Movements of elephants in the Selous-Niassa-Wildlife Corridor, southern Tanzania

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Distribution and Movements of Elephants and other Wildlife in the Selous-Niassa Wildlife Corridor, Tanzania

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Preface

Tropical ecosystems are the life-sustaining basis for the majority of the Earth's human population. Their mounting destruction and degradation, especially in the so-called developing countries, is jeopardizing efforts to attain sustainable development and effectively alleviate poverty.

Within the German development cooperation the Tropical Ecology Support Program (TOEB) has provided targeted support to research on tropical ecology. It has thus contributed to more effective processing, evaluation and implementation of the knowledge and experience gained on these issues.

Until 2001 TOEB was a project providing its services on a supraregional basis, implemented by Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH on behalf of the German Federal Ministry for Economic Cooperation and Development (BMZ).

The Program supported more than 180 back-up studies on tropical ecology issues which further developed concepts to conserve and sustainably use tropical ecosystems. In addition, it was possible to derive innovative tools for environmentally-sound development cooperation. Following termination of the Program's active phase, 19 projects will continue to be backed up until their results have been published.

It was pivotal to the design of the Program that German and partner country scientists worked jointly on applications-oriented issues. TOEB thus also made an important contribution to the practical upgrading of counterparts and to the establishment of tropical ecology expertise in partner countries.

Through its publication series, TOEB makes accessible to an interested public the findings and recommendations for action that derive from its back-up studies.

We are pleased to present to you the results of our latest research project with this publication

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We are very grateful to K. Wilhelm and S. Schütte (IZW, Berlin,Germany) for their invaluable technical assistance in the production of this publication.

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Abbreviations

CBC	Community Based Conservation
CBCTC	Community Based Conservation Training Centre
CWM	Community Wildlife Management
DRDP	District Rural Development Programme
GIS	Geographical Information System
GTZ	German Agency for Technical Cooperation
IZW	Institute for Zoo and Wildlife Research, Berlin, Germany
MCP	Minimum Convex Polygon (to determine a home range)
SCP	Selous Conservation Programme
SNWC	Selous-Niassa Wildlife Corridor
SODA	Songea Development Action (predecessor of Songea DRDP)
SUA	Sokoine University of Agriculture, Morogoro, Tanzania
TAWIRI	Tanzania Wildlife Research Institute, Arusha, Tanzania
VDO	Village Development Officer
VEO	Village Executive Officer
WMA	Wildlife Management Area (on village land)

Executive Summary

- This study assessed the status and importance of the Selous Niassa Wildlife Corridor (SNWC) in southern Tanzania as a conservation area and biological corridor for wildlife, principally the African elephant (*Loxodonta africana*) and other key wildlife species. To this end we investigated the distribution and movements of elephants and other wildlife species, their population structure and population size. With a view to identify key conservation and development issues, we also assessed the relationship between people and wildlife, in particular potential sources of conflict, local knowledge about and attitudes towards wildlife. The data were derived from a novel combination of local knowledge of wildlife, own field observations, and advanced technology including satellite-based location and tracking of radio-collared individual elephants. The present study also evaluated the data collected by village game scouts (VGS) to assess their potential and effectiveness as a low cost monitoring system for the number, distribution and population structure of elephants. The study was conducted between July 2000 and December 2002.

- Biogeographically, the SNWC is part of the extensive miombo woodland system of eastern and southern Africa. Scientifically, it belongs to a habitat type of important conservation value about which relatively little is known. Census results and distribution records suggest that the SNWC should be viewed as an internationally important wildlife conservation area, and as a biologically important corridor, linking globally significant populations of Roosevelt's sable antelope (*Hippotragus niger roosevelti*), Liechtenstein's hartebeest (*Alcelaphus*

buselaphus lichtensteinii), Nyassa wildebeest (*Connochaetes taurinus johnstoni*), eland (*Taurotragus oryx*) and greater kudu (*Tragelaphus strepsiceros*) and other wildlife and plantlife in the Selous Game Reserve and ecosystem in Tanzania with the Niassa Game Reserve and ecosystem in Mozambique.

- The SNWC is home to at least 2,400 African elephants and a globally significant population of at least 4,460 Roosevelt's sable antelope. The SNWC contains a number of well established, traditional movement routes for elephants that are still utilised by them, and numerous forest, bushed grassland, woodland and wetland areas that are important seasonal or year-round refuge habitats for elephants and other wildlife species. Elephants were present throughout the Corridor. Roosevelt's sable antelope, eland and greater kudu were also widespread. African wild dogs (*Lycaon pictus*) occurred on a seasonal basis, yet when present were widespread throughout the southern section of the Corridor, emphasizing the value of the Corridor for seasonal key migratory species. However, there is also some evidence that wildlife populations have experienced declines. Liechtenstein's hartebeest had a fragmented distribution, and there is currently no positive evidence that Niassa wildebeest are still present in the Corridor.

- To understand the long-term population development of elephants and other wildlife in the SNWC, continuous ecological monitoring is advisable. However, a large proportion of this area is outside the priority census zone and not regularly surveyed. Thus, the development of a simple, yet effective, low cost and sustainable monitoring system is essential for an assessment of the population structure and dynamics of elephants and other wild animals. Data collected by village game scouts (VGS) on the number, distribution and population structure of elephants based on elephant groups encountered in the field were considered as such a potential monitoring system. The VGS data fairly described the presence, distribution and population structure of elephants on different village lands. The data on their own were, however, not sufficient for an accurate estimate of elephant numbers. A protocol is recommended that combines direct field observations from encounters with elephant groups with regular dung counts along permanent transects by VGS during their routine anti-poaching patrol.

- Data on factors reducing the yield of agricultural crops were obtained from governmental records and interviews with local people and assessed for Songea Rural (Namtumbo) District, an area that includes the western part of the SNWC. Crop damage attributed to wildlife was claimed to be a common cause of significant reduction of crop yield. Crop damage caused by wild animals was claimed to occur throughout the year. Several wildlife species were considered to be involved. Interviewed people and governmental records reported damage by elephants, hippo (*Hippopotamus amphibius*), buffalo (*Syncerus caffer*) and sable antelope. In contrast to these claims, analysis of reports on the extent of crop damage attributed to each species and data from satellite-based tracking of radio-collared elephants indicated that only a small proportion of crop damage could be attributed to elephants.

- Crop production would be increased if more efforts towards preventing crop damage were focused on the control of weeds, crop diseases and "small pest species" such as rodents or birds. Where possible, alternative methods of dealing with crop-raiding elephants and other large wildlife species should be put into practise to ensure the protection of elephants in this part of Tanzania. With a reduction in poaching owing to the improvement of anti-poaching surveillance in the Selous Game Reserve and the surrounding buffer zones at the northern end of the Corridor and the increase in the population of people in this area, conflicts between people and elephants and other animals are likely to increase. In order to minimize conflicts between people, elephants and other wildlife in future, comprehensive conservation strategies that take into account both conservation and people-focused perspectives, in line with current Tanzanian wildlife policy, need to be implemented.

- The distribution and movements of elephants were assessed by ground-based census and satellite-based telemetry of radio-collared elephants. Three major movement routes from the Ruvuma river and the border between Tanzania and Mozambique at the southern end of the SNWC, to the centre of the Corridor and four other routes from the centre of the Corridor towards the north were identified. Satellite-based tracking and field observations confirmed that elephants used these routes for their movements, ultimately connecting the Ruvuma River with the Selous Game Reserve at the northern end of the Corridor. Local people knew the major elephant movement routes that were revealed by satellite-based tracking.

- Data from satellite-based tracking were used to determine habitat preferences and home ranges and to trace movements across international borders. Ten radio-collared elephants (2 cows and 8 bulls) were tracked for periods from 8 to 24 months. During both dry and wet season, elephants significantly preferred forests, bushed grasslands and riverine areas and avoided cultivated areas. During the dry season, elephants also preferred woodland; during the wet season they also avoided swamps. Home range sizes varied between 328 and 6,905 km^2. Observed home range sizes fell into three groups: small home ranges (328 to 576 km^2), medium home ranges (1494 to 3,135 km^2) and large home ranges (from 4,421 to 6,905 km^2). Elephants with small home ranges spent their time mostly in areas between the Selous Game Reserve and the adjoining buffer zone at the northern end of the Corridor. Elephants with medium sized home ranges stayed in the central areas of the SNWC and occasionally visited Sasawala Forestry Reserve. Elephants with large home ranges moved across the central and southern sections of the SNWC, with extensive movements between Tanzania and Mozambique, and within Mozambique. Extensive movements of elephants were reported by local interviewees to occur in the months of March and April and June and December. Satellite tracking however showed extensive movements to occur during November and December and limited mobility between March and May. Food, access to water and possibly repeated contact with people in some localities are considered to be factors likely to influence elephant movements.

- Data from ground-based observations and satellite-based telemetry confirmed that elephants frequently moved across the international border between Tanzania and Mozambique along the Ruvuma River. These data support the importance of protecting the SNWC as an important elephant range and corridor, linking two of the largest protected areas in Africa, the Selous and Niassa Game Reserves in Tanzania and Mozambique, respectively.

