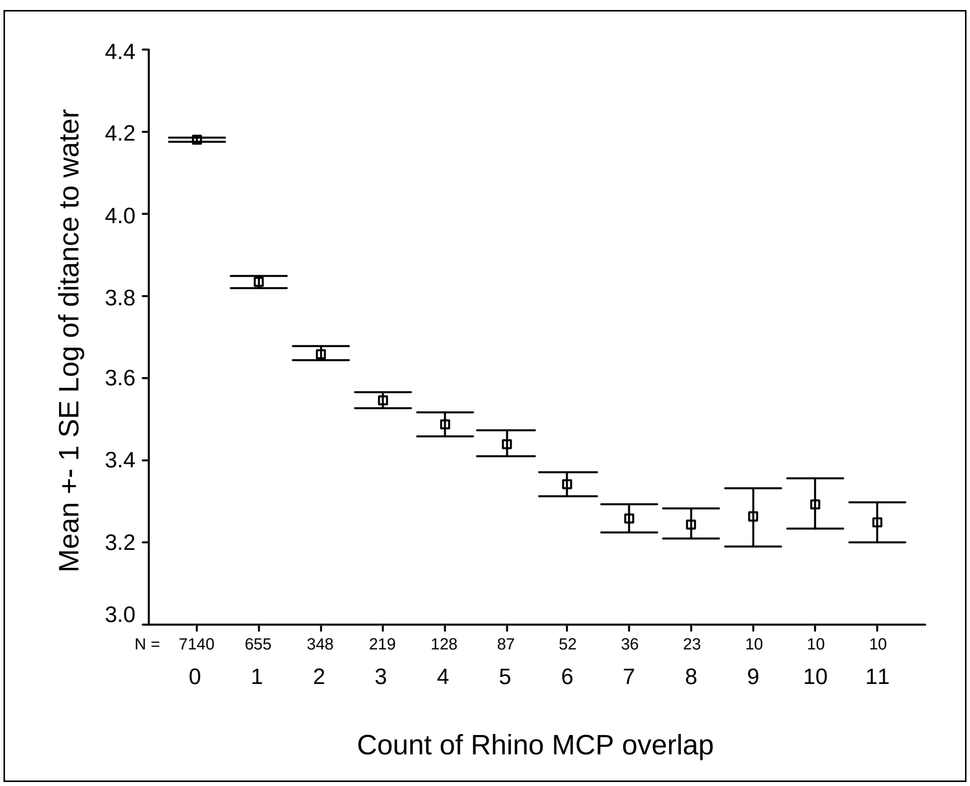


Figure 10. Relationship of the mean distance to permanent springs and rhino density, expressed as the mean distance to water and number of overlapping MCPs per 2x2km grid square.

4.2.2 Revised subdivision of the population area

In the GIS, different layers of data were imported from SRT's database and the MET atlas project database (Mendelson *et al.* 2002) to revise the zonation of the range area. These included individual MCPs of rhino distribution, topography, vegetation units, rainfall isohyets and barriers (e.g. the veterinary cordon fence, main roads etc.) (Figure 11). These sub-divisions, or zones, were then used to compare performance indicators across the revised range area in relation to variations in local density.

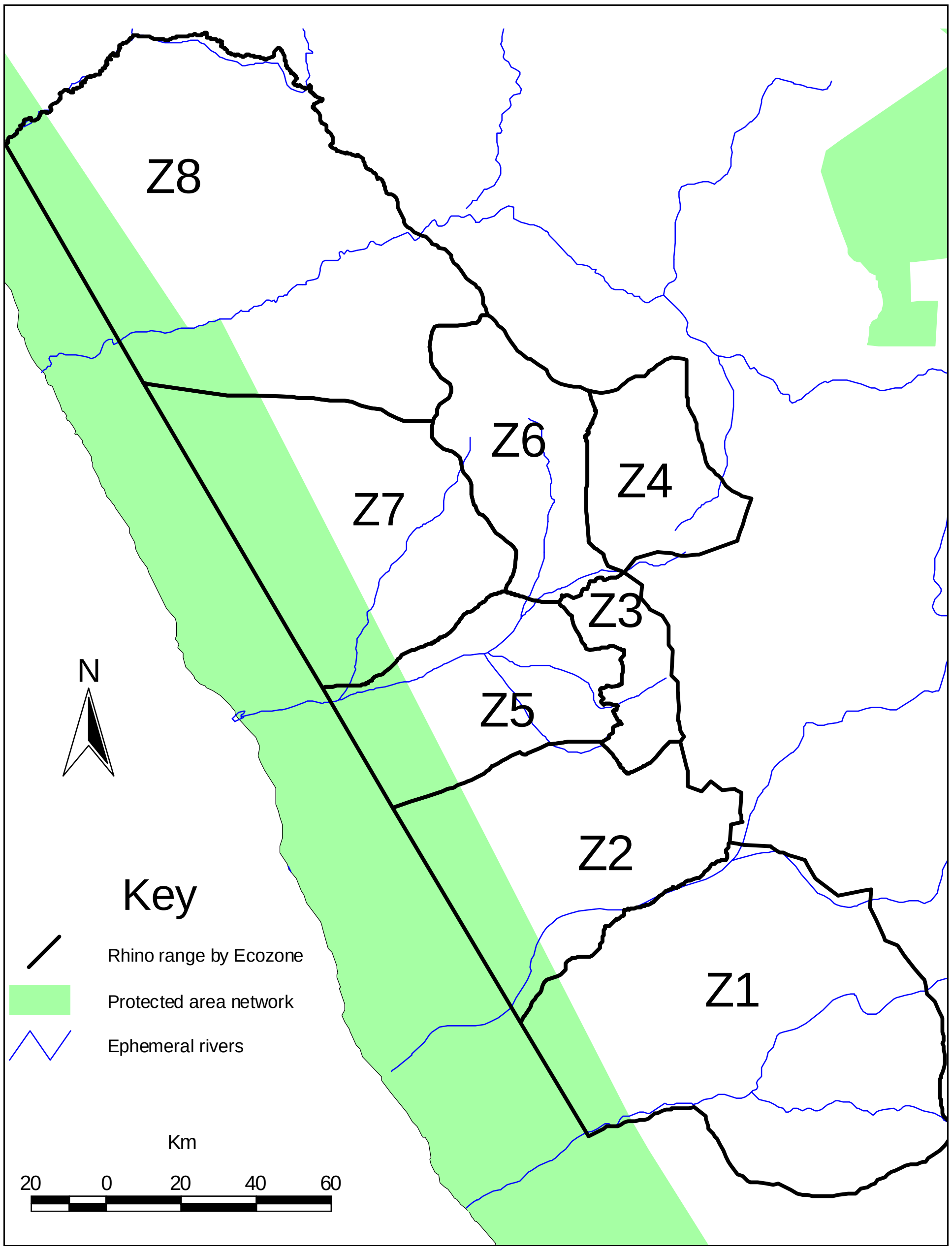


Figure 11. Revised sub-division of rhino range using: rhino MCPs; vegetation units; and, natural and manmade barriers (modified from Mendelson *et al.* 2002).

Table 4 summarises the different rhino density levels for each zone (Figures 11 and 12). This includes the area of each zone and the core rhino areas. Core rhino area was calculated from the analysis of MCPs for all rhino sightings in each zone. Table 4 also includes a summary of the major vegetation units occurring in each zone.

Table 4. Characteristics of the sub-divisions of the Kunene black rhino range area.

Zone	Zone size/km2	Size of core rhino area/km2	Major Vegetation Unit
1	4,787	1080	Commiphora dwarf shrubland of the escarpment region
2	2,530	516	Euphorbia basalt foothills and gravel plains
3	613	246	Euphorbia basalt foothills and plateau region
4	1,108	69	Euphorbia basalt foothills and plateau region
5	1,786	734	Euphorbia basalt foothills and gravel plains
6	1,500	732	Euphorbia basalt foothills and plateau region
7	3,112	1540	Gravel plains
8	5,561	944	Commiphora shrubland of the escarpment region

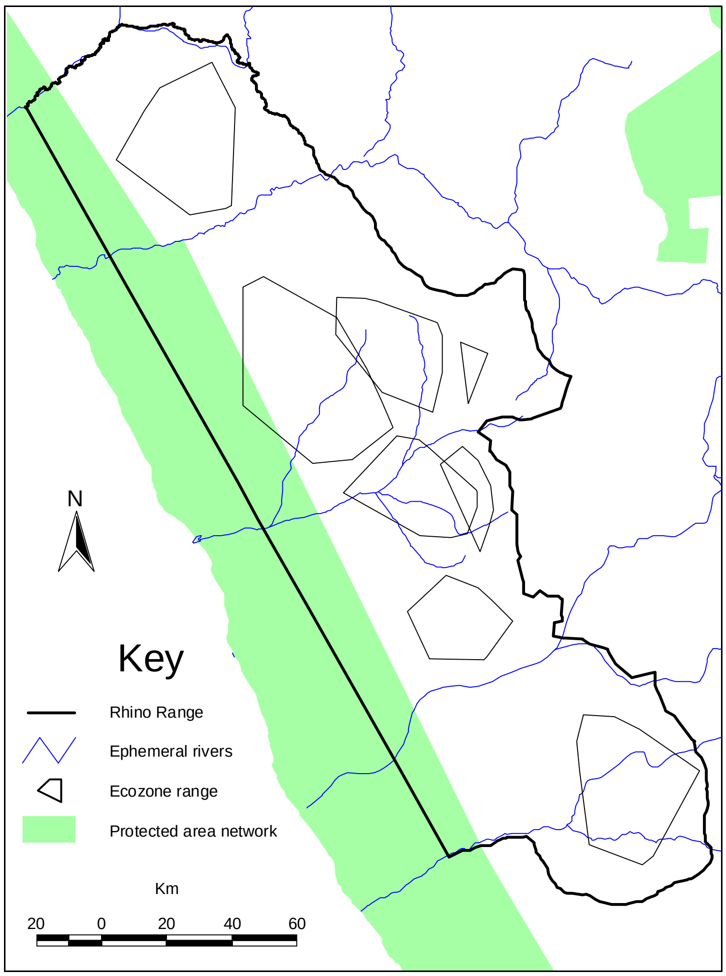


Figure 12. Core rhino areas for each zone, calculated using MCPs of all sightings in each zone (modified from Mendelson *et al.* 2002).

4.2.3 Home range and distribution

The data for a sample of known male and female rhinos was used in the analysis of home ranges. The home range of males in the Kunene population varied from 39.79 km^2 to 791.02 km^2 (mean=164.96 ± 175.21 km^2; *n*=20) (Figure 13). The home range of females in the Kunene population varied from 26.37 km^2 to 514.50 km^2 (mean= 158.77 ± 117.93 km^2; *n*=24) (Figure 14). Using a smaller data set Berger (1997) found home range to vary from 101 km^2 to 2067 km^2 (mean= 538 km^2 ±161 km^2; *n* = 13).

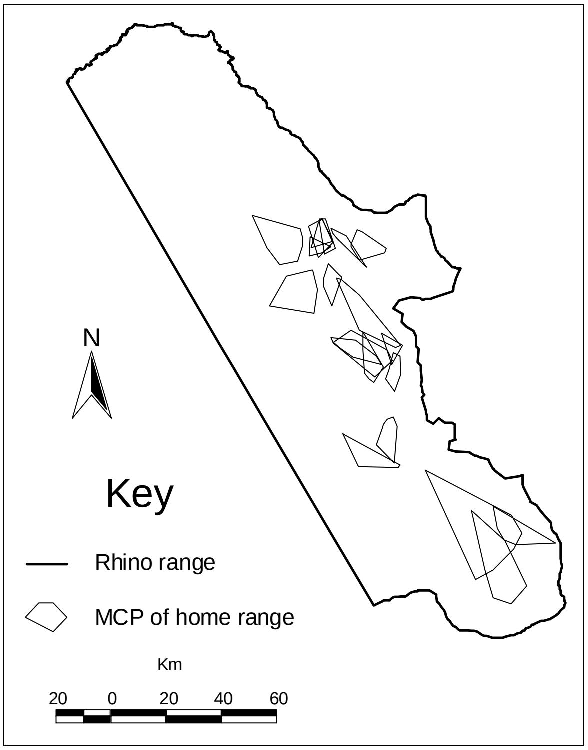


Figure 13. Male rhino home ranges (n = 20) of adults with greater than ten sightings.

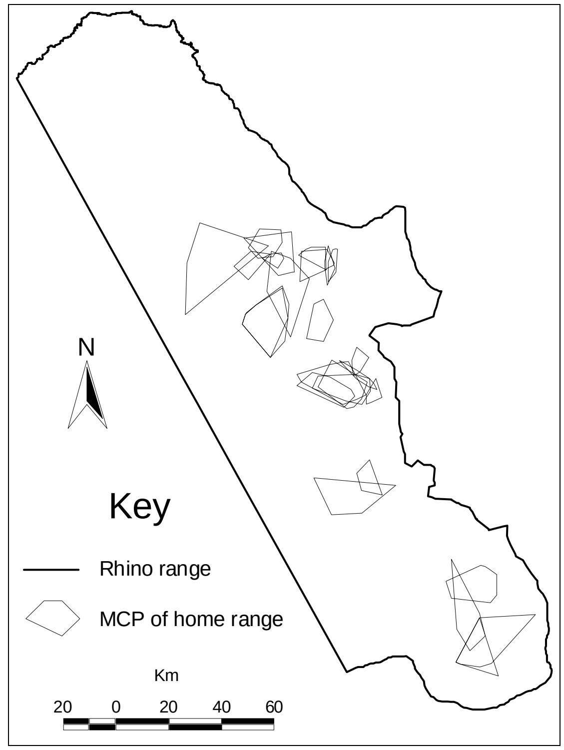


Figure 14. Female rhino home ranges (n = 24) of adults with greater than ten sightings.

The mean home range of males between zones across the Kunene range area differed significantly (Kruskal Wallis, x^2 = 17.877, df = 5, P = 0.003) (Table 5).

Table 5. Mean and range of home range for adult males with more than 10 individual fixed sightings, calculated using minimum convex polygon, for each of the revised zones of the Kunene range area.

Zone	*N*	Mean	Range	Std. Error
1	3	455.70	174.14-791.02	180.01
2	2	115.49	98.70-132.27	16.79
3	2	52.10	40.97-63.22	11.12
5	3	141.44	90.12-235.96	47.32
6	8	85.54	39.79-223.77	21.46
7	2	244.12	242.48-245.77	2.32

The mean home range of females between zones across the Kunene range area also differed significantly (Kruskal Wallis, x^2 = 12.719, df = 5, P = 0.026) (Table 6).

Table 6. Mean and range of home range for adult females with more than 10 individual fixed sightings, calculated using minimum convex polygon, for each of the revised zones of the Kunene range area.

Zone	*N*	Mean	Range	Std. Error
1	4	218.04	164.02-313.19	32.68
2	2	167.96	70.55-265.36	97.41
3	3	34.45	29.78-39.36	2.77
5	4	190.29	144.24-245.76	21.36
6	9	79.86	26.37-190.51	17.62
7	2	334.17	259.18-514.50	52.25

4.2.4 Population performance indicators across range area

In Figure 15 and 16 the population structure for the Kunene population as of the end of December 2001 is summarised by age, using criteria devised by Hitchens (1970) and developed further by Emslie *et al.* (1993).

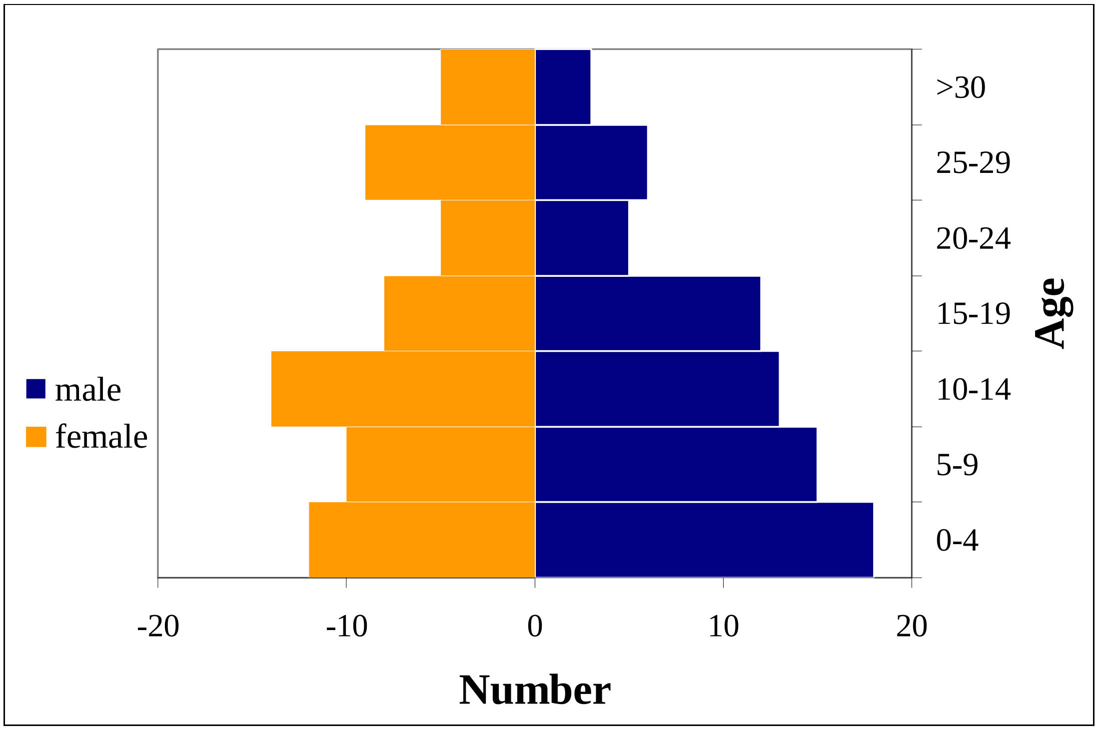


Figure 15. Kunene population structure, by age.

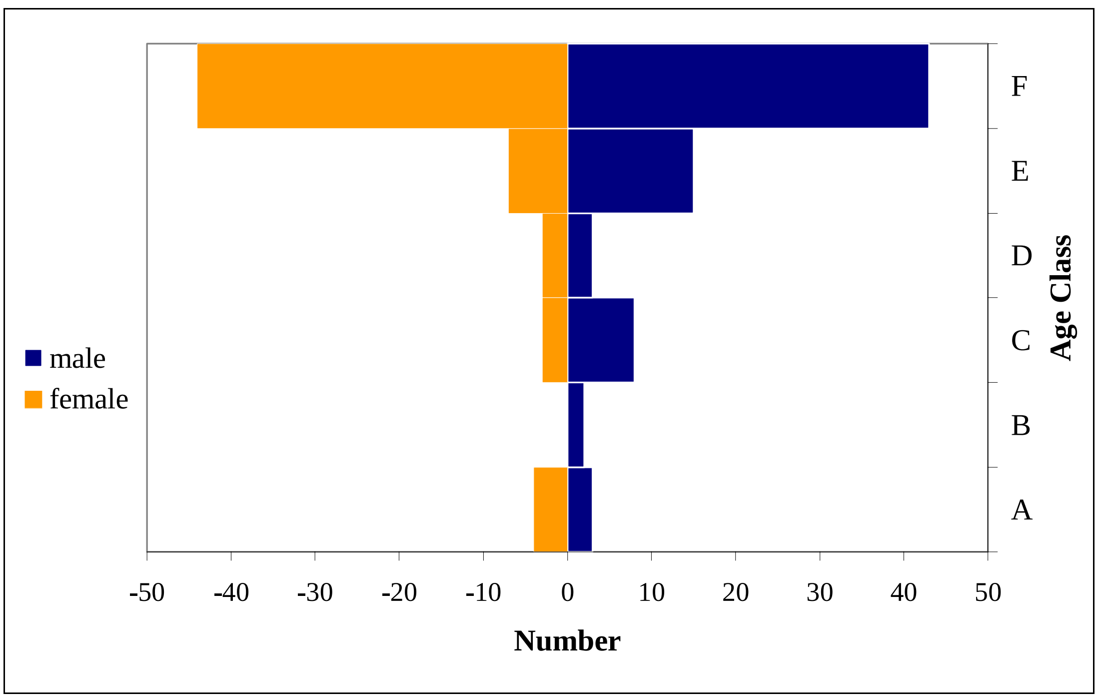


Figure 16. Kunene population structure by age, calf sizes A-E refer to immature rhino age classes, as originally devised by Hitchens, 1970.

Table 7 summarises the performance for the Kunene population of black rhino for each zone. Data includes known individuals (*n*=124), and an estimate of the number of clean animals in the population (*n*=11). The term ''clean'' refers to the fact that no identifying features are apparent (e.g. intact ears and conventional horn shape) to allow the animal to be positively identified on a different occasion by a different observer.

Table 7. Population structure and local densities of the Kunene rhino range zones, and breeding performance across the range area expressed as the calves per adult female per year, with recorded natural mortalities of calves since 1990.

	Distribution 2001		**Population structure 2001**			**Breeding performance 1990-2002**		
Zone	**Core range area/km^2**	**Density/ km^2**	**Total Adults**	**E Class Juveniles**	**M:F sex ratio**	**Known calf mortalities**	**Calves born**	**calves/ female/yr.**
Z1	1080.49	0.008	9	0	0.80	4	8	0.149
Z2	515.93	0.021	8	3	0.83	3	10	0.188
Z3	246.05	0.041	7	3	0.67	0	11	0.306
Z4	69.17	0.029	2	0	-	1	4	-
Z5	733.56	0.018	9	4	2.25	0	10	0.210
Z6	732.43	0.046	24	10	1.18	3	28	0.242
Z7	1540.23	0.015	20	3	0.92	1	17	0.186
Z8	943.79	0.007	7	0	2.00	1	1	-
TOTAL	**5,861.65**	**0.019**	**86**	**23**	**1.23**	**13**	**89**	

Using criteria developed by the Rhino Management Group, over the last six years calving proportions for the population have indicated poor performance (for calves <1 year, levels have been less than 8%, and below 28% for calves <3.5 years). Fluctuations in calving success were also recorded. On average, calf mortality was often >10% per annum. In 1999 alone, the Kunene population calf mortality was at 57%. Adult mortality, on average, remained below 4% per annum.

Age of the mother at first calving is often hard to estimate due to the difficulty in recording birth dates for a population ranging over such a large and inaccessible region. However, for a small sample of animals, with birth dates less than one year, age at first calving ranged from 7.01 – 13.09 years (mean=10.08 ± 2.03 yrs; *n*=16). The lowest age at first calving was found in zone three.

The population growth rate has averaged 3.27% per annum for the last five years and only 2.73% over the last ten years. However, growth rates have been above 5% per annum for the last two years.

Figure 17 explores the impact of rainfall on population performance. Breeding is expressed as calving per adult female per year. Rainfall varies across the range area considerably. Therefore, data from two stations within the range were used: Wereldsend, on the westerly extreme of the range area; and, the town of Khorixas just to the east of the range area.

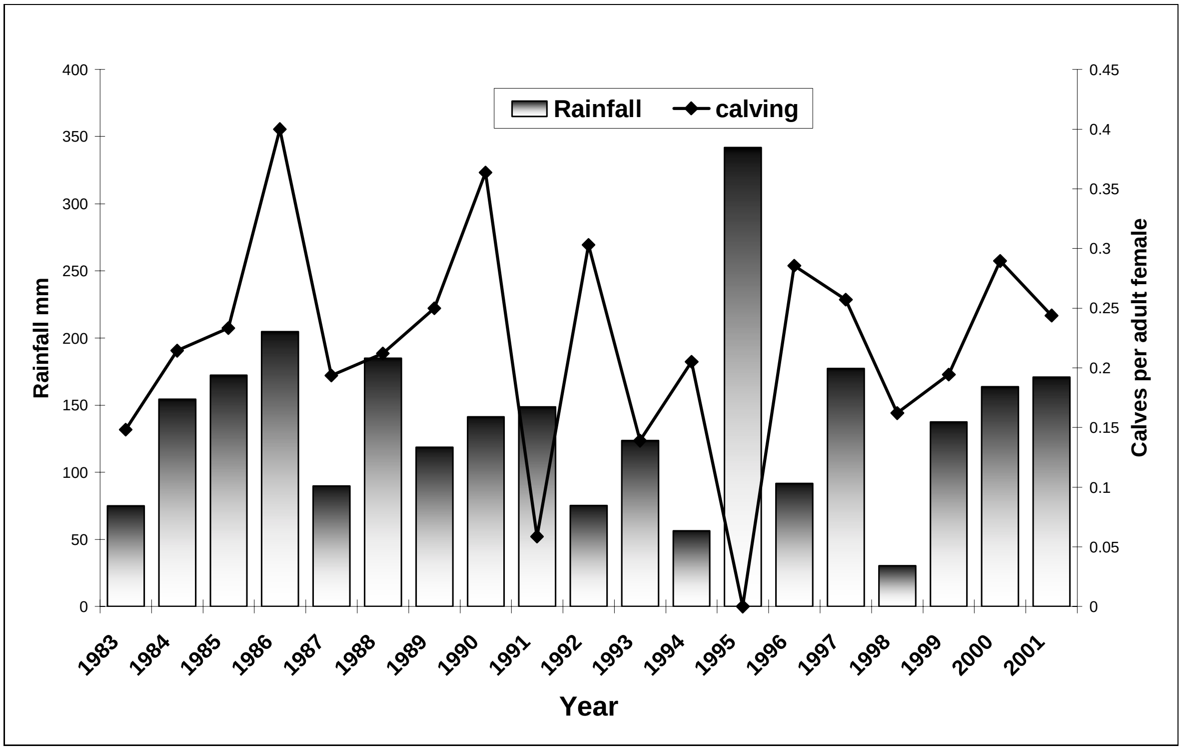


Figure 17. Breeding in relation to annual mean rainfall in (mm) from two stations in North-western Namibia, expressed as calves per adult female per year.

The correlation of the mean number of calves sired per female over two years with mean annual rainfall was weak (Pearson Correlation; r=0.221; *n*=17; P=0.411) (Figure 18). This suggests there maybe a lag effect of rainfall on breeding with browse suitability improved beyond the event of a single rainy season. Rainfall in years such as 1995 would therefore result in a temporary increase in the regions carrying capacity for black rhino. However, both calf and adult mortality were high after these rains.

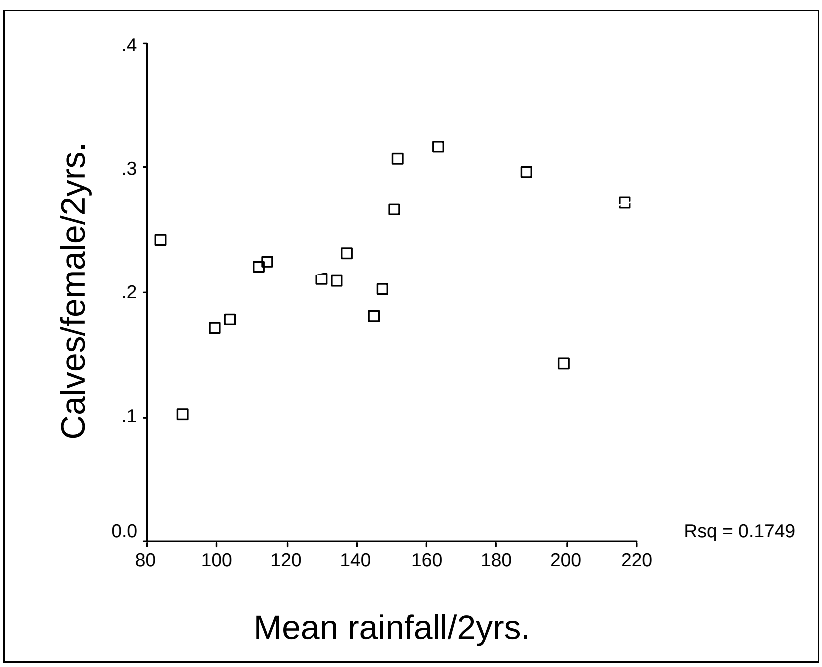


Figure 18. Breeding in relation to annual mean rainfall in (mm) from two stations in North-western Namibia, expressed as the calves per adult female per year.

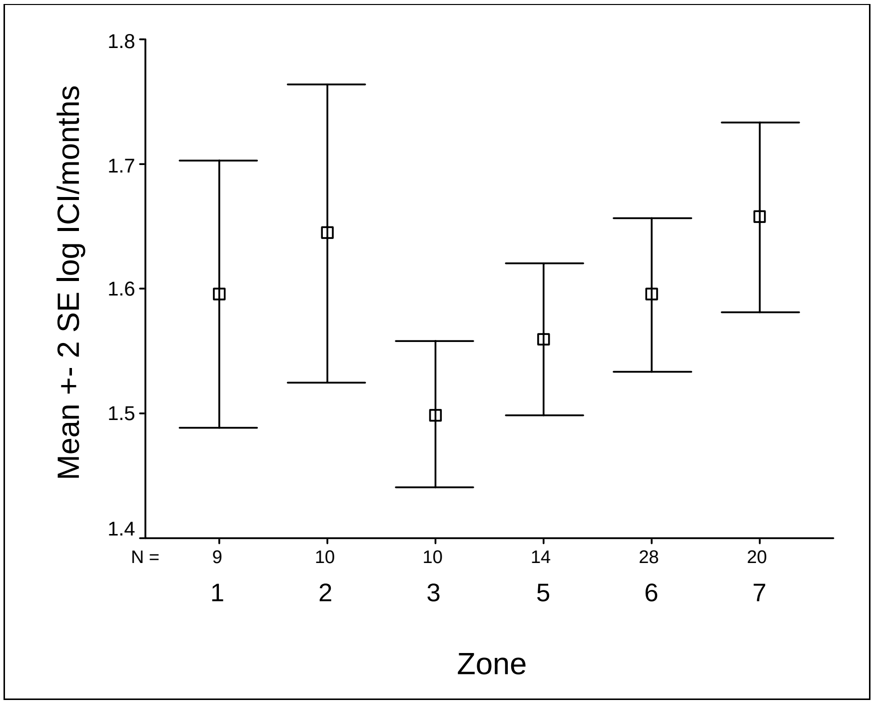


Figure 19. Calving interval, expressed in months, across the range area.

Inter-calf intervals (ICI) collected from across the Kunene range area varied from 20–109 months (mean=42.80 ± 17.901 *n*=99). Due to the likelihood that with long intervals calves may have been aborted or died soon after birth and were never recorded, three outliers were ignored in the analysis of ICI across the Kunene range area. Intervals from zones 4 and 8 were also ignored due to very small sample sizes. Figure 19 summarises the variation in ICI across the remainder of the range area (*n*=91). Differences were not significant between zones 1, 2, 3, 5, 6 or 7 (one-way ANOVA, F=1.758, df=5, *P*=0.130). Once areas with high variance (zones 1 and 2) were dropped from the analysis differences were significant between zones 3, 5, 6 and 7 (one-way ANOVA, F=2.803, df=3, *P*=0.46).