Zusammenfassung

- Diese Studie bewertet den Status und die Bedeutung des Selous-Niassa-Wildtier-Korridors (SNWC) in Südtansania als Naturschutzgebiet und als biologischen Korridor für Wildtiere, hauptsächlich für den afrikanischen Elefanten (*Loxodonta africana*) und anderer Schlüsselarten. Zu diesem Zweck untersuchten wir die Verbreitung und die Raumnutzung der Elefanten und anderer Wildtierarten, ihre Populationsstruktur und -größe. Um die Brennpunktthemen für Naturschutz und Entwicklungsvorhaben im Korridor herauszuarbeiten, ermittelten wir die Beziehung zwischen der lokalen Bevölkerung und Wildtieren, insbesondere potentielle Konfliktquellen, das lokale Wissen über Wildtiere und die Haltung gegenüber Wildtieren. Die Daten wurden mit Hilfe eines neuartigen Forschungsansatzes erhoben, bei dem wir die Ermittlung des örtlichen Wissens über Wildtiere, mit eigenen Feldbeobachtungen und dem Einsatz von hochentwickelter, Satelliten-unterstützter Telemetrie zur Ortung von Elefanten kombiniert, die mit einem Halsbandsender versehen waren. Die vorliegende Untersuchung wertete auch Daten aus, die von dörflichen Wildhütern gesammelt wurden, um das Potential und die Effektivität dieser Daten als preisgünstige, nachhaltige Überwachungsmethode zur Ermittlung der Anzahl, Verbreitung und Populationsstruktur von Elefanten zu nutzen. Die Studie wurde zwischen Juli 2000 und Dezember 2002 durchgeführt.

- Der SNWC ist biogeographisch ein Teil des umfangreichen Miombo Waldsystems von Ost- und Südafrika. Wissenschaftlich gehört es zu einem natürlichen Lebensraum, dessen Erhaltung von großem Wert und über den relativ wenig bekannt ist. Ergebnisse der Zählungen und

Verbreitungsdaten unterstreichen, dass der SNWC als international bedeutendes Tierschutzgebiet und als biologisch bedeutender Korridor angesehen werden sollte, der global bedeutende Populationen der Roosevelts Rappenantilope (*Hippotragus niger roosevelti*), Liechtensteins Kuhantilope (*Alcelaphus buselaphus lichtensteinii*), Nyassa Gnu (*Connochaetes taurinus johnstoni*), Elenantilope (*Taurotragus oryx*) und Großkudu (*Tragelaphus strepsiceros*) und anderer Wildtiere und Pflanzen im Selous-Wildtier-Reservat und Ökosystem von Tansania mit dem Niassa-Wildtier-Reserrvat und Ökosystem von Mosambik verbindet.

- Der SNWC ist die Heimat von mindestens 2.400 Afrikanischen Elefanten und einer global bedeutenden Population von mindestens 4.460 Roosevelt Rappenantilopen. Der SNWC verfügt über eine Anzahl gut etablierter traditioneller Wanderrouten für Elefanten, die aktiv genutzt werden, zahlreiche Miombo-Waldgebiete, Galeriewälder und Sumpfland, die entweder saisonal oder ganzjährig wichtige Rückzugsgebiete für Elefanten und andere Wildtierarten darstellen. Elefanten wurden überall im Korridor angetroffen. Roosevelt Rappenantilopen und Kudus waren ebenfalls weit verbreitet. Roosevelt Rappenantilopen, Elenantilope und Großkudu waren ebenfalls weit verbreitet. Afrikanische Wildehunde (*Lycaon pictus*) erschienen jahreszeitlich bedingt, waren dann aber im Süden des Korridors weit verbreitet. Dies unterstreicht die Bedeutung des Korridors für Tiere, die saisonal den Korridor als Lebensraum beanspruchen. Es gibt allerdings auch Anzeichen dafür, dass einige Wildtierpopulationen einen Rückgang erfahren mussten. Die Lichtenstein Kuhantilope hat eine fragmentierte, örtlich stark eingegrenzte Verbreitung. Gegenwärtig gibt es keine Hinweise, dass das Nyassa Gnu noch im Korridor existiert.

- Um die langfristige Populationsentwicklung von Elefanten und anderen Wildtierarten im SNWC verstehen zu können, ist eine fortlaufende ökologische Überwachung (Monitoring) ratsam. Jedoch liegt ein großer Teil des Korridors außerhalb des Schwerpunktgebietes, indem regelmäßig Tierzählungen durchgeführt werden. Daher ist die Entwicklung eines einfachen, effektiven, kostengünstigen und nachhaltigen Überwachungssystems für die Bewertung der Populationsstruktur und -dynamik von Elefanten und anderen Wildtieren dringend erforderlich. Daten, die von dörflichen Wildhütern bezüglich der Anzahl, Verbreitung und Populationsstruktur von Elefanten an Hand von Feldbeobachtungen erhoben hatten, wurden für ein solches mögliches Überwachungssystem in Betracht gezogen. Diese Daten dokumentieren in angemessener Form die An- oder Abwesenheit und die Populationsstruktur von Elefanten in den dörflich verwalteten Gebieten. Für eine genaue Schätzung der Anzahlen waren diese Daten aber nicht nützlich. Wir empfehlen ein Datenerhebungsprotokoll, bei dem die Auswertung direkter Feldbeobachtungen von Elefantengruppen mit Dungzählungen kombiniert werden, die regelmäßig entlang festgelegter Zählrouten (transects) von den Wildhütern bei ihren Routinepatrouillen durchgeführt werden könnten.

- Daten über Verluste bei Feldfrüchten wurden aus Regierungsunterlagen und aus Interviews mit Einheimischen erhoben. Sie wurden für den Verwaltungsbezirk Songea Rural ausgewertet, der den westlichen Teil des SNWC mit einschließt. Wildtiere wurden häufig für substantielle Ernteschäden verantwortlich gemacht, die das ganze Jahr über auftreten könnten. Verschiedene Wildtierarten seien daran beteiligt.

- Interviewergebnisse und Regierungsunterlagen stellten fest, dass der Schaden durch Elefanten, Flusspferde, Büffel und Rappenantilopen verursacht würde. Im Gegensatz zu diesen Behauptungen belegten die quantitative Analyse der Regierungsunterlagen und die Ergebnisse der Satelliten-unterstützten Telemetrie, dass Elefanten sehr wenig beteiligt sind.

- Die Ernte könnte gesteigert werden, wenn sich die Bemühungen auf die Vermeidung von Unkraut, Abwehr von Krankheiten oder Schutz vor kleinen Schädlingen (Nagetiere oder Vögel) konzentrieren würden. Soweit dies möglich ist, sollten alternative Methoden im Umgang mit Schadens-verursachenden Elefanten und anderen großen Wildtierarten praktiziert werden, um den Schutz der Elefanten in diesem Teil von Tansania zu ermöglichen. Wenn sich die Elefantenpopulation erholt, weil die Wilderei durch die Verbesserung der Anti-Wilderei-Überwachung im Selous-Wildtier-Reservat und der umgebenden Pufferzonen an der nördlichen Grenze des Korridors zurückgeht, und gleichzeitig die Bevölkerung in diesem Gebiet wächst, werden zukünftig vermehrt Konflikte zwischen Menschen und Elefanten und anderen Tieren auftreten. Um solche Konflikte in Zukunft zu minimieren, müssen in Übereinstimmung mit der nationalen tansanischen Politik umfassende Schutzstrategien durchgeführt werden, bei denen die Belange und Interessen von Mensch und Tier berücksichtigt werden.

- Die Verbreitung und Raumnutzung von Elefanten wurden auf der Grundlage von Bodenzählungen und der Satelliten-unterstützten Telemetrie von besenderten Elefanten analysiert. Wir fanden drei große Wanderrouten vom Ruvuma-Fluss, der Grenze zwischen Tansania und

Mosambik an der südlichen Grenze des SNWC, zum Zentrum des Korridors und vier weitere Routen vom Zentrum des Korridors in Richtung Norden. Die Satelliten-unterstützte Telemetrie und Feldbeobachtungen bestätigten, dass die Elefanten diese Routen für ihre Ortsbewegungen nutzten und dabei letztlich den Ruvuma-Fluss mit dem Selous-Wildtier-Reservat im Norden verknüpften. Die wichtigen Wanderrouten, die die besenderten Elfanten nutzten, wurden korrekt durch Einheimische vorhergesagt.