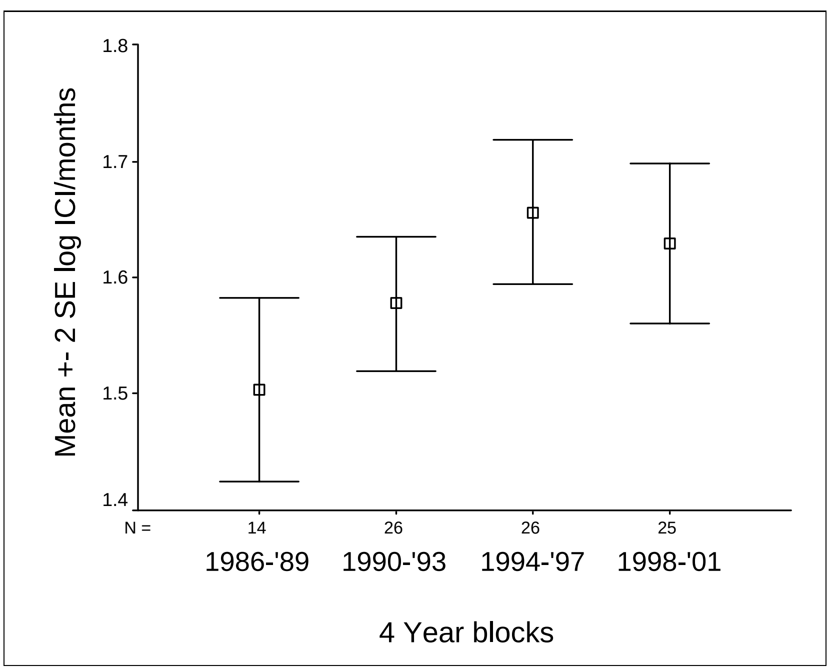


Figure 20. Calving interval, expressed in months, in four year blocks, 1986–2002.

Figure 20 suggests that calving intervals have lengthened over time, indicating decreasing population performance. However, between 1998 and 2002 the mean ICI dropped. The above average annual rainfall in 1995 (Figure 17) could explain this.

4.3 ACCESS INTO THE RHINO RANGE

4.3.1 Distribution and use of entry points across Kunene

Access roads, and the level of use, were monitored by routine patrols by SRT and in two cases at basecamps, manned during the majority of year by SRT staff. Figure 21 shows the major towns in relation to the range area. Figures 22, 23 and 24 presents the number of tourists and vehicles entering the area from data collected at SRT's basecamps.

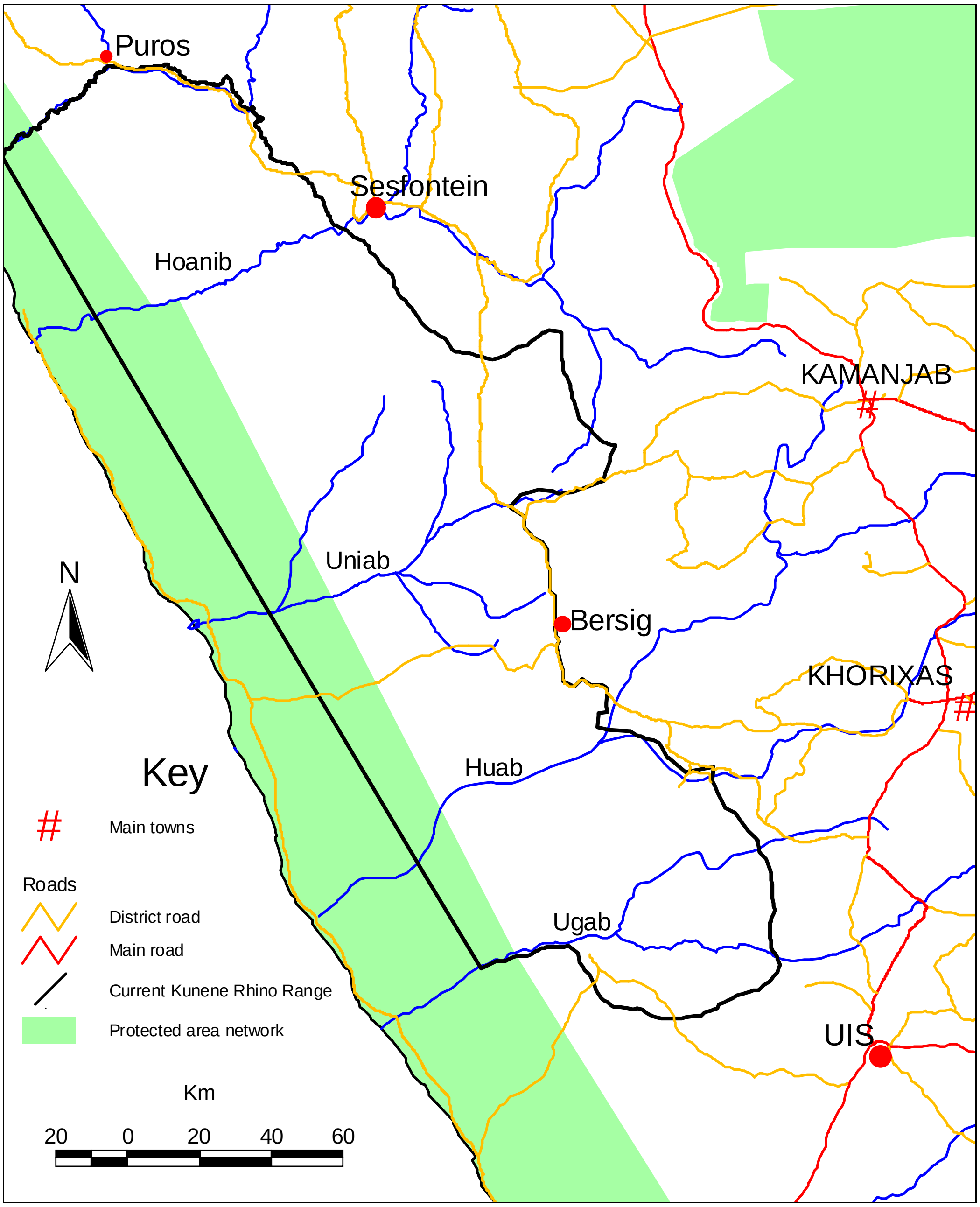


Figure 21. Distribution of major towns and roads in relation to the rhino range area (modified from Mendelson *et al.* 2002).

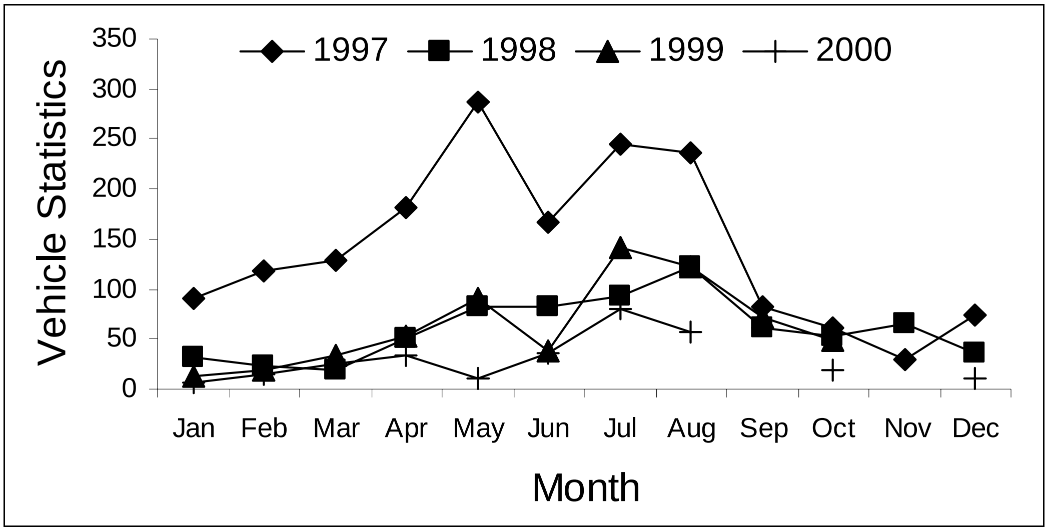


Figure 22. Distribution and total number of vehicles passing the Hoanib entry point, near Sesfontein (1997 – 2000).

Though there were some months when vehicle and/or tourist statistics were not collected data from both the Hoanib and Ugab rivers entry points indicated that the majority of tourism traffic entering the Kunene range area are self-drive, usually 4x4, tourists. Tourist data presented in Figure 22 for the Hoanib entry point indicates the levels of use that can be expected. **1997 saw the highest number of vehicles enter the Hoanib River** – thought to be due to an article in a popular 4X4 magazine in southern Africa, *Getaway Magazine,* a total of 1701 vehicles passed through the Hoanib entry point 1997. This dropped to 719 in 1998, 630 in 1999 and dropped further to 294 in 2000.

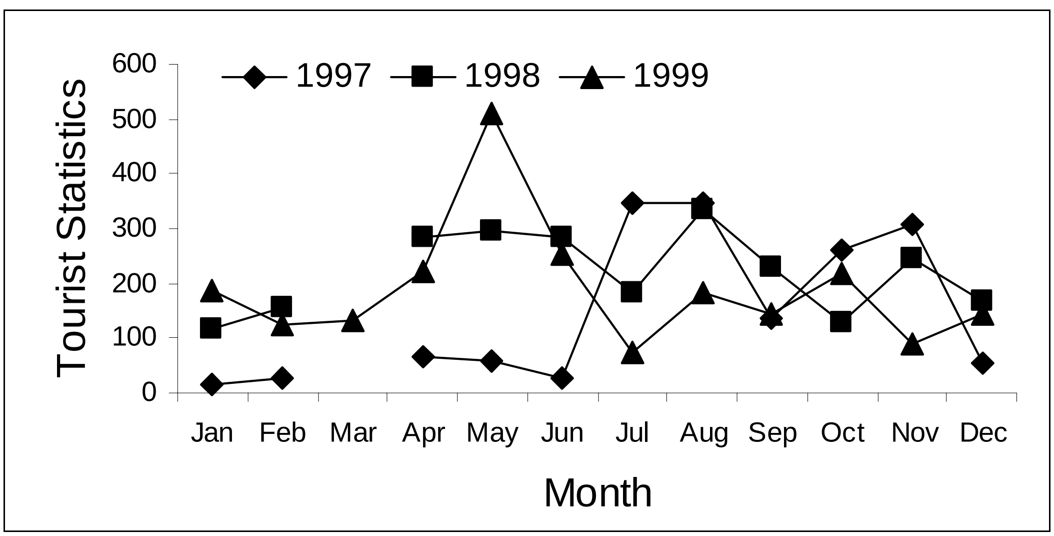


Figure 23. Distribution and total number of tourists passing the Ugab entry point to the rhino range (1997 – 1999).

At the Ugab basecamp, in 1997 a total of 1643 tourists passed through the camp. This increased to 2428 in 1998 and dropped to 2290 in 1999 (Figure 23). For 2001 vehicle statistics collected from the Ugab basecamp, from May – December, indicated 696 vehicles passed through the area. For 2002, 1206 vehicles passed through the area (Figure 24). At both the Hoanib and Ugab entry points visitor numbers appear to peak in April/May and in

July/August. These data suggest that the majority of visitors in April were from South Africa and Namibia. For July and August the majority of visitors were European tourists.

Data for 2001 and 2002 from the Ugab basecamp showed a peak in the Christmas period. The majority of these visitors were local Namibians. The Hoanib River did not show a similar trend. This could be due to the Hoanib River often flowing during this period and not allowing tourists to pass through the area.

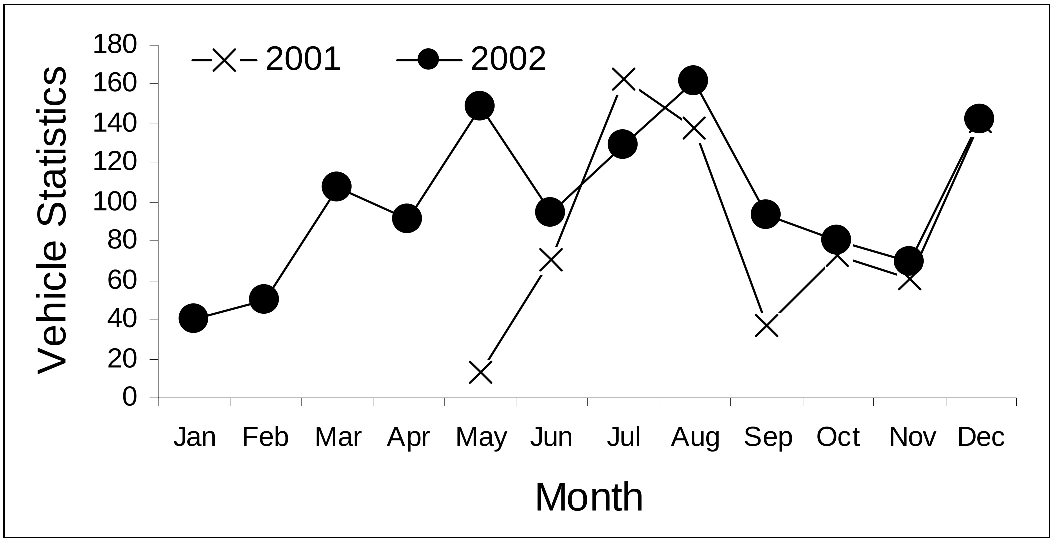


Figure 24. Distribution and total number of vehicles passing the Ugab entry point to the rhino range (2001 – 2002).

A total of fifty two entry points were distributed on the periphery of the Kunene range area and accessible by tourists and local traffic (Figure 25). Based on the amount of traffic estimated to be using the entry points, from the regularity of vehicle tracks observed at entry points by patrol teams, use of each entry point was ranked low, medium or high. Entry points with high levels of use were then prioritised for appropriate controls to limit access into the rhino range (Figure 26).

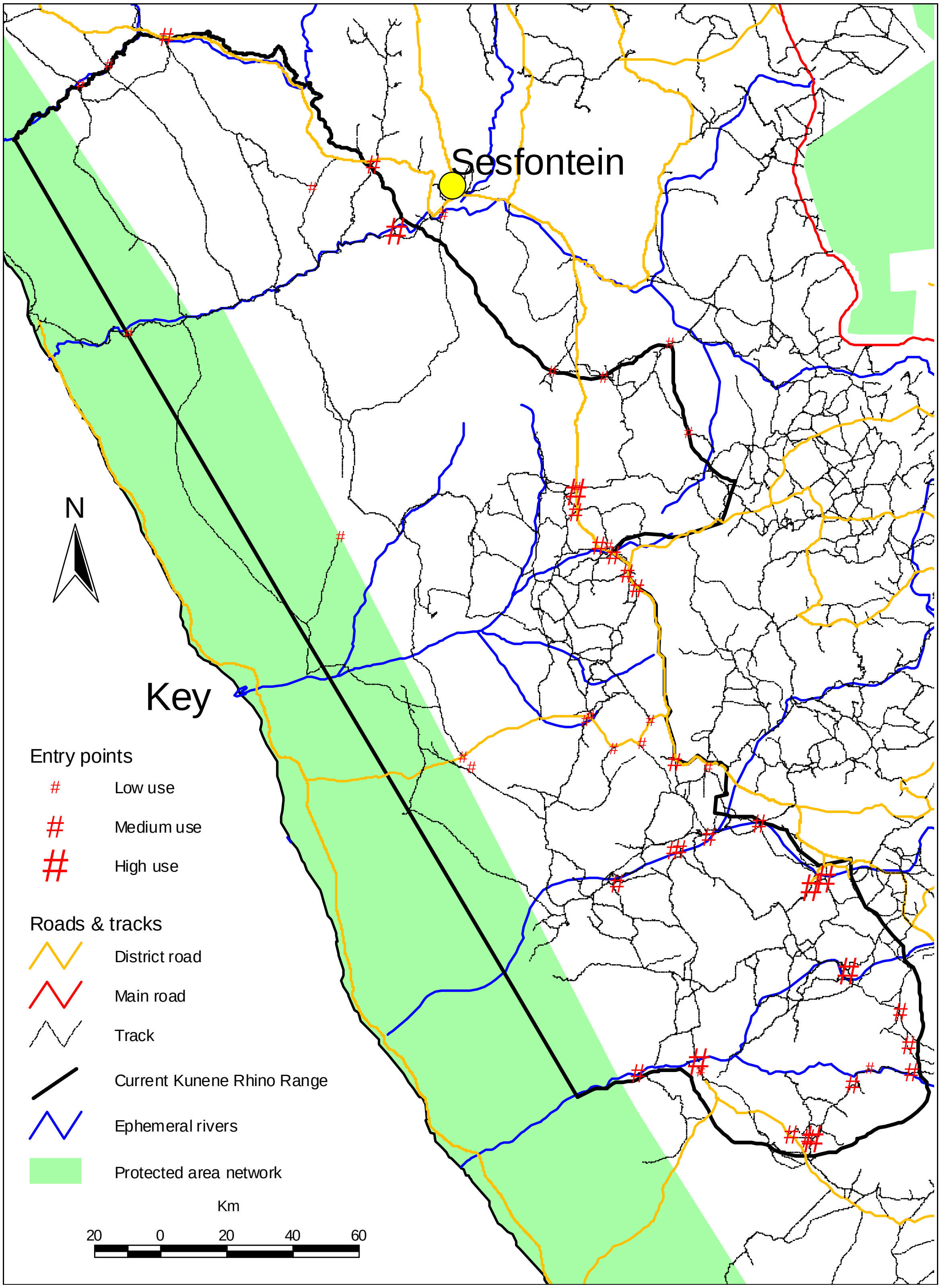


Figure 25. Distribution of entry points across the range area. Use is ranked as low, medium or high on the basis of the regularity of vehicle tracks recorded at each entry during patrols(modified from Mendelson *et al.* 2002).