- Die Ergebnisse der Satelliten-unterstützten Telemetrie wurden auch eingesetzt, um Habitatpräferenzen und Streifgebiete zu bestimmen und Ortsbewegungen über die internationale Grenze zu verfolgen. Zehn „besenderte“ Elefanten (2 Kühe und 8 Bullen) wurden in einem Zeitraum von 8 bis 24 Monaten telemetriert. Während beider Jahreszeiten (Trocken- und Regenzeit) bevorzugten Elefanten signifikant Galeriewälder, verbuschtes Grasland und Flussgebiete. Sie vermieden eindeutig Ackerbaugebiete. Während der Trockenzeit bevorzugten die Elefanten auch Miombo-Waldgebiete; während der Regenzeit vermieden sie außerdem Sumpfgebiete. Die Größen der Streifgebiete variierten zwischen 328 und 6.905 km². Die Größe der Streifgebiete können aufgrund in drei Klassen eingeteilt werden: kleine (328 bis 576 km²), mittlere (1494 bis 3.135 km²) und große Streifgebiete (von 4.421 bis 6905 km²). Elefanten mit kleinen Streifgebieten pendelten meistens zwischen dem Selous-Wildtier-Reservat und der angrenzenden Pufferzone. Elefanten mit einem mittleren Streifgebiet verblieben im Zentrum des SNWC und besuchten gelegentlich das Sasawala-Forst-Reservat. Elefanten mit großem Streifgebiet bewegten sich in der Mitte und im Süden des SNWC mit ausgedehnten Ortsbewegungen über die Grenze zwischen Tansania und Mosambik und auch auf der Mosambikanischen Seite. Interviewantworten sprachen von ausgedehnten Wanderungen der Elefanten in den Monaten März, April, Juni und Dezember. Die Satelliten-unterstützte Telemetrie zeigte jedoch, das ausgedehnte Ortsbewegungen in den Monaten November und Dezember erfolgten und sich die Elefanten besonders wenig während der Regenzeit zwischen März und Mai bewegten. Nahrung, Zugang zu Wasser und möglicherweise wiederholter Kontakt mit Menschen in einigen Gegenden werden als die Faktoren betrachtet, die die Raumnutzung der Elefanten beeinflussen.

- Die Daten aus den Feldbeobachtungen und der Satelliten-unterstützten Telemetrie bestätigten, dass Elefanten häufig die internationale Grenze zwischen Tansania und Mosambik entlang des Ruvuma Flusses überqueren. Diese Ergebnisse betonen die Wichtigkeit des Schutzes des SNWC als einem bedeutenden Streifgebiet und Korridor für Elefanten, das zwei riesige Schutzgebiete in Afrika verbindet, nämlich das Selous Wildtier-Reservat in Tansania und das Niassa-Wildtier-Reservat in Mosambik.

1 Introduction

1.1 Development policy context

In Africa, conservation areas with some degree of legal protection, including National Parks, have a long history of over-exploitation of natural resources by local communities (Campbell & Hofer 1995, Hofer et al. 1996, 2000). Participation of local communities in wildlife management decisions, the sustainable utilisation of natural resources, and the distribution of income generated by natural resources on a local level can help to limit over-exploitation and habitat degradation by local communities (Lewis & Alpert 1997). This has been recognised by the Government of Tanzania in its Wildlife Policy published in March 1998, where it commits itself to (1) involving all stakeholders, particularly local communities, in the conservation and management of wildlife areas; (2) establishing Wildlife Management Areas (WMA) as a new category of protected areas with local people having a full mandate of managing and benefiting from conservation efforts; and (3) cooperating with neighbouring countries in the conservation of migratory species and trans-boundary ecosystems (Baldus & Siege 2001).

1.2 The Selous-Niassa ecosystem

The Selous–Niassa ecosystem is one of the largest trans-boundary natural ecosystems in Africa, covering approximately 154,000km^2 and extending across southern Tanzania and the border into neighbouring Mozambique (Figure 1). Currently, natural resources in this ecosystem are covered by some form of official protection in the Tanzanian (68,000 km^2) and Mozambiquan (42,400 km^2) sectors in terms of the Selous Game Reserve in Tanzania (48,000 km^2), and the Niassa Game Reserve in Mozambique (42,400 km^2).

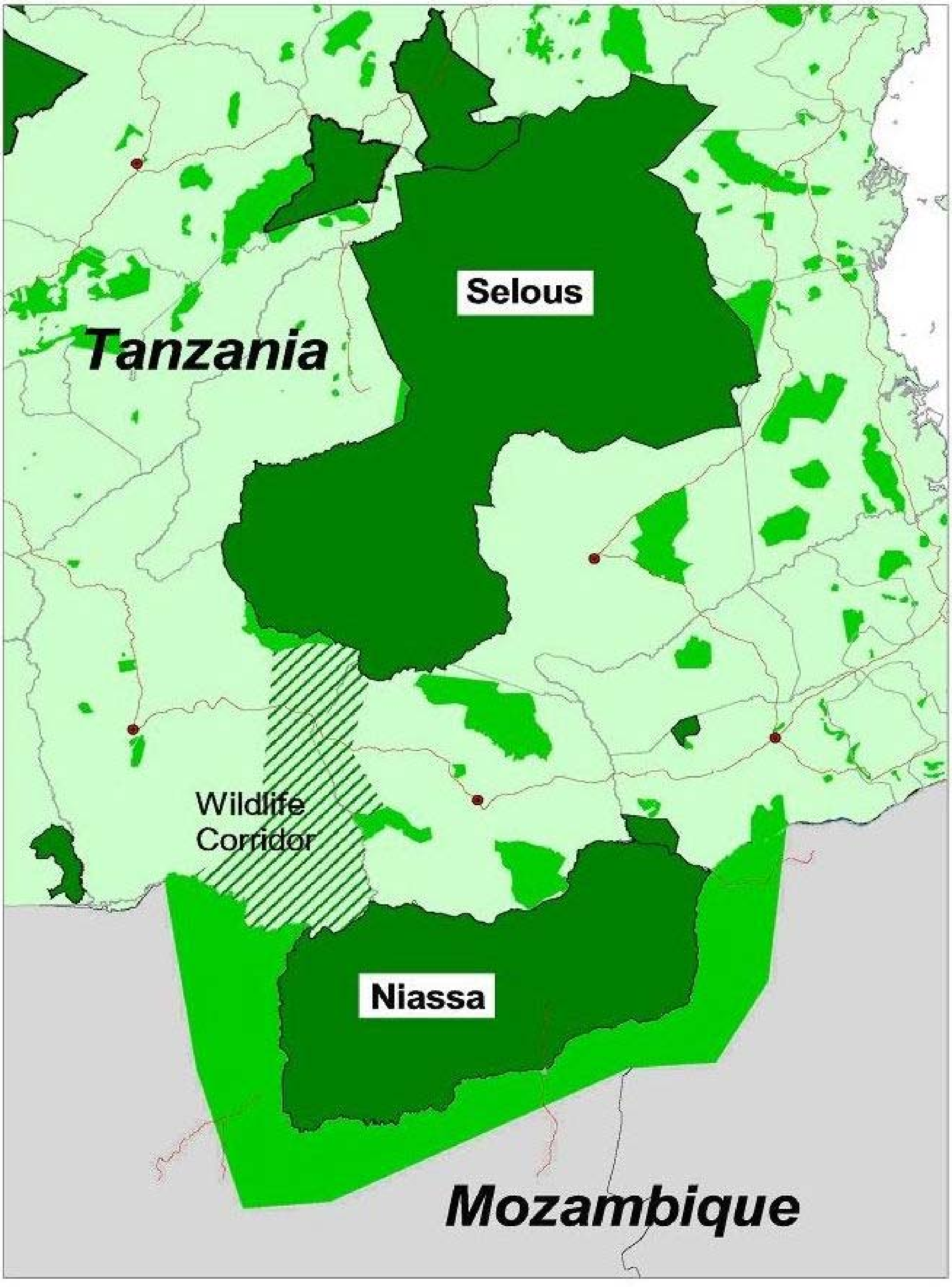

Figure 1: The Selous-Niassa ecosystem

The Selous Game Reserve is linked to the Niassa Game Reserve by the Selous-Niassa wildlife corridor (SNWC), a currently sparsely settled area (population density about 4 people/ km^2) of approximately 6,000 - 8,000 km^2 covering a distance of approximately 200 km (Baldus et al. 2003). The corridor links the world's largest miombo woodland ecosystems, covers a traditional migratory routes for elephants between two of the biggest intact elephant populations in Africa (Said et al. 1995) and links globally significant populations of Roosevelt's sable antelope, Liechtenstein's hartebeest, Nyassa wildebeest, eland and greater kudu. The corridor also harbours a variety of large carnivores including African wild dog, lion and leopard, smaller mammals, and other rare Tanzanian fauna.

1.3 Conservation and development in the Selous-Niassa Wildlife Corridor

A long-term (1987 until 2003) development cooperation project, the Selous Conservation Programme (SCP), has been implemented by GTZ and the Wildlife Division of the Ministry of Natural Resources and Tourism in the Selous Game Reserve and the buffer zones surrounding the Selous Game Reserve. The work in the buffer zones is being continued by another joint Tanzanian-German project, the "Community Wildlife Management" advisory project. This work has been extended into the northern part of the Selous-Niassa Wildlife Corridor as a series of WMA that are managed by local villages as part of the Selous Game Reserve's bufferzone project guided by the Wildlife Division and the GTZ. These WMAs will complement the protection accorded to the area by the Muhuwesi Forest Reserve.

However, the southern part of the Corridor (3,000-4,000 km^2) is currently not protected and threatened by

- poaching for meat and ivory;
- habitat degradation due to uncontrolled and destructive wildfires and likely agricultural expansion in the form of tobacco farming;
- associated increased demand for charcoal for curing.

These processes will ultimately exterminate resident wildlife populations in the Corridor and prevent the movement of wildlife populations between the Selous Game Reserve and Niassa Game Reserve, leading to

- habitat degradation within reserves by large herbivores such as the African elephant, because animals will no longer be able to move in response to changing levels of water and food supply;
- the genetic isolation of wildlife populations (Soulé et al. 1979, Hudson 1991, Burkey 1994, Newmark 1996, Hanski & Gilpin 1997);
- an increase in the potential for inbreeding and the chance of population extinctions in both reserves, particularly for wide-ranging endangered species such as the African wild dog (Burrows et al. 1994, Woodroffe et al. 1997);
- an increase in conflicts between elephants and other wildlife with local people, particularly farmers.

A development cooperation project to protect and manage the southern part of the corridor through a network of village WMAs is currently being planned. The goal of this project is to protect the wildlife corridor by having the local communities participate and benefit from sustainable utilisation, and to combat trans-boundary elephant poaching through an agreement of cooperation and law enforcement between the Governments of Tanzania and Mozambique. Benefits could include (1) legal supply of game meat, obtained through annual hunting quotas for each participating village, (2) participating villages to be empowered to protect themselves and their property against problem and crop raiding wild animals, (3) generate income in terms of cash (for community projects) from sustainable utilisation of wildlife (photo or hunting tourism), and (4) to provide employment, for example as village scouts or in the tourism sector.

1.4 The SNWC research project

The current research project was initiated by the development cooperation project in order to provide base line data for the planning and implementation of the SNWC development cooperation project. Its planning was coordinated by representatives of the Selous Conservation Programme (SCP/GTZ) and run by the Institute for Zoo and Wildlife Research, Berlin, Germany (IZW) in cooperation with the following partners:

- Selous Conservation Programme/GTZ, Tanzania;
- Wildlife Division, Ministry of Natural Resources and Tourism, Dar es Salaam, Tanzania;
- Department of Veterinary Surgery, Obstetrics and Reproduction, Faculty of Veterinary Medicine, Sokoine University of Agriculture, Morogoro, Tanzania;
- Veterinary Unit, Tanzanian Wildlife Research Institute, Arusha, Tanzania.

1.5 Research objectives

Define the area that requires protection as a wildlife corridor in particular with respect to elephant movements, in order to assist the preservation of the genetic viability and persistence of two of the largest elephant populations in Africa and the implementation of attempts to minimize conflicts between wildlife and local communities.

- Currently, the distribution, status and possible migration routes of the populations of key mammal species in the Selous-Niassa Wildlife Corridor are unknown. Thus, for the setting up of the corridor and the identification of priority areas, it is vital to map the distribution and migration routes of, and establish the status of populations of elephants and those of other large mammals.

- Conflicts between wildlife, particularly elephants, and local people are well known from elephant populations confined to small reserves. Whereas opinions abound as to why such conflicts occur and what to do about it, the scientific data basis is limited and does not include experience of elephant populations that originate from larger reserves. Even if there are currently few conflicts, systematic data collection on this aspect would contribute to a better understanding of the sources of these conflicts and improve attempts to minimize them.

Assess population size, health status and reproductive potential of key wildlife species, primarily elephants, that are valuable in terms of hunting licences and non-consumptive photo-tourism to local communities and the Government, to provide appropriate background information.

- Assess aspects of reproduction of those species that are most likely to be subjected to hunting quotas or other forms of exploitation. Currently, very little is known about the reproductive potential of mammal populations in southern Tanzania.

- Assess the health status of the populations of key wildlife species and if possible their contacts with people and their livestock. Very little is known about the health status of elephant populations or those of other key herbivores around the country, although there have been several cases of unexplained elephant deaths in protected areas in northern Tanzania where some form of disease is suspected. The recently discovered endotheliotropic herpes viruses that can kill African elephants (Richman et al. 1999) may be important in this context; the extent to which they are distributed in natural populations of East African elephants or possibly in other host species is currently unknown. In recent years, the importance of maintaining "healthy" ecosystems has increasingly been recognised, as wildlife populations may be vulnerable to outbreaks of pathogen-related disease, particularly exotic diseases and new strains of established viral diseases (McCallum & Dobson 1995). Elephants and other wildlife species moving through wildlife corridors may be at greater risk from pathogens borne by domestic stock than those within protected areas, and thus may assist the spread of pathogens to uninfected populations (Hess 1996).

2 Methods

2.1 Description of the study area

The Selous-Niassa Wildlife Corridor (SNWC) lies in southern Tanzania and is located north of Niassa Game Reserve in Mozambique. The Corridor is separated from the Niassa Game Reserve by the Ruvuma River, the international boundary between Tanzania and Mozambique. The Corridor lies within the administrative unit of Ruvuma Region in the two Districts of Songea Rural, now renamed Namtumbo (major western section of SNWC) and Tunduru (smaller eastern section of SNWC). In total the SNWC covers approximately 6,000 – 8,000 km^2 and extends approximately 160-200 km in north-south direction.

The area is mostly covered by miombo woodland and wooded grassland, and there are substantial areas of open savannah, seasonal and permanent wetlands and riverine forests along numerous rivers and streams. The Corridor receives rain during a single period from late November to April and May with an average of 800 – 1,100 mm per year. The Songea-Tunduru road via Namtumbo and Kilimasera forms the watershed between the northern and southern sections of the Corridor. The Mbarangandu River and its tributaries drain towards the north into the Selous Game Reserve towards Kilombero and the Rufiji River system. In the southern section, rivers such as Sasawara, Lukimwa, Nampungu and Msangesi drain into the Ruvuma River.

The landscape consists of plains, valleys, undulating topography and inselberg mountains at altitudes between 400 m at the Ruvuma River and 1,283 m in the Mtungwe mountains. The most important ranges are Mtungwe (1,283 m), Changalanga (901 m) and Kisungule (688 m) mountains; other prominent ranges occur in the southern section of the Corridor.

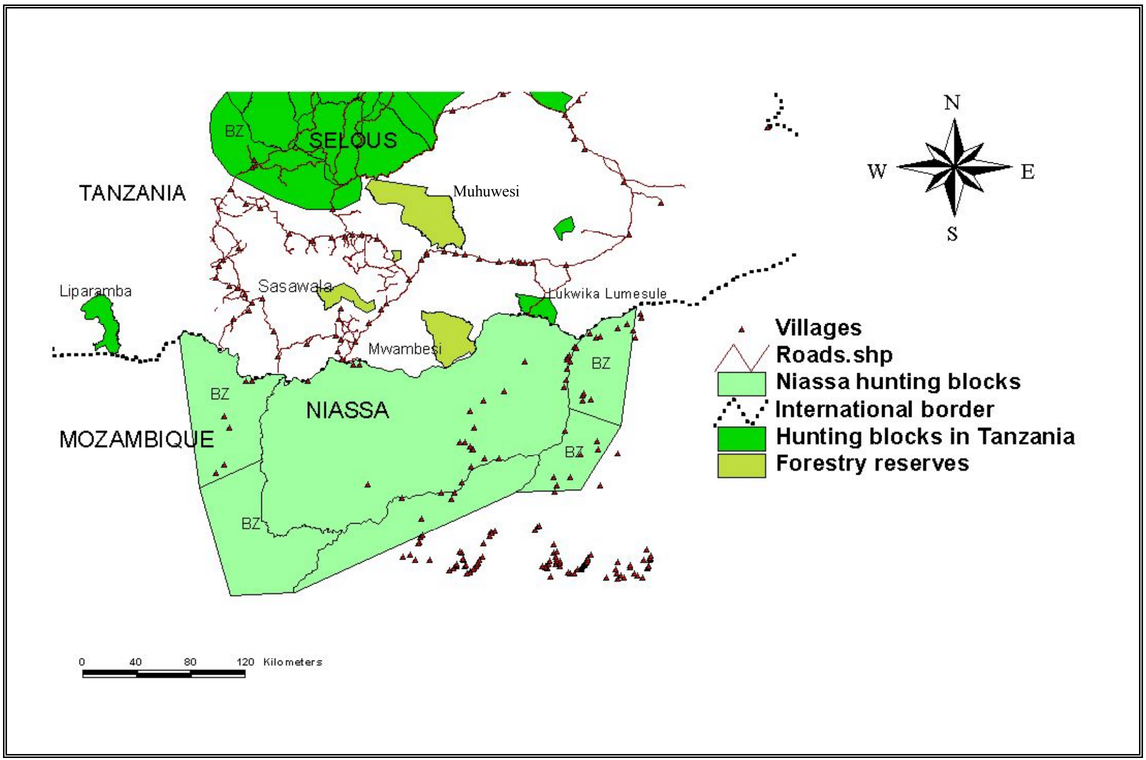

Figure 2: The distribution of villages and roads in relation to the protected areas in and around the Selous-Niassa Wildlife Corridor in Tanzania and Mozambique.

BZ: bufferzones around Selous are separate from the Game Reserve around Niassa are part of the Game Reserves.

There are 17 villages in the northern section of the SNWC. Most of their land is currently managed by a series of Wildlife management areas (WMAs) run by the local people as part of the Selous Game Reserve buffer zone project guided by the Wildlife Division and GTZ's community based conservation programme. In the southern section of the SNWC are 21 sparsely populated villages where WMAs do not currently exist and (with the exception of the Sasawara = Sasawala Forest Reserve) other forms of protection are currently not available (Figure 2).