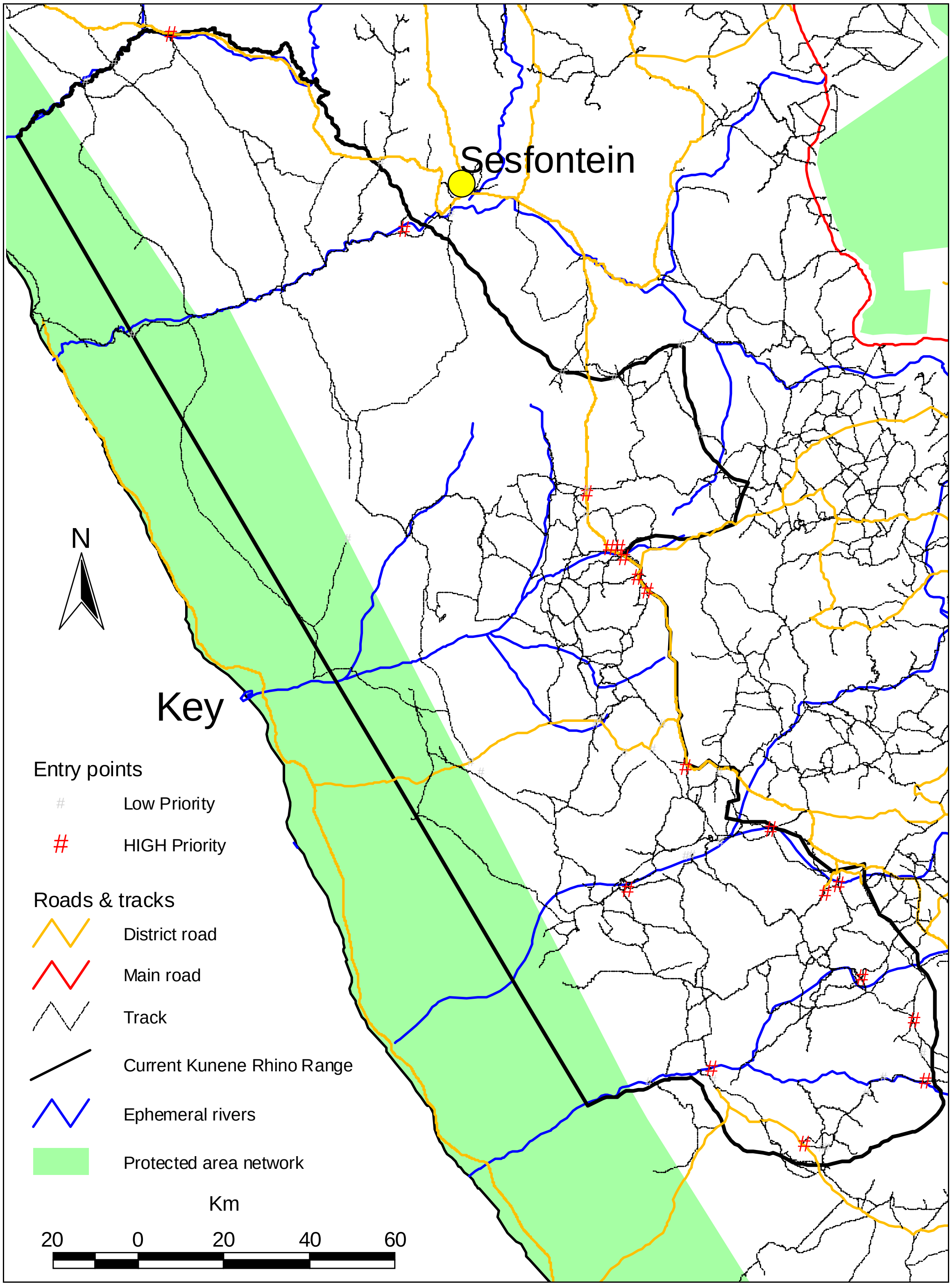


Figure 26. Priorities for appropriate control measures at 'key 'impact'' sites across the range area, priority for control determined from the level of use and the ability to control traffic (modified from Mendelson *et al.* 2002).

4.4 DEVELOPING A HABITAT SUITABILITY MODEL

To design field work and provide initial insight into spatial habitat patterns, the 3 DEM-based variables of slope, aspect and elevation were initially combined (Figure 27). From this information, 36 preliminary ELU's were mapped for the study area (Figure 28). Some examples are shown in Table 8. Predicted suitability of these ELU's for rhino was determined from a study's carried out in Kunene (Loutit *et al.*, 1987; Sullivan, 1998, 1999; Hearn *et al.*, 2000). Fieldwork will test the hypothesis that changes in slope, elevation and aspect have an impact on rhino distribution.

Table 8. Example ELU's and predicted rhino habitat suitability.

ELU #	Slope	Elevation	Aspect	Predicted Suitable Habitat?
13	0º - 2º	0 - 528 m	0º - 180º	Yes (gentle slope, low elevation, East Facing)
16	3º - 6º	0 - 528 m	270º - 360º	Yes (moderate slope, NW Facing)
23	13º - 30º	528 - 1056 m	0º - 180º	No (steep slope, mid-elevation, E Facing)

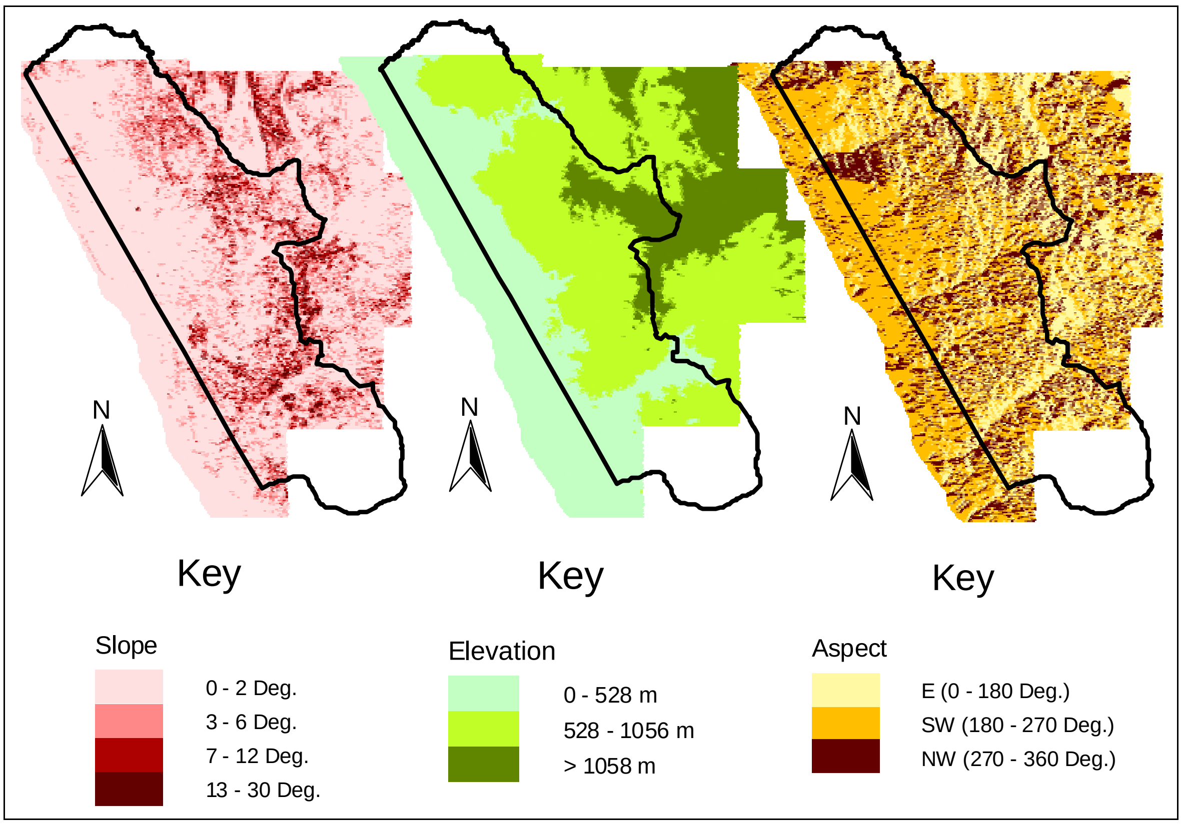


Figure 27. Slope, elevation and aspect model to predictor habitat productivity based on moisture regime, prevailing winds and differences in forage characteristics.

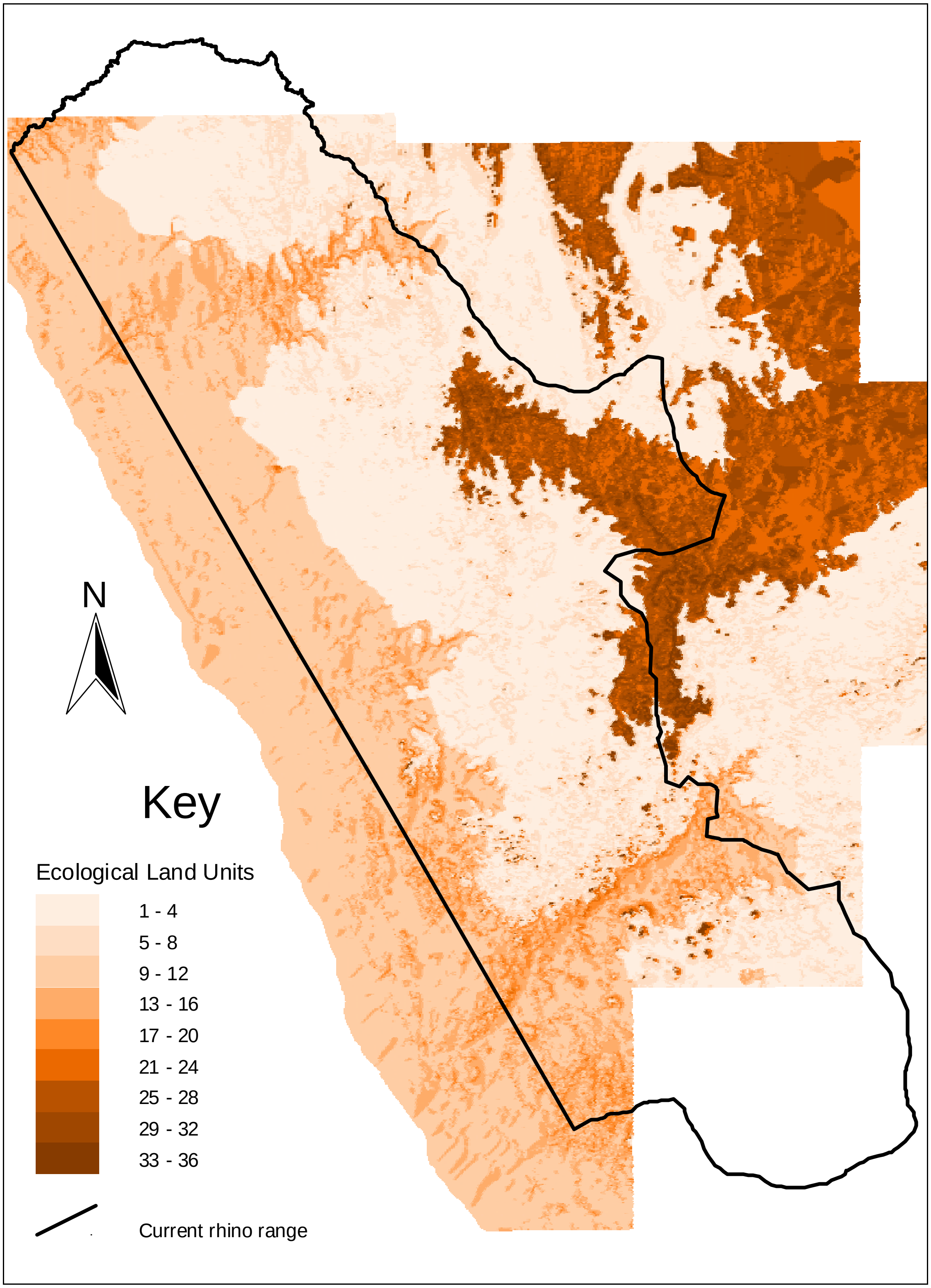


Figure 28. Model of ecological land unit classification. Ranking assigned to each unit based on habitat productivity for black rhinos.

4.5 THE USE OF SPOOR AS A MONITORING TOOL

4.5.1 Spoor distribution

Mean spoor density was 0.032 per km^{-1} ±0.0038 km^{-1} across the two study sites. Spoor density in the western area (0.049 per km^{-1} ± 0.0036 km^{-1}) was higher than the eastern site (0.025 per km^{-1} ± 0.0026 km^{-1}). Thirteen spoor samples were excluded from analysis as they were taken to be from the same individual. To assess the distribution of spoor, spoor density was tested between roads. Individual roads were found to differ significantly in spoor density (G_{28} = 61.3, p =<0.05). However, the density of spoor on each road was not related to road length (r^2 = 0.01, t = -0.19).

Table 9. Area, road data, sampling effort, number of spoor and independently estimated population density in each study area.

	Eastern area	Western area
Area (km^2)	470.1	395.5
Number of road units	45	37
No. of samples (road units driven)	919	341
Range (repeats per road unit)	10 – 38	7 – 13
Total distance (km)	2394	913
Road penetration*	4.01	3.99
Perennial water points	6	11
Total number of spoor	68	52
Spoor frequency (km)	39.7 ± 3.9	20.3 ± 2.8
Spoor density (km^{-1})	0.025 ± 0.0026	0.049 ± 0.0036
Rhino density**	0.0095	0.0257

*The ratio of area (km^2) to total road length (km).

**Number per km^2 based on Minimum Convex Polygon home ranges inferred from re-sightings of known individuals.

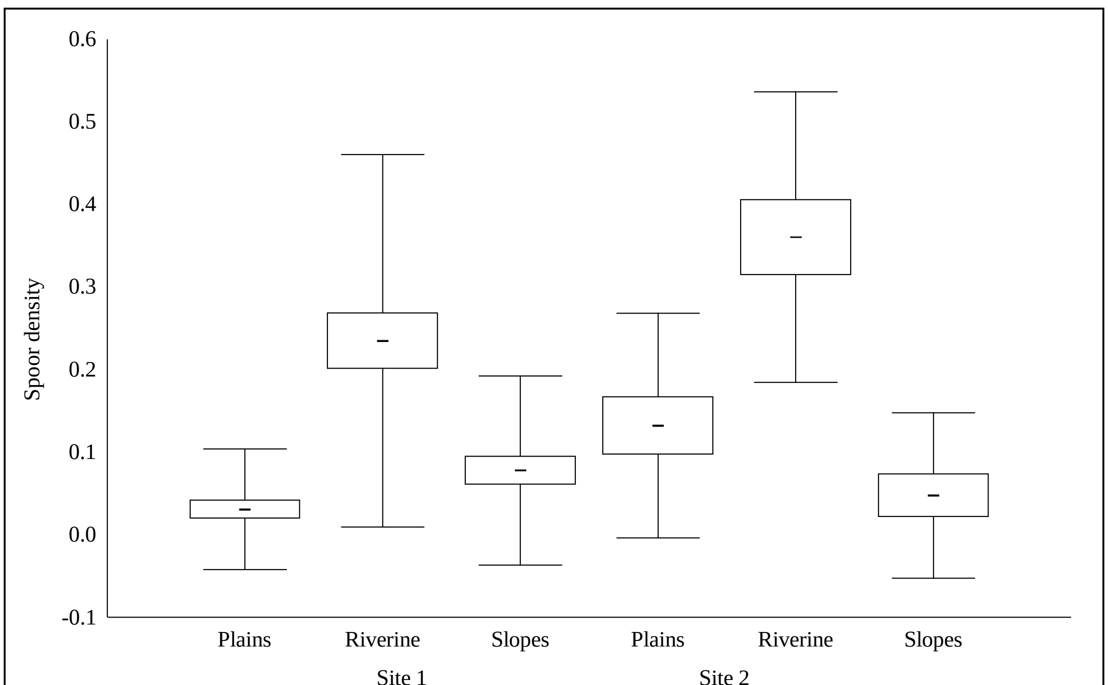


Figure 29. A comparison of the density of rhino spoor found in each of the three different habitats (mean ± SE) in each study site.