Each village owns or has been allocated village land, some of which may cover large areas of dozens of square kilometres. By including the majority of villages from both sections of the SNWC, the study aims to obtain a representative picture of wildlife issues affecting local communities throughout the Corridor.

This study used state-of-the-art techniques such as GPS/ARGOS satellite transmitters for remote tracking of elephants, and advanced methods to assess their health status. In a novel way, it combined such advanced technology with a distinctly low technology approach by involving local personnel based in study villages to gather basic ecological data. Data were also collected by conducting public village meetings, through standardized personal interviews using questionnaires and from field observations during extensive field trips. Other sources of information were reports from district and regional game and livestock offices, and the monthly field patrol reports from village game scouts, including villages from the southern part of the Corridor.

2.2 Public village meetings

Village meetings were conducted in order to

- obtain baseline information on the presence or absence of key wildlife species on village land as perceived by local communities;
- obtain baseline information on the type of crops grown and livestock kept in the proposed wildlife corridor;
- get an idea of the extent of the damage inflicted by wild animals on local people and their properties (crops and livestock) and the views of local communities on potential conflicts with wildlife species;
- record local people's view on wildlife, current local methods of wildlife utilisation and their attitude towards wildlife conservation.

Meetings were conducted using a participatory approach with elders and the most influential people in the village by the Tanzanian project scientist, Donald Mpanduji, accompanied by a village game scout. These people were selected by the village chairperson or a village executive officer (VEO). At least 20 people were involved; in some villages (Amani, Marumba / Morandi and Misiaji), the entire village participated. Prepared questions were read out in Kiswahili and discussed. Responses were summarised and entered into data sheets. Table 1 lists details on villages where public village meetings were conducted.

2.3 Individual questionnaire-based interviews

Individual questionnaire-based interviews were conducted to obtain more detailed information on local wildlife issues, particularly

- the presence or absence of key wildlife species on local village land;
- possible migratory habits of wildlife, seasonality of presence, and traditional migratory routes of elephants and other migratory mammals on local village land;
- conflicts between local people and wildlife, particularly elephants;
- plant species that elephants might prefer as food plants and the timing of their fruiting or peak maturity in relation to elephant movement and/or possible crop raiding activity.

In each village, the VEO or the village chairperson selected, organised and arranged the venue for structured individual interviews using questionnaires. Five people were interviewed per village: the VEO or the village chairperson, two elders familiar with the village land and its boundaries, a traditional hunter and a teenager. Data were collected by direct approach. Questions were read out in Kiswahili and the answers given by the respondent filled in the questionnaire data sheet by the researcher. Direct communication between the researcher and the respondent reduced the risk of miscommunication. In villages without WMAs, interviews were conducted by the Tanzanian project scientist, Donald Mpanduji, accompanied by a game ranger, and in villages designated to run WMAs by the village development officer (VDO). Table 1 lists details of the villages where structured interviews were conducted.

Table 1: Details of villages in the study area where village public meetings, individual questionnaire surveys and field observations were conducted

Villages along the north of the Songea-Tunduru road belong to the northern section of the Selous Niassa Wildlife Corridor (SNWC), villages south of the road to the southern section of SNWC.

#	**Village**	District	Section of SNWC	Village meeting	Inter-view	Field observations on village land	Village included in wildlife management area scheme?
1	Ligunga	Songea	South	✓	✓	✓	No
2	Msisima[1]	Songea	South	-	✓	✓	No
3	Matepwende[1]	Songea	South	-	✓	✓	No
4	Magazini	Songea	South	✓	✓	✓	No
5	Linguseguse	Songea	South	✓	✓	✓	No
6	Amani	Songea	South	✓	✓	✓	No
7	Milonji	Songea	South	✓	✓	✓	No
8	Lusewa	Songea	South	✓	✓	✓	No
9	Mteramwahi	Songea	South	✓	✓	✓	Yes; in SCP/CBC
10	Songambele[2]	Songea	North	-	✓	✓	Yes; in SCP/CBC
11	Mchomoro[2]	Songea	North	-	✓	✓	Yes; in SCP/CBC
12	Kilimasera[2]	Songea	North	-	✓	✓	Yes; in SCP/CBC
13	Marumba	Tunduru	South	✓	✓	✓	No
14	Morandi	Tunduru	South	✓	✓	✓	No
15	Misyaje	Tunduru	South	✓	✓	✓	No
16	Ndenyende	Tunduru	South	✓	✓	✓	Yes; in SCP/CBC
17	Mbatamila	Tunduru	South	✓	✓	✓	No
18	Hulia[2]	Tunduru	North	-	✓	✓	Yes; in SCP/CBC
19	Darajambili[2]	Tunduru	North	-	✓	✓	Yes; in SCP/CBC
20	Namwinyu	Tunduru	North	✓	✓	✓	Yes; in SCP/CBC
21	Namakungwa	Tunduru	North	✓	✓	✓	Yes; in SCP/CBC
22	Nampungu	Tunduru	South	✓	✓	✓	No

Note: [1]Villagers unwilling to conduct a public meeting.

[2]Village meeting not conducted, the villages already run the community based conservation (CBC) programme organised by the Selous Conservation Programme (SCP/GTZ)

2.4 Field Observations

Direct field observation was conducted on village land of villages where WMA have not (yet) been put into practise (see Table 1).
The purpose of these observations was to

- record encounters with and signs (tracks, faeces, carcasses) of key wildlife species to provide information on relative abundance and distribution of wildlife, particularly in the southern section of the Corridor;
- locate traditional movement routes of elephants and other large mammals in the Corridor;
- identify key food plant species for elephants and relate their fruiting or peak maturity with elephant movement and / or crop raiding activities;
- locate human activities such as logging, bee keeping, poaching, and fishing.

Excursions were made to remote areas of village land to confirm information previously recorded in the public meetings and individual questionnaire-based interviews. Animal signs such as footprints, faeces, feeding sites, or den holes were observed and entered in a field observation book. Plant species reported to be selected by elephants as food were identified, collected and stored for future identification. The exact locations in fractions of degrees latitude and longitude of tracks and movement routes for large mammals such as elephants were noted and recorded using hand-held Global positioning system (GPS) devices. If a group of elephants or other key wildlife species was encountered, the GPS position was noted and total group size, mother/calf ratio and adult sex ratio were recorded.

Signs of human activities such as logging, bee keeping, poaching, and fishing were documented wherever they occurred and their GPS location and extent noted. The "density" of elephant signs per kilometre transect traversed by foot was calculated as described by Sundaram et al. (2003). Direct observations of elephants and other wild animals were recorded as and when they occurred. For each participating village, excursions took a minimum of two days and project scientists were accompanied by one or two traditional hunters or any other guide familiar with the village borders, porters and a game scout from the respective district.

2.5 Field patrols by village game scouts

To understand more about the population of key wildlife species, particularly elephants, village game scouts and game officers were furnished with field patrol data sheets to record location, group size, group composition and group structure of key mammalian species encountered during field patrols. By involving scouts from several villages, a larger area was covered than could have been assessed by a single project scientist, thus sample sizes were increased and data became more representative. This also provided an opportunity to test whether such data might be a reliable basis for a low cost effective population monitoring system.

2.6 Crop damage and livestock records

Data on crop damage and other conflicts inflicted by wild animals on local people and their property were retrieved from village monthly crop damage reports, district and regional annual reports, including reports from periods before and after the establishment of WMA in some villages.
This will provide a longer-term view of the trends in conflicts between people and wildlife.

Information on the type, number and distribution of domestic livestock, associated diseases and the temporal distribution and intensity of their occurrence were collected from district and regional livestock offices.

2.7 Elephant immobilisation and radio collaring

In order to track movements of elephants in the Corridor, 10 elephants were collared with GPS/ARGOS satellite telemetry system devices (Telonics, Arizona, USA) and examined as described in detail by Mpanduji et al. (2003). Capture operations were organised for three different periods: during the first two periods in late August to early September 2000 and in November 2001 elephants were radio-collared and their health and reproductive status assessed. During the third period in October 2002 radio-collars were removed from study animals.

During the first capture period, scouting and tracking of elephants was performed by foot. When trackers found fresh signs (spur, dung or recently destroyed food plants) the teams followed the ensuing elephant trail. Once spotted, elephants were approached on foot under cover from downwind and darted at a distance of about 20-30 meters. Once the animal was successfully darted with the drug etorphine hydrochloride (M99), it was followed cautiously until it went into recumbency. While the veterinarian in charge of anaesthesia monitored and recorded the vital parameters routinely, body measurements were taken, samples (including hair, faecal and blood samples) collected, and the radio collar was fitted. The animal was examined for the presence of skin lesion and parasites, their locations were recorded and a lesion biopsy taken, and ectoparasites (ticks and flies) were collected. After completion of these procedures, the animal was given a reversing agent (Naltrexone-HCL, Trexonil™, Wildlife Laboratories Inc., USA) to accelerate its recovery.