Given that the distribution of spoor was found to be non-random across different roads, the relationship between spoor density and habitat was assessed. Riverine habitats had much greater spoor densities than either plains or slopes (Kruskal Wallis, $X^2_2 = 25.76$, $p =<0.05$) (Figure 29). This was probably as a result of rhino using this habitat to feed in. Also, these routes are used to reach water points that fall in riverbeds.

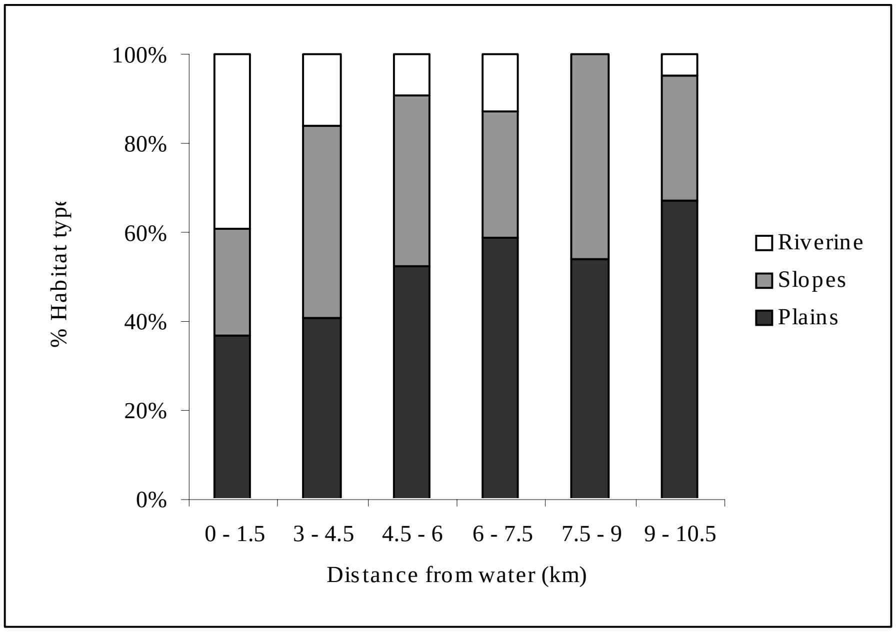


Figure 30. The percentage of roads in each of the three habitat types in each 1.5 km incremental buffer zones.

The percentage of each habitat type in each buffer zone was calculated to assess the effect of distance from water on vegetation (Figure 30). Riverine habitat is predominant in the buffer zone closest to water (0 – 1.5km) and there is a clear trend of decreasing riverine habitat with increasing distance from water. To assess the effect of water availability on spoor distribution, spoor density on all roads within each buffer zone was calculated.

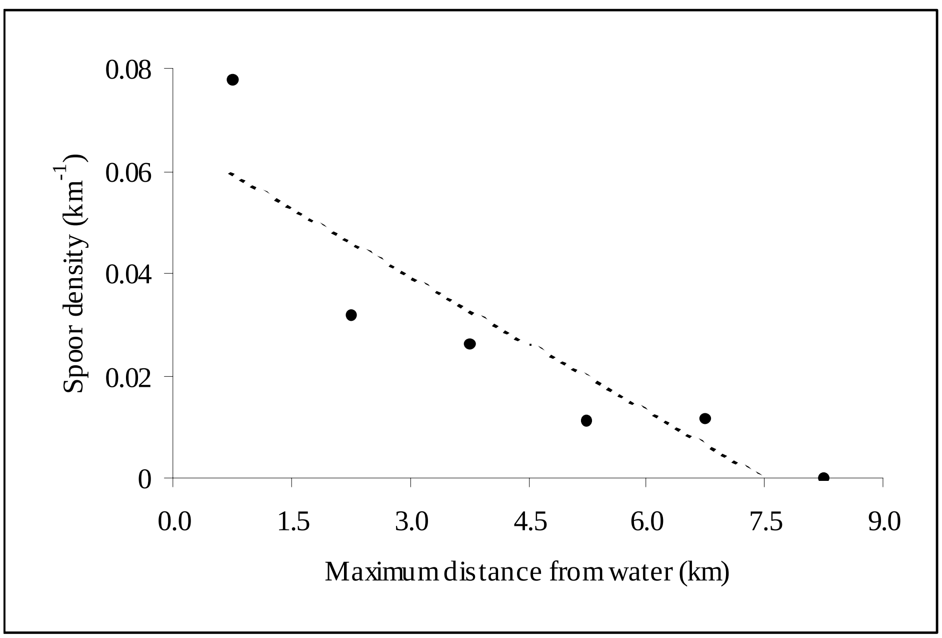


Figure 31. Spoor density in relation to distance from perennial water points.

There was a significant decrease in spoor density with increasing distance from water (r^2 = 0.81, t = -4.11, p = 0.015) (Figure 31). No spoors were found further than 7.5 km from water. Spoor density was also calculated within each habitat within the buffer zones. There was a strong correlation between spoor density and distance from water in the riverine habitat (r^2 = 0.93, t = -7.35, p = 0.0018). Spoor density in slopes and plains habitats did not differ significantly between buffer zones (slopes; r^2 = 0.61, t = -2.49, p = 0.068; plains; (r^2 = 0.20, t = -1.01, p = 0.37) (Figure 32).

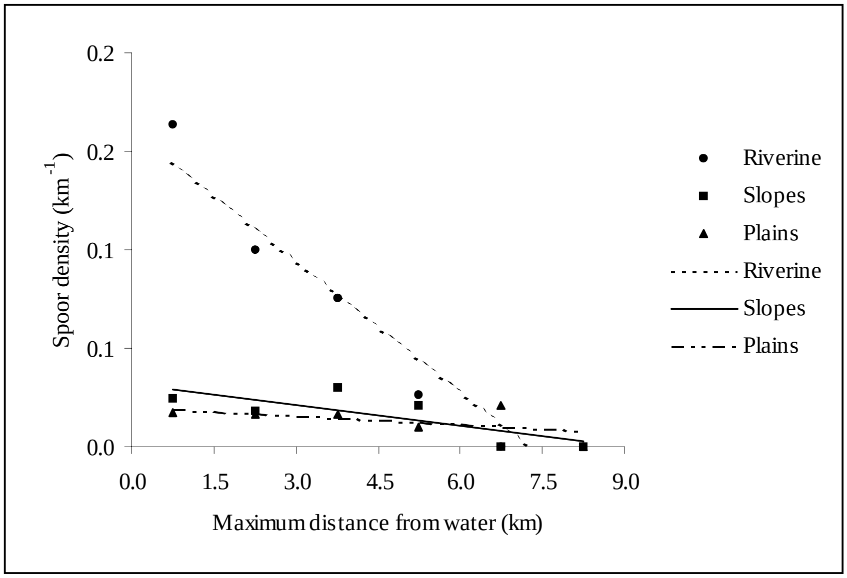


Figure 32. Spoor density in different habitats on roads in buffer zones of 1.5 km from perennial water points.

4.5.2 Rhino density

The density of rhinos for the study area was 0.017 km^{-2}. This was based on calculations using minimum convex polygons to calculate individual home ranges (overall home ranges 183 ± 48 km^2; n = 17; range = 14-791 km^2). The lowest range of 14 km^2 is unrealistic for this area and is likely to be a function of the low number of data points for this rhino (n = 4). However, the number of sightings of an individual was not found to be significantly related to home range size (r^2 = 0.03, t = 0.79, p= 0.44). The percentage overlap of each individual home range over the study sites ranged between 13 – 100% (Figure 33 A – C).

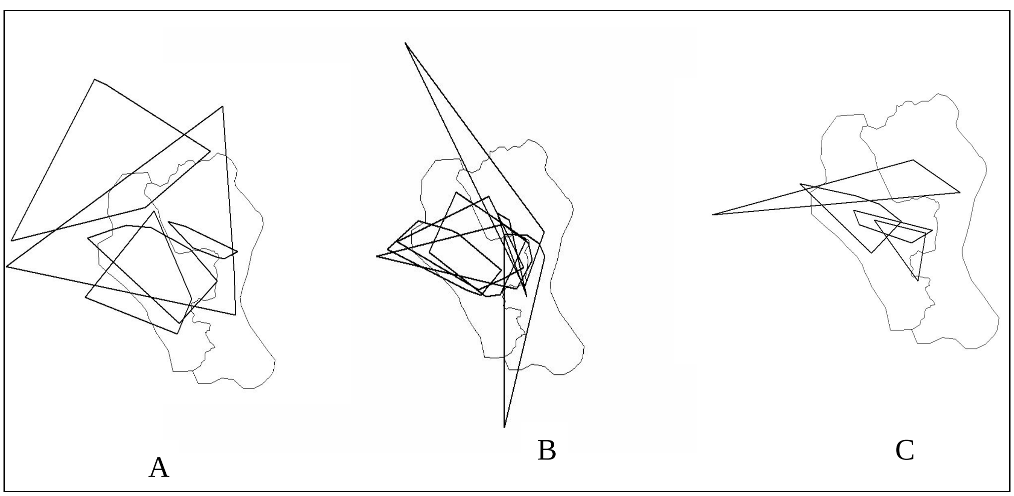


Figure 33. The minimum convex polygon home ranges for all adult males (A), females (B) and immature (C) rhino overlapping the study areas.

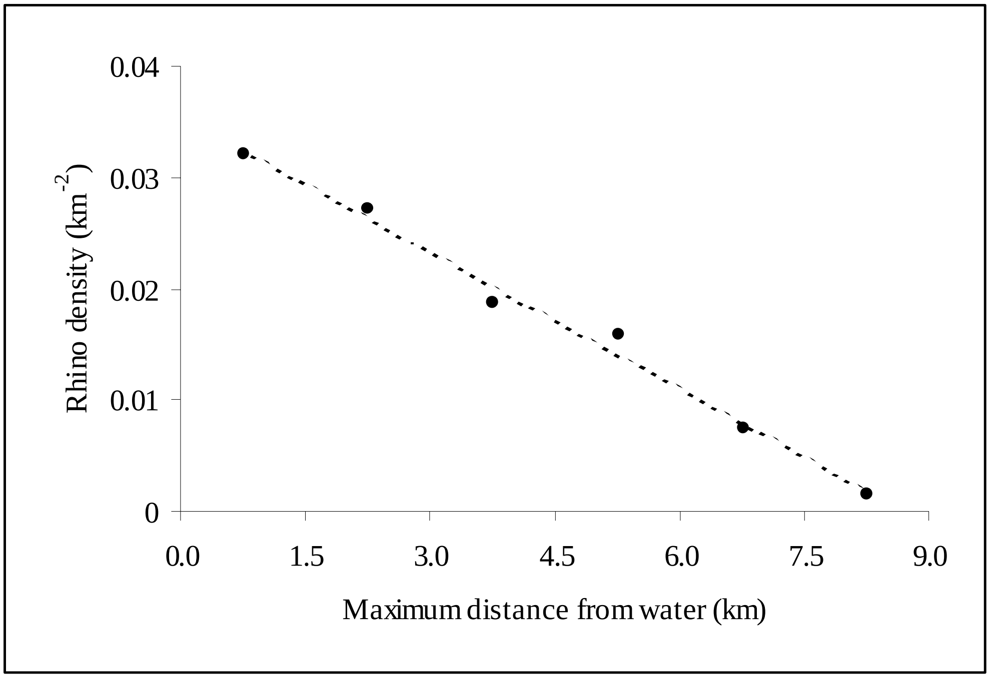


Figure 34. Rhino density calculated using minimum convex polygons in buffer zones of 1.5 km from perennial water points.

Rhino density calculated using minimum convex polygons was very strongly correlated to distance from water. Rhino density was highest in the buffer zone closest to water and decreased significantly with increasing distance (r^2 = 0.99, t = -19.30, p = 0.000042) (Figure 34). Spoor density was significantly correlated with estimated rhino density in the buffer zones (r^2 = 0.77, t = 3.62, p= 0.022). This relationship was strengthened when rhino density was correlated with spoor in the riverine habitat only (r^2 = 0.90, t = 5.85, p= 0.0043) (Figure 35).

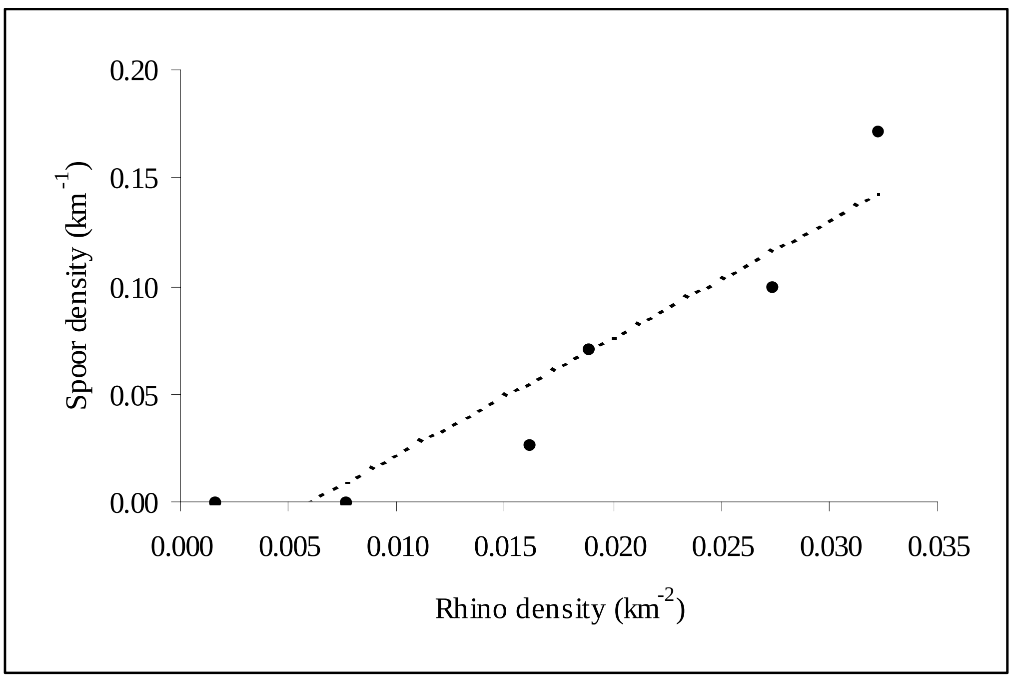


Figure 35. The relationship between rhino density calculated using minimum convex polygons and spoor density in riverine habitat in incremental 1.5 km buffers from perennial water points.

4.5.3 Disturbance

To ensure that the presence of vehicles performing data collection on the roads was not affecting rhino movements and therefore distribution of spoor on roads, spoor frequency was calculated separately for each day. This was tested against the cumulative number of days collecting data in that area. Spoor frequency was not found to be related to the increasing length of time spent collecting data for either site (Spearman Rank Order correlation; site 1 $r^2 = -0.006$, t = -0.41, n = 45; site 2 $r^2 = 0.17$, t = 0.63, n=15).