In general, darting free-ranging elephants on foot proved to be difficult. Much of the area is covered in thick miombo woodland and has a history of ivory poaching and of licensed hunting, with up to 30 elephants hunted under license each year. The first capture period illustrated that elephants tended to retreat into remote and extremely dense vegetation during the day and were very wary of people. The dense woodland and riverine vegetation, often in areas with steep terrain, made scouting of elephants by car impossible and by foot difficult and time consuming. Due to these obstacles, scouting and immobilisation during the second and third capture periods were performed with the assistance of a helicopter. With a helicopter, it was possible for the pilot to manipulate the herd by directing the movement of both darted individual and undarted animals into open areas within a short time, hence minimising possible stress for the darted individual. With a helicopter, the recovery process was also closely monitored from the air, reducing the danger to personnel compared to darting operations on foot. The helicopter was also used to guide revived animals in a safe direction.

2.8 Satellite-based radio-tracking of elephants

In addition to observations of elephant signs and groups encountered incidentally in the field as described above, elephants were also located using a GPS device and a hand held Yagi antenna and telemetry receiver (Telonics, Arizona, USA) that received the VHF signal of the GPS/ARGOS transmitter system (see below).
The GPS locations recorded in the field were later downloaded to a laptop computer using Fugawi software (Northport System, Canada) and then exported to a geographical information system (GIS) computer program (ArcView 3.2a).

The bulk of elephant location data came from satellite-based remote tracking of elephants using the fitted electronic devices (Telonics, Arizona, USA) that included

- a GPS (Global Positioning System) receiver for highly accurate records of the latitude and longitude of the elephant's location at pre-set intervals to an accuracy of better than 100m;

- an ARGOS satellite communication unit that broadcasted the GPS records to the low-orbit ARGOS satellite at regular, pre-set intervals, and thus enabled the remote downloading of location data;

- a VHF component that permitted elephants to be located using conventional radio-tracking techniques (over distances of 3-4 km on the ground or up to 40km using aircraft).

The ARGOS satellite received information broadcasted by the elephant collar and passed all information to the ARGOS ground station in France. In contrast to previous, conventional satellite tracking technology, the ARGOS satellite system was used as a system to relay information in addition to providing an estimate of the current location of the transmitter. ARGOS ground station then transferred the information by electronic transfer to the IZW in Berlin where the data were processed. The extracted locations were used for analysis of animal movements, home ranges and habitat use and preferences.

Home range sizes were calculated using a special module available for ArcView, applying the well-known and most commonly used home range models reviewed by Harris et al. (1990). Seasonal (wet and dry season) habitat use and habitat preferences and seasonal changes in habitat preferences were analysed by using state-of-the-art techniques developed by Manly et al. (1993) and implemented by Höner et al. (2002).

3 Results

3.1 Status and distribution of wildlife

The results from questionnaires and village meetings suggested the widespread presence of a large variety of wildlife species in the corridor (Table 2). Seventeen species of wild herbivores, six species of carnivores, and two species of primates were reported to be present. The presence of a number of species not reported during village meetings and individual questionnaire-based interviews were confirmed during field-work (Table 2).

The distribution of species varied substantially. Waterbuck were apparently restricted to the major rivers (Mbarangandu and Ruvuma). Few respondents mentioned the occurrence of black rhino, and neither field observations nor field patrols by village game scouts produced positive evidence of their presence. Species reported to be "migratory" comprised elephant, buffalo, hartebeest and zebra. Populations of buffalo, sable antelope, eland, common duiker, common reedbuck, yellow baboon and vervet monkey were reported to be increasing.

Seventy-five percent of informants reported more frequent sightings of wild animals during the wet season than the dry season, 22% reported no difference in the frequency of wild animal sightings between seasons and the remainder (2.3%) reported more sightings during the dry season.

Traditional hunters and village game scouts in the southern section of the Corridor reported the occurrence of one large migratory herd of buffalo. The presence of this herd was confirmed during field-work near Nampungu river, south of Namakungwa and Namwinyu villages. Lone bulls and small groups of non-migratory buffaloes were also reported to occur elsewhere in this area. The aerial census conducted by CIMU during the dry and wet season of 2000 reported a clumped distribution of buffaloes (CIMU 2001). A few scattered small groups of buffaloes were seen during the dry season aerial census in the northern and central sections of the corridor. During the wet season, the population was concentrated in small areas along the Mbarangandu river. These observations suggest that the buffaloes are principally migratory, confirming the assessment by village game scouts and traditional hunters.

No signs of hartebeest were observed during our own field-work, yet a herd of about six individuals was observed by L. Siege in the southeastern section of the Corridor near Mkasha mountain. Bush meat from hartebeest, buffalo and duiker were recovered during field-work in one of the fish camps along the Ruvuma River in an area near Matepwende village. Buffalo meat was reported to have come from Mozambique, whereas duiker and hartebeest meat was obtained from within Tanzania.

Aerial surveys conducted in 2000 did not observe zebras in the southern section of the SNWC, although 9% of respondents to questionnaires reported to have encountered zebra. Half of the positive respondents were from the southern section of the corridor. A few fresh spoors of zebra were observed during field-work in the western part of Mtungwe mountain near Ligunga and Mtelamwahi villages in the southern section of the corridor. Village game scouts and traditional hunters in Mtelamwahi village also recorded a few sightings during their monthly routine patrols.

Table 2: Status and distribution of wildlife species as assessed by village group discussions.

Based on individual questionnaire-based interviews and aerial censuses during the wet and dry season 2000.

	Wildlife species	Proportion of villages that reported occurrence in vicinity of village boundaries (n = 22)	Proportion of interviewed people reported presence in the vicinity of village boundaries (n = 88)	Proportion of field observations in the vicinity of visited field villages (confirmed presence) (n = 22 villages)	Aerial census by CIMU (2001)	
					Wet season (May 2000)	Dry season (October 2000)
1	Elephant	91	74	91	2404 ± 508	3114 ± 1407
2	Eland	77	42	64	170 ± 165	0
3	Buffalo	77	34	64	222 ± 112	6407 ± 6145
4	Sable	82	59	86	4460 ± 833	5335 ± 2004
5	Zebra	36	10	18	107 ± 110	0
6	Greater kudu	27	14	36	96 ± 53	0
7	Hartebeest	32	13	9	95 ± 92	0
8	Impala	5	0	0	0	0
9	Bushbuck	36	25	41	36 ± 25	0
10	Waterbuck	73	5	36	220 ± 110	0
11	Common reedbuck	59	27	23	95 ± 45	77 ± 54
12	Common duiker	73	50	82	474 ± 44	204 ± 80
13	Bushpig	95	92	95	19 ± 18	0
14	Warthog	50	44	64	493 ± 177	0
15	Hippopotamus	13	24	5	0	0
16	Klipspringer	0	0	27	0	0
17	African wild dog	55	95	50	0	0
18	Lion	73	75	68	0	0
19	Leopard	73	70	73	0	0
20	Spotted hyena	68	42	73	0	0
21	"Jackal" *	27	27	27	0	0
22	Baboon	41	90	59	18 ± 18	0
23	Vervet monkey	59	90	0	0	0
24	Aardvark	41	0	50	0	0
25	Hare	23	6	14	0	0
26	Porcupine	32	0	18	0	0
27	Cane rat	5	11	0	0	0
28	Crocodile	9	0	5	19 ± 18	0
29	African civet	0	4	0	0	0
30	African wild cat	0	7	0	0	0
31	Black rhinoceros	0	2	0	0	0

* unclear whether black-backed and/or side-striped jackal

Large numbers of sable antelope were reported to occur almost everywhere throughout the Corridor, an assessment confirmed by regular encounters during field-work, and an estimate of a minimum population size of 4,460 animals (Table 2).

Amongst carnivores, lion, leopard, spotted hyena and African wild dog were reported to occur throughout the corridor, whereas “jackal” (black-backed and/or side-striped), African wild cat and African civet seemed less widespread (Table 2). African wild dog was the only carnivore reported to be highly migratory and seasonal in occurrence. Their presence on village land appeared to peak during February, June/July and December. Fresh signs of wild dogs were recorded during field observations at three sites: south of Magazini, on the eastern face of Mtungwe Mountain and in the forests surrounding Mtelamwahi. Village game scouts in different areas of the Corridor had also recorded the presence of wild dogs and other carnivores during their routine monthly patrols. In general, people’s attitude towards wild dogs was very positive, as they were considered to be beneficial in preventing crop damage by wild herbivore species. Several respondents also suggested that African wild dogs sometimes preyed on domestic animals and thus cause loss of property and income.

3.2 Status and distribution of elephants

Elephants were reported to be common and widely distributed throughout the corridor, with a minimum population size of at least 2,400 (Table 2). When participants at village meetings were asked to comment on the population of elephants in their area they all reported an increase in elephant population size. Similar results were obtained in questionnaire replies where 74% of informants reported an increase.

Both resident and migratory herds of elephant were reported to occur in the Corridor, with some respondents suggesting that herds of elephant moved from the Selous at the northern end of the Corridor to Niassa Game Reserve in Mozambique in the south. In most cases, male groups and mixed herds of adult and young were reported. Signs of the presence of large numbers of elephants were observed during field-work (Table 3) and in sightings reported by the village game scouts. Village game scouts regularly recorded group and age structure in five survey areas (village lands) in the central and northern section of the Corridor. The following analysis is derived from these data.

Mean elephant calf:female ratios were generally high (between 0.53 and 0.96) throughout the five years of records but showed no systematic trend (Figure 3).

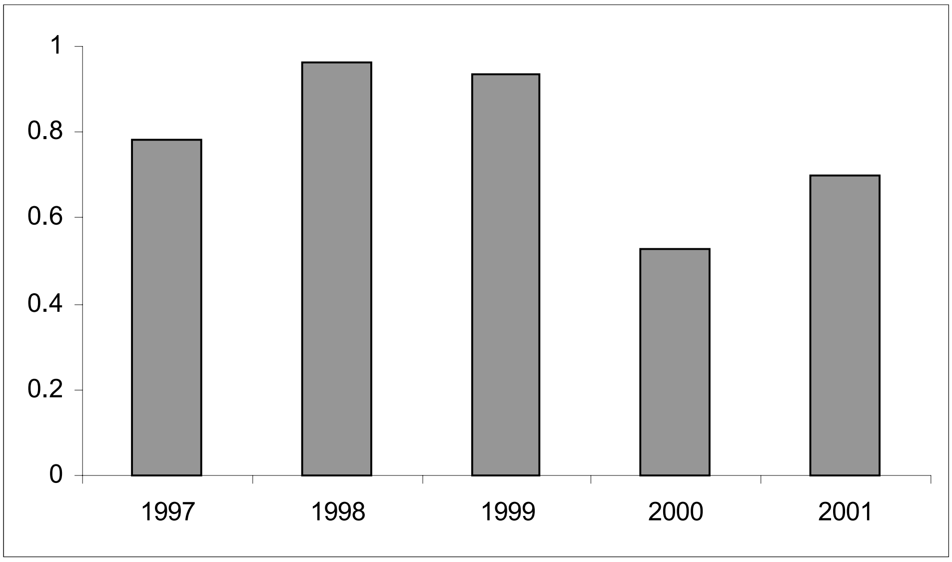

Figure 3: Mean elephant calf:female ratios in six different survey areas of the Selous-Niassa Wildlife Corridor

The operational sex ratio for the entire study area was 0.66 or 39% males and 61% females.

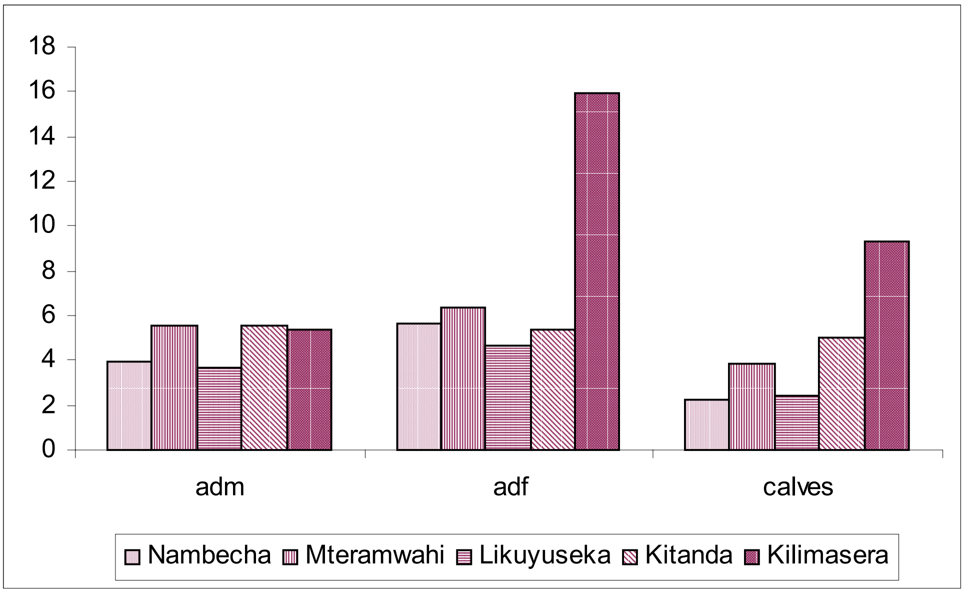

Figure 4: Sizes of different age-sex classes in elephant groups in five different survey areas in the northern and central section of the Selous-Niassa Wildlife Corridor
averaged over 5 years between 1997 and 2001.
Adm = Adult male, Adf = Adult female.

There were clear differences in the size of groups between one survey area and the other four. Kilimasera had three times more females per group than the other areas (Figure 4). In comparison with the other survey areas, there were very few males in relation to female numbers around Kilimasera and Nambecha. Average group sizes showed an increase over the five years, suggesting that the Corridor elephant population is expanding (Figure 5).

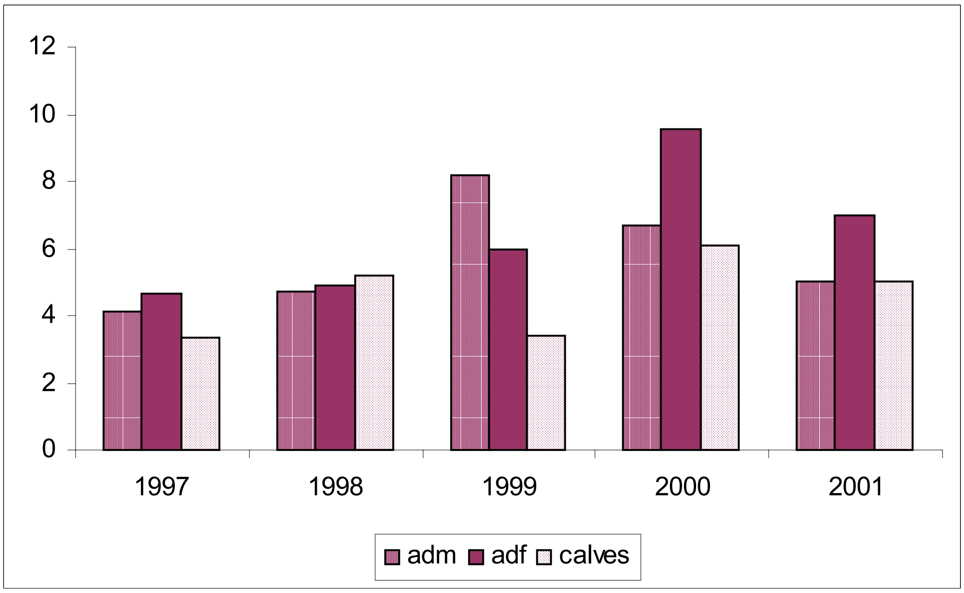

Figure 5: Sizes of different age-sex classes in elephant groups averaged across five different survey areas in the northern and central section of the Selous-Niassa Wildlife Corridor between 1997 and 2001.

Adm = Adult male, Adf = Adult female.

Table 3: Village areas where field observations for elephant signs were carried out including "encounter densities" for each area.

Village	Fresh Spoors	Old Spoors	Tracks	New Dung	Old Dung	Wallowing site	Sighting	Total "encounters"	Estimated distance (km)	"Encounter density" (items / km)
Mtelamwahi	15	-	15	5	-	7	-	42	NA	-
Ligunga	-	1	8	-	-	-	-	9	35.7	0.25
Amani	-	-	2	1	-	-	-	3	24.5	0.12
Magazini	-	-	30	46	150	-	6	232	99.5	2.33
Lingusenguse	-	6	7	-	2	-	-	14	25.8	0.54
Marumba/Morandi	7	-	20	1	-	1	-	29	25.0	1.16
Misiyaji	1	6	16	-	1	11	-	35	46.0*	0.76
Lusewa/Milonji	-	-	-	-	-	-	-	0	NA	-
Mbatamila	5	10	100	2	25	-	-	142	35.9*	3.95
Nampungu	6	-	8	1	-	-	2	17	35.8	0.47
Namwinyu/Namakungwa/Darajambili/Ndenyende	4	1	23	11	102	8	12	161	60.4	2.66
Mchomoro/Songambele/Hulia/Kilimasera	-	-	-	-	-	-	129	129	142.0*	0.91
Matepwende	-	-	26	-	-	-	-	26	13.7	1.90
Msisima	-	-	-	-	-	-	-	0	22.0	0.00

* Distances traversed by foot and by car, NA – not available

3.3 Losses of crops: the role of wildlife

Results from the village meetings, questionnaire-based interviews and district annual reports showed that most of the people practise subsistence agriculture for their livelihood. Most agricultural plots were in close proximity to villages although a few were reported to be located well beyond 10 km. Acquisition of the land for cultivation is typically done by bush clearing and inheritance within the family.