In order to assess the distribution of spoor on the roads throughout the sites, spoor frequency was tested between roads. Individual roads were found to differ significantly in spoor frequency in both sites (G test – site 1, G = 66.5, df = 13;site 2,G = 56.2, df = 15). However, the density of spoor on each road was not related to road length (Pearson Product-Moment Correlation – site 1, $r^2 = -0.42$, t = 0.180; site 2, $r^2 = 0.04$, t = 0.0018).

4.5.4 Sampling effort

As the spoor count technique requires all roads to be driven, sampling intensity was assessed for the overall length of road combined in each site, not divided by different habitats. Initially the effect of road penetration, defined as the ratio of area (km^2) to total road length (km), was assessed to determine the minimum length of sampling roads required for accurate spoor measures of frequencies. Roads were selected at random and systematically combined to increase length and hence the road ratio of penetration to study area. After each increase in total road length, and subsequent penetration rate, a fresh mean and 95% confidence interval was calculated (Figure 36, Figure 37).

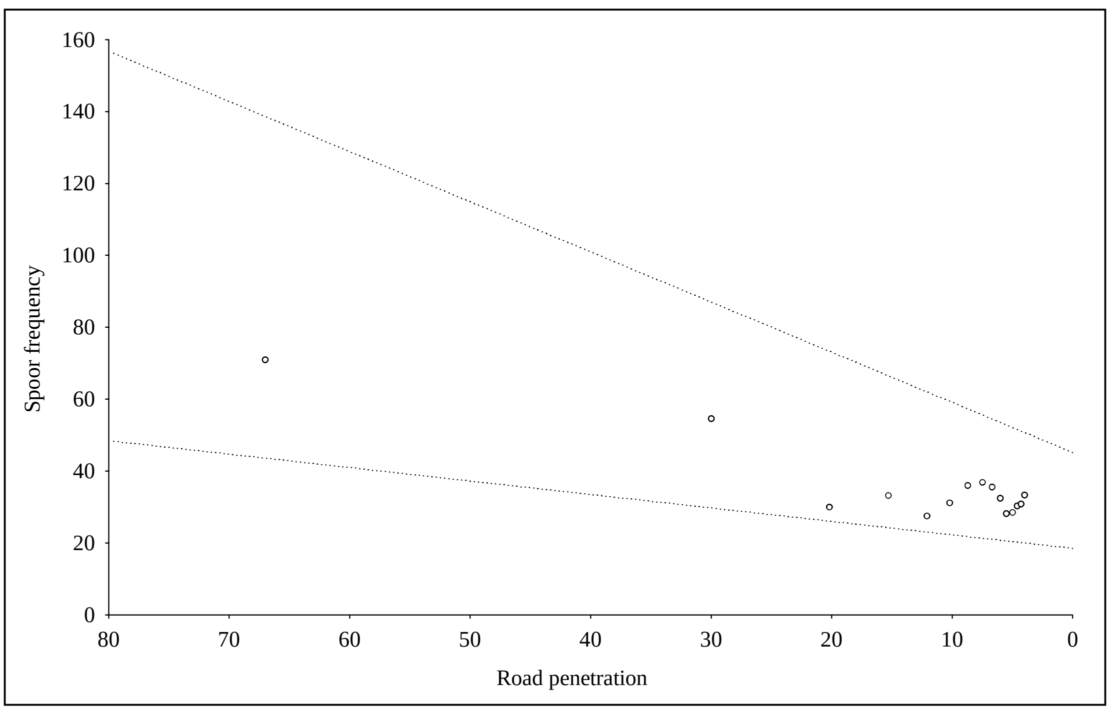


Figure 36. The relationship between the spoor frequency (number of kilometres per spoor) and road penetration (the ratio of km² surface area per 1km of road) in site 1. Dotted lines indicate 95% confidence intervals.

With low road length and low road penetration, mean spoor frequency was high with large error. As road penetration increased error around the mean was reduced and mean spoor frequency dropped. For site 1 at a road penetration ratio of 1km: 6km² mean spoor frequency was 32.5 ± 8.9, this was reached at a road distance of 78.4 km. At maximum penetration frequency was 33.0 ± 8.0, however there was a reduction in mean spoor frequency between these points to 28.2 ± 5.8 at a road penetration of 1km: 5.5km² (Figure 36). In site 2, when road penetration reached 1km: 5.7km², at road length 69.1 km mean spoor frequency was 12.9 ± 3.7 (Figure 37). Increasing road penetration beyond this ratio did not have a large effect on mean spoor frequency or error. The actual road penetration for all roads utilised was 1 km: 4km².

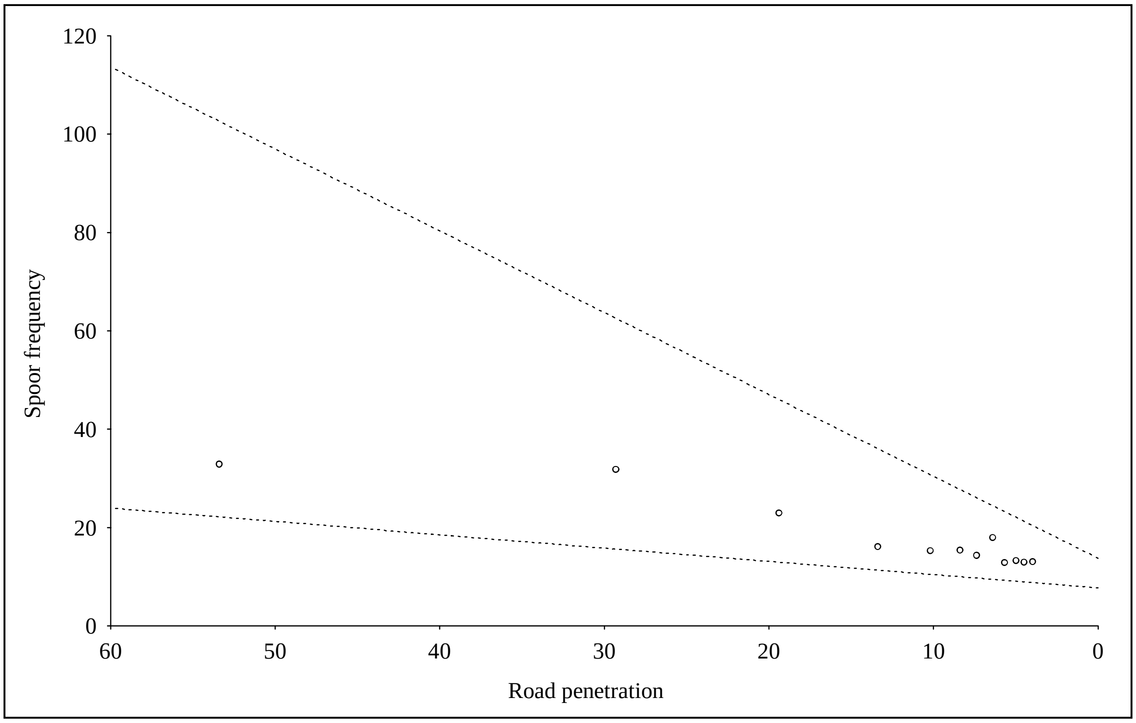


Figure 37. The relationship between the spoor frequency (number of kilometres per spoor) and road penetration (the ratio of km² surface area per 1km of road) in site 2. Dotted lines indicate 95% confidence intervals.

To assess the effort required in terms of total distance driven on the roads to gain accurate and precise spoor count data, the mean spoor frequency and associated error was related to sampling effort. Mean spoor frequency does not vary greatly with increased sampling intensity, however, variance is reduced.

In site 1 at a sampling intensity of 820 km or 23 spoor, mean spoor frequency was 36.6 ± 8.0. Spoor frequency estimates did not change or markedly improve as sample size increased. At maximum sampling intensity of 2422 km or 68 spoor, mean spoor frequency was 35.6 ± 4.3 (Figure 38). Similar results regarding sampling intensity were found in site 2. At a sampling intensity level of 21 spoor or 375 km, mean spoor frequency was 18.6 ± 2.8. At maximum sampling intensity of 923 km or 52 spoor, mean spoor frequency was 18.0 ± 2.8 (Figure 39).

Mean spoor frequency was higher in site 2 than site 1, therefore the sampling distance driven for accurate spoor frequency values was lower in site 2. However, in both sites the variance of spoor frequency estimates stabilised between 20 and 25 spoor samples (Figure 39).

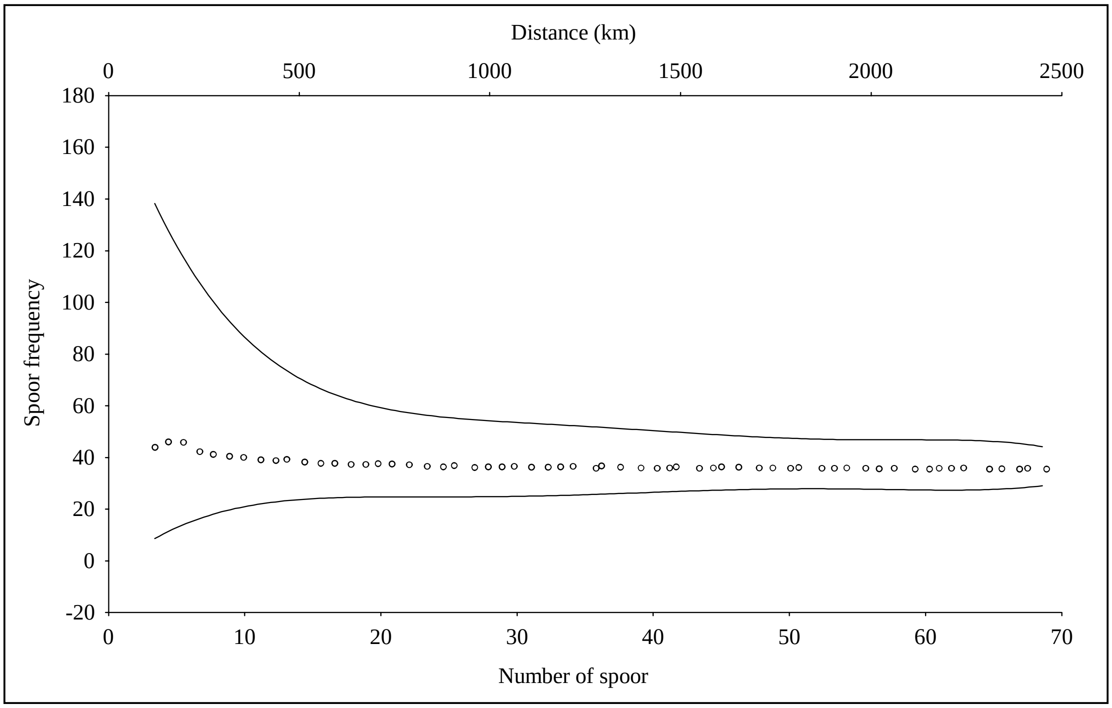


Figure 38. The relationship between spoor frequency (number of kilometres per spoor) and sampling effort in Site 1. Solid lines indicate 95% confidence intervals.

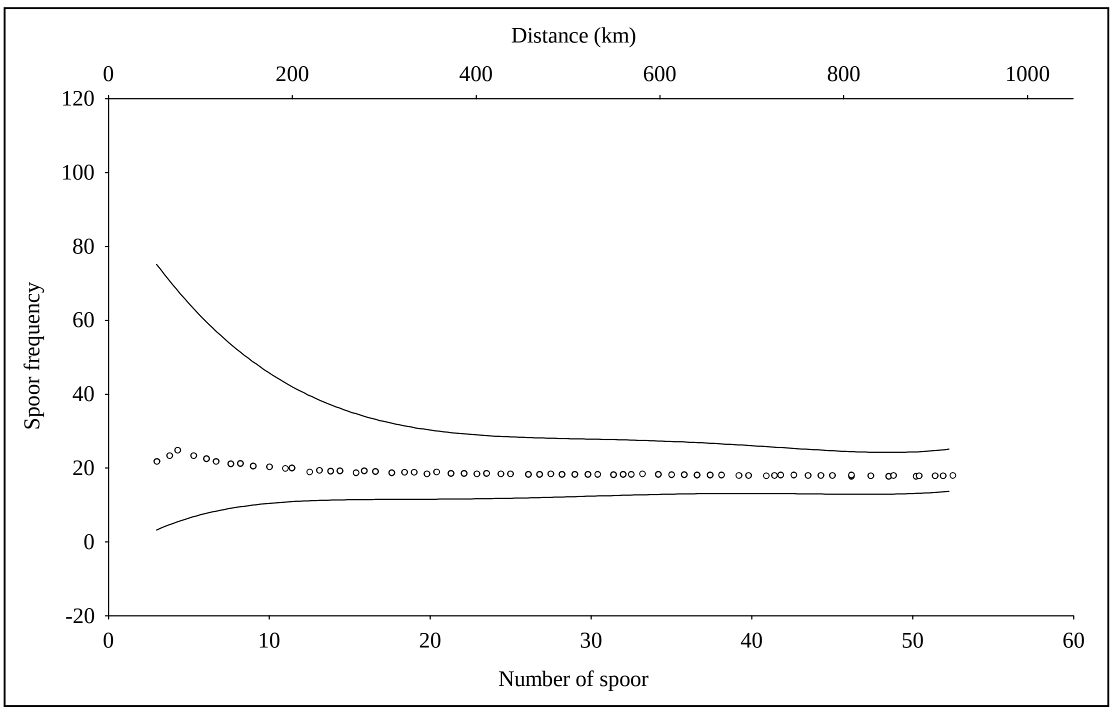


Figure 39. The relationship between spoor frequency (number of kilometres per spoor) and sampling effort in Site 2. Solid lines indicate 95% confidence intervals.

The precision of spoor count data was also considered in the sampling design. Precision, measured by coefficient of variance (SE as the percentage of the mean) was greatly increased with an initial increase in sample size. However, although precision continued to improve, the increase was reduced beyond 30 spoor samples in both sites. In site 2 an asymptote was reached at a sample size of 200, equivalent to 535 km or 30 spoor samples where coefficient of variance was 20.7% (Figure 40). At maximum sampling intensity of 341 samples the coefficient of variance was 15.7%, an increase in precision by 5%. In site 1, for a sample size of 405, equivalent to spoor sample of 30 or 1055 km, the coefficient of variance was 19.4% (Figure 41). At a sampling intensity equivalent to the maximum intensity for site 2, i.e. 52 spoor samples, the coefficient of variance was 15.5%. The coefficient of variance for maximum sampling intensity of 68 spoor samples in site 1 was 11.9%. The relationship between sampling effort, measured as the number of spoor samples, and the coefficient of variance, is very similar in both sites. Initially, precision in spoor count data is greatly increased, but this reduces with further effort at about roughly 30 spoor samples in both sites.

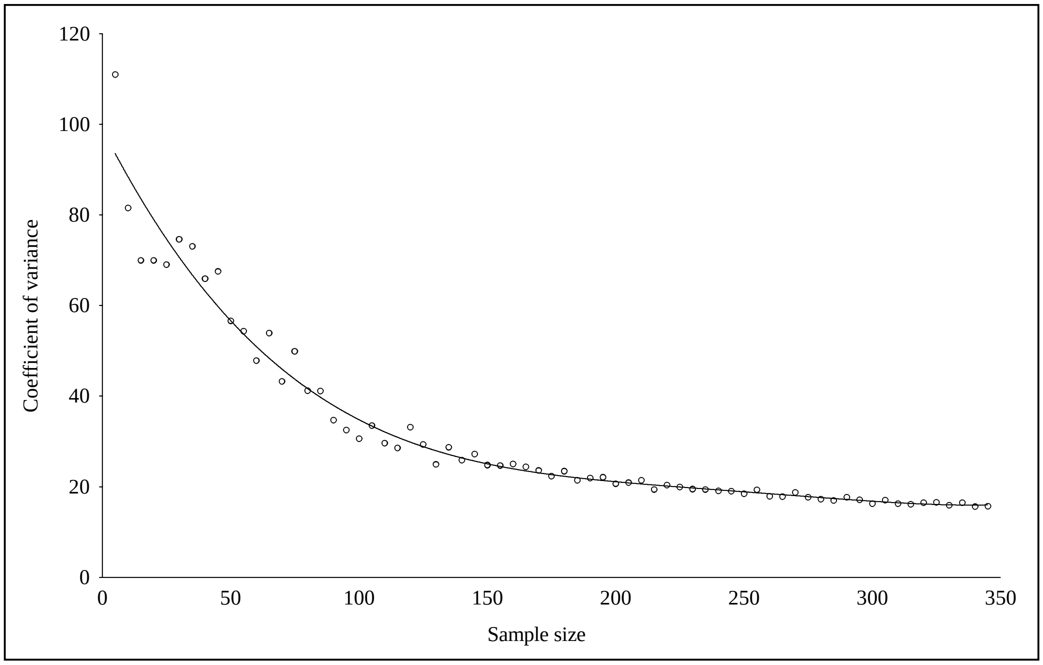
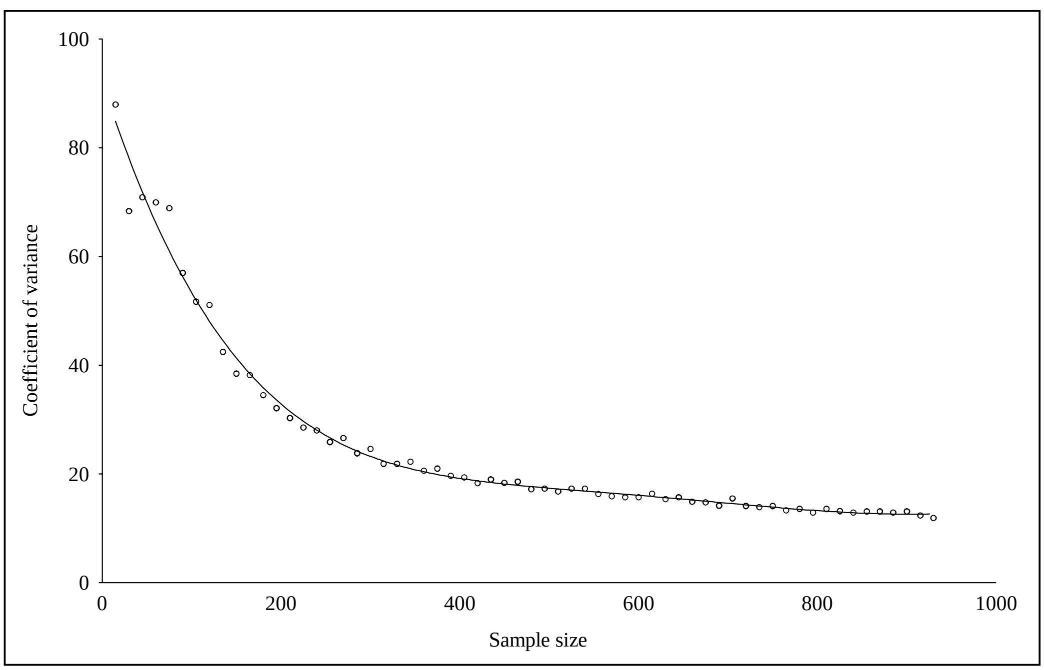


Figure 40. The relationship between sampling precision, measured by coefficient of variance (SE as a percentage of the mean), and increased sample size in site 2.



.**Figure 41.** The relationship between sampling precision, measured by coefficient of variance (SE as a percentage of the mean), and increased sample size in site 1.

CHAPTER 5: DISCUSSION

5.1 GENERAL DISCUSSION

The results indicate that differences in geology, topography and distance to water influence rhino density. The GIS successfully showed the relationship between these landform properties and differences in female home range and breeding performance across the Kunene range area (figure 35). With the increased availability of preferred browse species on the shallow slope habitats of the Kunene range (Hearn *et al.*, 2000) and lower distance to permanent springs in the basalt foothills, the hypothesis that the movement patterns of desert-dwelling rhino across the range are related to these resources, notably food and water, appears to hold.

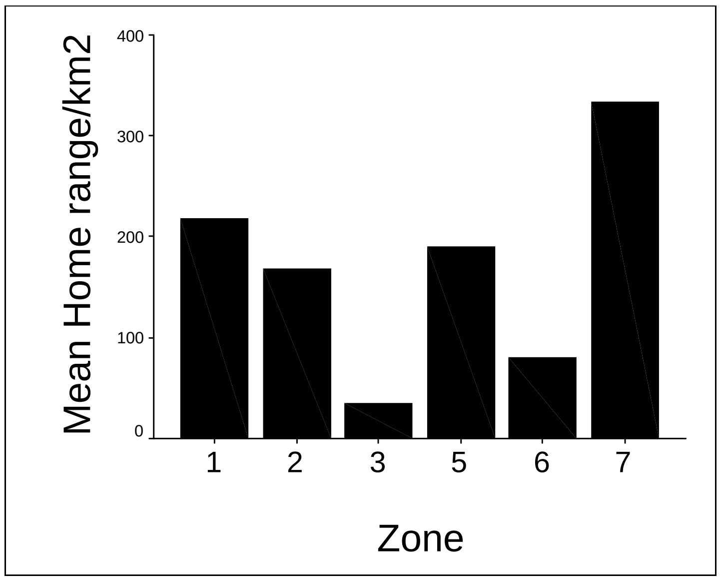


Figure 35a. Home range size, expressed in square kilometres, of adult females in zones across the range area.

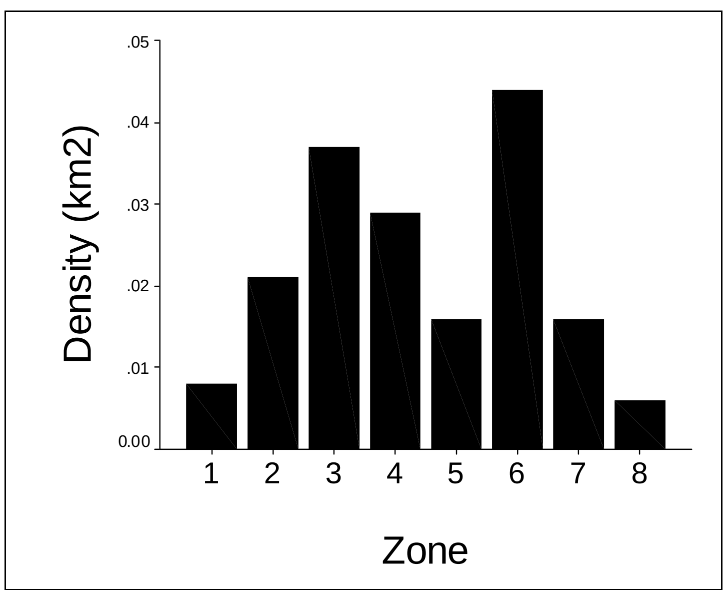


Figure 35b. Density of all adults and independent E class juveniles across the range area.

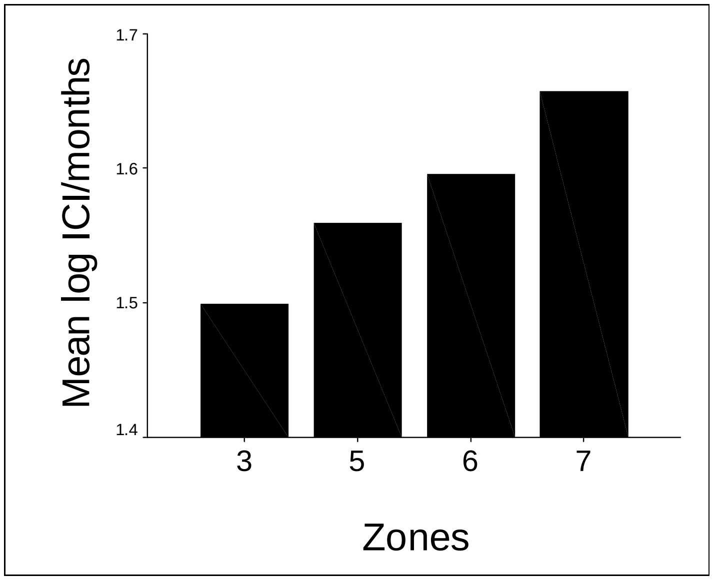


Figure 35c. Intercalf interval (ICI), expressed in months, across the range area.

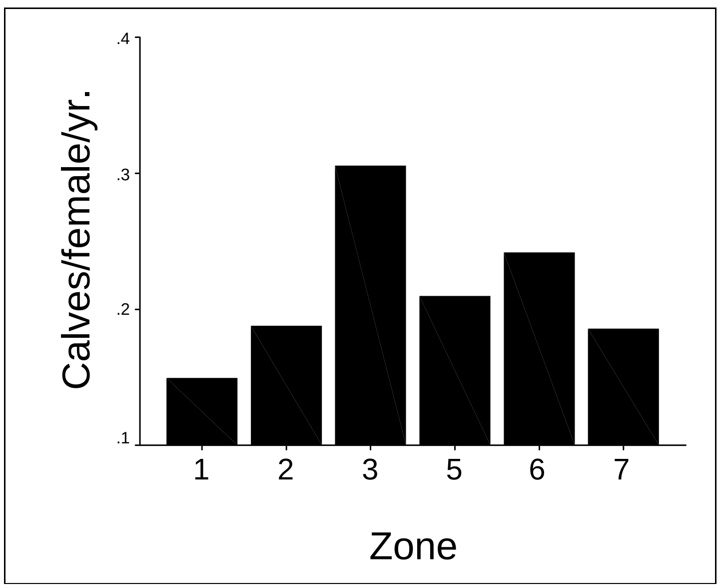


Figure 35d. Breeding performance across the range area, expresses as the calves per adult female per year.

Figure 35. Summary of the demographic properties of the Kunene range area (all data are derived from tables and figures in the results section).

Focusing on the core rhino areas – zones 3, 5, 6 and 7 – the home range of females was lowest in zones 3 and 6. The lower density of rhino in zones 5 and 7 (figure 35b), where the major habitat type was gravel plains (table 4), appears to be a result of the lower browse availability recorded in this habitat type (Hearn *et al.*, 2000). Figure 35c and 35d suggest that the necessary increased investment in resource uptake in this habitat type results in a higher inter-calf interval and reduced breeding performance. In addition, when comparing zones 3 and 6 the impact of higher density in zone 6 (figure 35b) resulted in an increase in inter-calf interval and reduced breeding performance (figure 35c and 35d).

The drafting of a suitability model, as part of the study, further investigated the interaction of density-dependent and density-independent factors when predicting black rhino ranging patterns. Here, using multivariate regression analysis, the interaction of habitat characteristics such as slope and aspect can be further explored in combination with other variables. The issue of spatial autocorrelation, where neighbouring points in the analysis are likely to share similar values and so are not independent (Koenig, 1999), further complicated the analysis of spatial data in predicting factors impacting rhino ranging patterns in Kunene during this study. Studies predicting human–elephant conflict in the Tsavo ecosystem (Smith and Kasiki, 2000), elephant conflict issues in the Mara ecosystem (Sitati *et al.*, 2003), and black rhino spatial patterns in the Masai Mara (Walpole *et al.*, 2003) have used modifications of the logistic regression methodology and adjustments to the resolution when analysing spatial data to minimise the impact of autocorrelation. These methods will be further investigated in future studies.

The conservancy design, where units of proprietorship and management are devolved to the land user, is inappropriate to meet the biological management needs of a widely dispersed, ‘fugitive’ mega-herbivore such as the black rhino. Though the theory of conservancy design is sound, the results of this study show some rhino range over as many as five different conservancies and the entire Kunene range covers some 12 different emerging and registered conservancies. Therefore the management for black rhino cannot be met solely by each individual land user/conservancy and wider biological management needs must dictate future priorities for rhino management that recognises the authority, accountability and responsibility of the land user/conservancy.

Recognition of the impact of HID throughout the conservancy land use planning process is vital when seeking to mitigate levels of disturbance on rhino in Kunene. These management plans must also ensure the successful implementation of biological meta-population goals for black rhino. Resources, both financial and ecological through appropriate land use planning, should be made available within conservancies to conserve this key source of revenue, in terms of black rhino as a unique tourism product. The success of the Damaraland Camp in the Torra Conservancy is an indication of how charismatic mega-fauna, along with the other unique aspects of Kunene’s landscape and people, can have a significant impact on improving local livelihoods.

The design of a spatial modelling framework will be a useful tool for understanding how fluctuations in the resource base impact rhino density and population performance. This will allow for a better understanding of the acceptable levels of offtake to ensure the continued growth and health of the Kunene population. This is in line with the recommendations by the Rhino Management Group for setting a percentage removal strategy (Goodman, 2001) for large populations, as opposed to estimating the Ecological Carrying Capacity (ECC).

The use of spoor frequency provides an interesting tool for monitoring in Kunene. This should provide a means of involving all those who have a stake in the survival of the rhino, whilst minimising any impact HID might have from increased monitoring levels. However, it must be stressed that to monitor health and growth of the population, there must be a focus on performance indicators that requires individual monitoring, by trained staff, in relation to actual population density, operating through the SRT, MET and conservancies.

5.2 USING GIS

5.2.1 Predicting habitat preference and performance

Density was highest in those grids closest to water and in the basalt foothills of the Kunene range area (Figure 9 and 10). Data presented in figures 6 and 7 indicate that, within this basalt region, rhino density decreases from east to west in response to the rainfall gradient. The *Euphorbia spp.* dominated basalt slopes were more favoured than the basalt plateau region, and the gravel plains had the lowest density within the basalt topographical region. Data from zones 2,3,5,6 and 7 show that home range size and breeding performance increases along a similar east west gradient (Figure 35a).

These results show that the use of a GIS does have great potential for understanding the factors predicting rhino occurrence and performance in the Kunene range area. Using a grid avoided the subjective pooling of data to compare presence and density of rhino across the range in relation to habitat types. This protocol is also recommended for defining boundaries of human elephant conflict (HEC), as any inconsistencies will strongly influence further analysis of the data (Smith and Kasiki, 2000). Issues of autocorrelation, where neighbouring 2x2 grids were not independent (Koenig, 1999), with the data of arid ranging patterns for rhinos were recognised and prevented further analysis of how breeding performance interacts with habitat in the Kunene range area. Methods to deal with this phenomenon can be incorporated into further studies that will compare the interrelationships that exist between habitat and breeding performance. This requires the Kunene range be divided up into a series of grid squares that are large enough to be spatially independent, while still building the key linear habitats, such as riparian vegetation, into the model.

5.2.2 Limitation of the GIS

Gathering spatial data was one of the most time consuming aspects of this project. Habitat data has recently become widely available with the Namibian Atlas Project launching a website to give access to a variety of spatial phenomenon that can be used to investigate impacts on rhino (e.g. cattle densities, human population concentrations and habitat characteristics). Future work can use these data, and recently acquired five metre resolution digital black and white aerial photographs, also a NASA website is releasing 30m resolution DEM data in 2005. This will allow for more detailed investigations in the future that can incorporate landform properties such as slope, aspect and the abundance of riparian vegetation.

The availability of GPS data on rhino sightings was inconsistent across the Kunene range area due to: the vast area the rhino inhabit, some 25,000km^2; the limited access, as a result of the rugged terrain; and, that some patrol teams do not have access to GPS receivers or batteries. The SRT, who provided the majority of the data, use various innovative means of patrolling the area, including the use of camels in the more mountainous regions to alleviate these compounding factors. However, areas with limited GPS data were evident, notably zones 2, 4 and 8. SRT's continued monitoring will allow further research to benefit from a larger data set, with fewer gaps in the availability of GPS data.

5.3 ECOLOGICAL CONSTRAINTS ON THE BLACK RHINO

5.3.1 The impact of density-dependent and density-independent factors

The importance of the rainfall in predicting breeding levels is clear from the analysis of data in Figures 17 and 18. The analysis of calving data and mean annual rainfall from two stations clearly displays a delayed population response, due to a gestation period of 15-16 months, as the availability and condition of browse is improved. The outliers in Figure 18 may have resulted from averaging the rainfall data across the Kunene range, when rainfall in the region is often localised and there is a high inter-seasonal variability in rainfall.

The performance indicators from zones 3 and 6 suggest density-dependent factors are impacting breeding. These two zones have similar rainfall patterns and habitat composition (*Euphorbia Spp.* dominated basalt foothills and plateau regions). Zone 3 has experienced greater poaching, notably in 1989 when six rhino were poached in one event (Figure 6). As a result of this action a dehorning operation by the MET was implemented with the goal of removing the horns of all animals in zones 2 and 3 to take away the incentive to poachers. During the operation 10 animals were also translocated from these zones and zone 4. Though in zone 4, where densities may have been reduced to critical levels that have limited performance, growth and indicators of optimum population performance in zone 3 have continued. In zone 6 breeding levels, e.g. calving intervals have increased over time resulting in reduced population performance.

5.3.2 Management implications

Figure 16 indicates a male bias in the population structure of 1.8:1 at the A-E class. This could have three important impacts on future management and security: increased fighting between males; "wandering" juvenile males moving into the communal farming areas; and, ultimately males out competing females for forage and reducing female condition, therefore impacting on the performance of the population. Comparing zones 3 and 6, the ratio of males to females is 0.67 and 1.18 respectively, indicating that density-dependent factors as well as a male bias could have major implications on future performance. This would be amplified should there be a drought in the region, resulting in a dramatic decline in breeding performance.

Currently, the MET has removed individuals from the population that persistently wander out of the current range area into communal and commercial farming areas. However, the emergence of conservancies, and traditional leaders support for investigations into the proclamation of parts of North-western Namibia, provide an opportunity to explore strategies that will meet the Rhino Action Plan goals for expansion of the Kunene range and increasing incentives for the support of black rhino conservation. This might allow the pioneering exploits of these wanders to be used to identify suitable areas for reintroduction, for example the Klip river in #Khoadi Hôas conservancy.

Estimating Ecological Carrying Capacity (ECC) is close to impossible due to the variable geology and its impact on soil development, the vegetation types and access to water. This is compounded further by the very low (<150mm per annum), unreliable and patchily distributed rainfall. Following a workshop of the Rhino Management Group, recommendations have been made for a proportional off-take approach to managing populations to alleviate the negative impacts on population growth associated overestimating ECC (see case studies in Emslie, 2001). Data presented appears to support the off-take approach as a management tool to ensure continued growth of the population. However, data presented here supports the conclusions that the arid conditions in the Kunene range require a more conservative off-take level that recognises the dramatic fluctuations in the resource base that can occur. Also, though examples of "wanderings" by both males and females into lower density areas or out of the range suggest these rhino may be good dispersers off-take levels should be set that consider local densities of sub-populations.

5.4 HID IN KUNENE AND ERONGO REGIONS

5.4.1 Introduction

The interpretation of comparative data between zones in the Kunene range area under varying degrees of disturbance is difficult due to variations in the disturbed area often being compounded by other factors. These include the variable geology and its impact on vegetation; topographical features; and, varying densities of other wildlife species competing for browse.

5.4.2 Management implications

If human disturbance has a potential effect on population performance, then this must be treated as a conservation concern and actions be taken accordingly. Rhinos in this area occur at very low density and rarely encounter people, therefore they are likely to react strongly to human activities. HID has been shown to lead to site abandonment in the Kunene range (Berger and Cunningham, 1995) and hence could have significant effects on this population. Thus deriving measures and indicators of HID are priorities. However, human activities that may affect rhino in this area, such as tourism, livestock grazing and consumptive wildlife use provide a valuable source of income for local communities.

The assessment of the levels and impact of traffic passing through the Kunene range area, Figure 25, clearly indicates some entry points are used more than others. Zone 1 appears to be under the greatest use in terms of the number and levels of use. This is for a variety of reason, including: the area's scenic landscape; the presence of a popular National Monument, Twyfelfontein; and, easy access from the town of Swakopmund, a major tourism destination in Namibia, and Uis (figure 21) making it a popular destination for self-drive tourists and guided camping tours. High levels of traffic have been recorded in Zone 1 of the range area (Figure 23 and 24). Zone 1 has also experienced large numbers of calf mortalities (Table 7) with calving levels already the lowest across the range (Figure 35d). Also, zone 1 has some of the largest home ranges (Figure 35a) recorded in the Kunene range area and poor access to permanent water (Figure 7 and 8). Linking the calf mortalities to the level of traffic is not possible. However, any impact it has would be amplified due to the high ecological stress this sub-population area is under.

For each area priority sites were identified to regulate access (Figure 26) based on minimising the impact across the Kunene range to mitigating levels of disturbance, within acceptable limits to meet both security needs, and future development needs, while ensuring HID does not impact on growth of the black rhino population.

5.4.3 In conclusion

The rhino of North-western Namibia are an important population in conservation terms; they also provide a major draw to potential visitors to the area. If tourism activities in this area are to provide maximum ongoing benefit to local communities, it is vital that they do not negatively impact upon the rhino population. As well as the need to ensure regional buy-in of biological management plan goals, it is equally important that communities view rhino as an asset and not a competitor for other land-use practices. Integrated land use planning, incorporating sustainable tourism activities, can provide the appropriate vehicle to achieve this.

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5.5 THE USE OF SPOOR AS A MONITORING TOOL

5.5.1 Rhino density

For the spoor frequency study density in the two sites used was estimated at 0.019 km^{-2}. This is slightly above the expected optimal density for the Kunene range area, which is thought shouldn't exceed 0.015 km^{-2} (MET, 1997; Brett, 1997). Rhino density estimates, made using minimum convex polygons, were highest in the buffer zone closest to water and decreased with increasing distance from water. The high level of rhino density in these areas is understandable given resource availability in terms of browse and water.

5.5.2 Spoor density

For the two sites spoor density was also highest closest to water and reduced in buffer zones of increasing distance from water. This is significantly related to the density of rhinos in these zones and potentially related to movement patterns. Spoor counts are known to be influenced by habitat utilisation, with higher spoor frequency in preferred habitat types (Smallwood and Fitzhugh, 1995; Stander, 1998). This suggests that rhino movements in the area are associated with riverine habitat. An earlier study in this region found that rhino home ranges were "umbrella" shaped as rhino move to water along the westerly-flowing ephemeral riverbeds (Joubert and Eloff, 1971). Tatman *et al.* (2000) also found the highest levels of spoor and other signs of rhino presence in riverine environment in a fenced rhino sanctuary in Kenya.

The hypothesis that there is a relationship between spoor density and rhino density was found to be true. Spoor counts, sampled at increasing distance from perennial water points, were correlated to rhino density. Spoor was non-randomly distributed on roads due to the diverse environment, which complicated interpretation of the relationship between spoor and rhino density. However, the relationship between rhino density and spoor density is strengthened when spoor counts are taken from the linear riverine habitats only.

5.5.3 Limitations

Using minimum convex polygons of home ranges, a correlation between spoor density and rhino density was determined and was strongest when only spoor found in riverine habitat was used. However, the ability of this technique to detect changes in population size cannot be tested. It is not known how black rhino home ranges in this area vary over time in relation to increases or decreases in density. Therefore, it is not possible to predict how home range or spoor counts would change with a change in density or to test the ability of spoor count techniques to detect this change. If understanding of rhino habitat utilisation and factors controlling home ranges is increased, it may be possible to model related effects on spoor counts.

Seasonality is likely to have a major influence on the distribution of spoor and home range size (Joubert and Eloff, 1971). Water availability in this area changes throughout the year, with a higher number of temporary water points available during the wet season. There are also associated changes in resource availability in terms of available browse. The suitability of the substrate for detecting spoor may also alter during the wet season.

The relationship between spoor density and estimated rhino density does exist for this population, occurring at a very low density in an arid environment with low water availability. This technique may also be valid for other species in the area for which a direct measure of density can be calculated.

5.5.4 Sampling effort

For both study sites used in the study of spoor frequency the level of road penetration and the minimum distance required to obtain data with least variance was the same. The level of sampling effort required in this study was determined at roughly 30 spoor samples. This is equivalent to an average of 15 days sampling. These results are very similar to those of Stander (1998) who used a spoor count method to produce an index for density of leopards (*Panthera pardus*), lions (*Panthera leo*), and wild dogs (*Lycaon pictus*) in a semi-arid environment.

5.5.5 The role of human disturbance in the application of this method

Berger and Cunningham (1995) found that spoor frequency detected on roads was reduced relative to the amount of time spent using an individual recognition-based tracking technique and setting up a base camp in the area. Following disturbance, individuals were forced into sub-optimal habitats (Berger and Cunningham, 1995). Displacement of animals from their preferred habitat to less profitable environments could have important consequences on individual fitness affecting body condition and, hence, survival and fecundity (Duschesne *et al.*, 2000). The presence of a research vehicle driving the tracks looking for spoor was not found to effect the level of spoor frequency detected. This is as expected, as data collection occurred during the day and the majority of rhino movement in the area occurs at dusk and dawn (Joubert and Eloff, 1971). This suggests that a technique based on spoor counts could be used in addition to current individual recognition-based methods, without causing increased disturbance to the population.

The current, individual-based monitoring technique plays an essential role in research, providing vital information on physical condition, behaviour, estimated birth date of calves, weaning dates of immature individuals and feeding preferences (Loutit *et al.*, 1987; Hearn *et al.*, 2000). An indirect sampling technique could not replace individual-based recognition monitoring. Nevertheless, additional low impact methods could be advantageous to limit the potential effects of HID. The study quantifies the relationship between an indirect sampling technique (spoor counts) and a direct sampling method (individual sightings). A better understand of the relationship between indirect and direct techniques reviewed by Eberhardt and Simmons (1987) recommend double sampling to calibrate and improve the reliability of cheaper indirect sampling techniques (Eberhardt and Simmons, 1987).

CHAPTER 6: RECOMMENDATIONS

6.1 IN SUPPORT OF NAMIBIAN RHINO ACTION PLAN GOALS

6.1.1 Stakeholder participation

Land-use in North-western Namibia spans many sectors: the private commercial tour operators on concessions; community tourism enterprises in the form of campsites; conservancies; traditional authorities representing the wider land-use practices of communities; NGO's involved in the development of conservancies and conservation programmes; and, government, both MET and other line ministries. Strengthening organisational ties across these sectors is a key short term priority. Each sector should nominate a representative to sit in on any RTAG meeting in the region and identify a mechanism to feedback information to the sector they represent.

6.1.2 Land-use planning and access

Appropriate land-use planning by conservancies, and within concessions, needs to take into account the spatial factors impacting distribution and performance of the black rhino as is highlighted in this study. This will allow the successful recovery of black rhinos to continue, and maximise benefits to communities beyond small "pockets" of benefit in the communities or conservancies in areas where population performance remains good.

Regulating access to the Kunene range area, and finding acceptable levels of tolerance for rhinos, are key priorities. This requires a programme be implemented to give input on rhino ecological and security needs at the local level during the ongoing conservancy management planning process. This also needs to be done at the regional level, through the MET's Directorate of Tourism's North-west Tourism Plan and the Directorate of Parks and Wildlife's proposed feasibility study for strengthening conservancy land tenure rights through the proclamation of a multi-use IUCN Category VI Protected Area in the northwest.

6.2 KEY FOLLOW UP ACTIVITIES FROM THIS STUDY

6.2.1 Short-term outputs from this study

Outputs of this programme should involve the following:

- first, the hosting of a workshop to devolve the findings of this study to traditional authorities and conservancy bodies to ensure regional by-in of biological management goals for the Kunene population of black rhino;
- second, assist with the design and development of mechanisms to regulate access into the rhino area in concession areas and registered conservancies identified by the feasibility study;
- third, implement a study to quantify tourism impacts on rhino to mitigate some of the problems associated with access without removing opportunities for development.

Research programmes to be implemented in support of these priorities are as follows:

- A social survey be undertaken of community perceptions towards rhino involving; those in close proximity, sharing access to resources (browse competition with domestic livestock); people involved in the management/monitoring of wildlife (including rhino); and, community members involved institutionally in wildlife and land use development (traditional authorities and conservancy committees).
- An assessment of habitat suitability in the historical and present range should be undertaken to allow for expansion of the range and stocking levels to be determined for the current range. This should use the spatial modelling framework developed as

an output of this programme to classify terrestrial habitats based on the predicted ecological needs of black rhinos.

- Continued emphasis should be placed on long-term monitoring by rangers to determine the population performance indicators to ensure improved data on individual rhino is available for analysis. This requires an initial focus on capturing positional data for rhino in zones 2, 4 and 8 (Figure 11).
- The study quantifying tourism impacts on rhino should examine the extent to which the current population is under impact from monitoring, tourism and other forms of HID. This study could make use of the ongoing activities of the SRT, and use methods from previous studies in India (Lott and McCoy, 1995) to quantify these impacts and make recommendations to control access into the current range. The study should include recording flight distances of other wildlife to quantify broader HID impacts on biodiversity.

6.2.2 Medium term outputs from this study

Medium term goals must deal with the following priorities:

- first, the training of local Namibian monitoring co-ordinators to ensure a sustainable monitoring programme is in place;
- second, considering that this study indicates density-dependent factors currently limit growth in the optimal habitat (Zone 6) a translocation programme is recommended as an intervention strategy with a view to determining acceptable levels of off-take that maximise optimal growth. To do this **the removal of at least ten animals from areas with the highest density of animals, e.g. the mountains area of the Palmwag concession - revised zone 6, is strongly advised**. Monitoring distribution and breeding following the offtake is essential to developing an adaptive management regime sensitive to the arid conditions and the observed dramatic fluctuations between seasons of the resource base; and,
- third, managing the densities of other browsers and habitat management should be considered.

6.2.3 Long term outputs from this study

This population of black rhino is one of four remaining unreconstructed populations of black rhino left in the world. Only the Masia Mara in Kenya, Hluwlewe and Umfolozi in South Africa and a small scattered population in Camaroon have indigenous populations that have never required reintroduction of animals. Therefore, the reintroduction of animals from other metapopulations in the country into areas of the northwest experiencing poor breeding is not advised so as to maintain the genetic and economic value.

Long term management intervention strategies to meet national action plan goals should recognise the following:

- First, any implemented translocation programme should be conducted with the full involvement of communal conservancies. Prior to considering sites for reintroduction guidelines or protocol need to be developed to prioritise allocation - e.g. to those areas identified from studies of: habitat suitability; historical distribution; and, where communities are willing to invest in rhino management using local institutes. When considering sites for reintroduction of rhino removed from the Kunene population, priority should be given to suitable sites within the historical range of black rhino in the northwest.
- Second, future protocol for monitoring this population should be built on the existing programme implemented by the NGO Save the Rhino Trust (SRT), who acts as a support service to MET and conservancies in the area. In conservancies where direct monitoring of rhino will take place, or tourism involving rhino tracking will occur,

training should be provided by SRT and once completed monitoring activities should be undertaken by the conservancy.

- Third, the goal for any further training and research activities should be to develop a code of practice for viewing rhino that is adopted by tour operators and includes self-policing by the private sector in partnership with communities. This has parallels with the monitoring of cetaceans – dolphin/whale watching – and will ensure sites for reintroduction could also be chosen on not only ecological criteria.
- Last, with this in mind, more formal liaison and communication between conservancies, tour operators, MET and SRT fieldstaff would be necessary to centralise the collation and analysis of monitoring data.

This project has successful highlighted some of key ecological needs to reconcile goals for both black rhino conservation and development in the region. For these to be successfully implemented the strengthening of community ties within the programme should be considered to allow formal participation of traditional leaders and registered conservancies in the management of black rhino in the region. In the last year the development of the MET's Rhino Technical Advisory Committee (RTAG) is seen as a positive step in this direction. Co-opting conservancy and community input on this committee will go a long way to the recognition of the community's stake in the survival of the black rhino in the region.

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