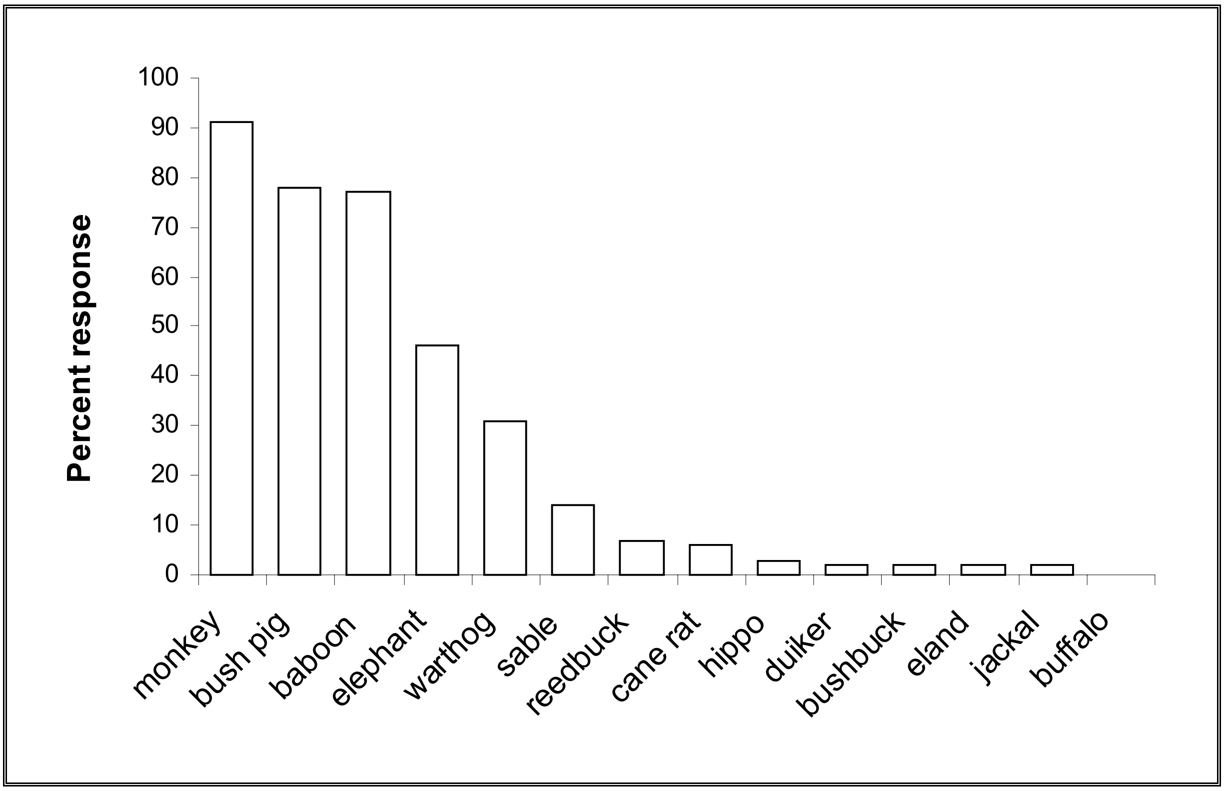

Figure 6: The relative frequency with which wildlife species were mentioned as being involved in crop raiding activities (n = 87)

As wild animals were reported to be actively involved in crop raiding activities, we asked, “which animals are involved in crop raiding activities” and offered respondents the opportunity to name several species. The most frequently named species were vervet monkey, followed by bush pig and yellow baboon (Figure 6). Interviews revealed participation in crop raiding by at least 13 wildlife species, yet the analysis of annual reports from district records suggested that only elephant, hippo, buffalo, eland and waterbuck are considered problem animal species.

When asked, “which crops are damaged ” the response was all crops. Raiding activities were reported to take place throughout all stages of crop development (Table 4). Incidences of crop raiding by elephants were reported to occur sporadically whereas raiding by so-called “small pest” species (rodents and birds) were said to occur daily. Table 4 summarises the pattern of crop damage by various wildlife species, the frequency of attack and the magnitude of loss that can be expected to result unless people intervene. Crop raiding is most common when crops are mature or are ready to be harvested, i.e. between the months of March and May.

Reports from district offices on crop damaged by larger wildlife species were consistent with the patterns reported by villagers. Lack of protection of crop fields during the wet season may lead to total loss of crop yield for the entire season. During this time of the year, it is the farmer’s mandate to guard their crops against marauding wild animals. Usually people are on guard on raised platforms (commonly known as vilindo) in crop fields shouting, drumming or banging on empty tins, throwing stones and sometimes chasing crop raiders with domestic dogs.

Table 4: Crop raiding wildlife species, damaged growth stages, type of damage and expected losses

Crop	Wildlife species	Stage of growth	Type of damage	Frequency of attack	Expected loss in acres
Maize	Bushpig, baboon, vervet monkey.	Flowering / harvest	eats immature/mature maize cobs	Daily	May cause 100% loss if unattended
	Sable, buffalo, reedbuck, warthog, cane rat	All stages,	Straw, leaves, immature cobs	sporadic	Substantial loss
	Elephant	All stages	Every thing, uprooting, trampling	sporadic	Sweep the entire farm in one attack
Cassava	Bush pig	Planting / harvest	Uprooting	Daily	May cause 100% loss if unattended
	Baboon, vervet monkey, porcupine	Harvest	Uprooting	Daily	May cause 100% loss if unattended
	Warthog	Harvest	Uprooting	sporadic	Substantial losses
	Elephant	Harvest	Uprooting, trampling	sporadic	Substantial losses
Sorghum	Sable	Flowering / harvest	eats whole plant	sporadic	Substantial losses
	Elephant	Flowering / harvest	eats mature plant	sporadic	May cause 100% loss
	Baboon, vervet monkey	Flowering / harvest	Straw and seeds	Daily	May cause 100% loss
Onions	Bushpig, baboon	Flowering / harvest	Uprooting	Daily	Substantial losses
Ground nuts	Guinea fowl, francolin	Flowering / harvest	Uprooting	Daily	May cause 100% loss if unprotected
	"Jackal"	harvest / post harvest	eats mature nuts	Daily	May cause 100% loss if unprotected
Rice	Common reedbuck, sable, bushbuck	before flowering	eats leaves	Weekly	On average 1 acre
	Warthog, bushpig	Harvest	eats leaves	Weekly	Substantial losses
	Birds	Harvest	eats rice seeds	Daily	On average 1 acre
	Elephant	Immature plant	eats everything	sporadic	Sweep entire farm
	Vervet monkey	Early maturity	eats maturing rice seeds	Daily	May cause 100% loss if unattended
	Hippo	Flowering / harvest	eats every thing	sporadic	May cause 100% loss in one attack
	Cane rat	Flowering / early maturity	eats straw and maturing seeds	Daily	Substantial losses
Cashew nut	Brown-headed parrot	Harvest	eats fruit of the nut; cracks shell	Daily	No information
	Baboon	Harvest	eats fruit of the nut; cracks shell	Daily	Substantial losses
	Elephant	Harvest	eats fruits and breaks leaves	sporadic	Substantial losses
	Bushpig	Harvest	eats fruit of the nut; cracks shell		
Tabacco	None	-	-	-	-
Leguminous crops	Duiker, bushbuck, bushpig	Planting / flowering	Eats leaves preferably the growing tips	sporadic	Substantial losses
	Baboon, vervet monkey	Harvest	Mature seeds	Daily	May cause 100% loss
	Elephant	Flowering / harvest	Eat every thing, uprooting, trampling	sporadic	May cause 100% loss in one attack

At night villagers may make fires in the corners of fields or used torches to discourage approaching wild animals. Other methods of damage prevention included more lethal measures such as setting snares and constructing pit-fall traps around the cultivated field. However, these methods were reported to be ineffective against elephants and other larger mammals such as hippos.

Because of the nocturnal nature of crop raiding by elephants and the inefficient traditional control measures, considerable crop damage was reported annually. Table 5 summarizes the damage caused by the larger wild animal species for the period from 1990 to 2000 in Songea Rural (Namtumbo) District. Rice and maize appeared to be the crops most affected. Elephants appeared to be most frequently involved in crop raiding, followed by hippo, buffalo and eland. As a result, 55 animals were shot by the district game officers, 80% of which were killed and 20% injured. Seventy five percent of all animals killed were elephants. The records of killed species appeared to be consistent with the reports on the frequencies of crop raiding incidences.

Table 5: Report of the crop "damaged" by larger wild animal species in Songea Rural (Namtumbo) District from 1990 to 2000

Crop	"Damage" attributed to specific wildlife species						Total
	Elephant	Hippo	Eland	Buffalo	Waterbuck	Others	
Rice	45.0	7.6	-	1.2	-	12.6	66.4
Maize	16.1	15.5	1.2	1.8	0.1	10.5	45.2
Banana	4.0	0.4	-	-	-	-	4.4
Tabacco	1.6	6.5	-	-	-	-	8.1
Leguminous plants	1.8	0.2	0.8	1.2	0.3	3.3	7.6
Cassava	4.0	-	-	-	-	2.8	6.8
Potato	-	0.8	-	-	-	-	0.8
Onions	0.1	-	-	-	-	-	0.1
Sorghum	-	-	-	0.2	-	-	0.2
Mixed crops	32.3	-	-	-	-	-	32.3
Total	104.9	31.0	2.0	4.4	0.4	29.2	171.9

Large wild animal species were not the only factors responsible for crop damage. The Songea Rural (Namtumbo) District agricultural office lists crop diseases, “small animal” pests and encroaching weeds as other factors reducing harvest yield. No data were available on the intensity or effectiveness of control measures instituted against these factors. Table 6 summarises the total area of cultivated crops and splits the area damaged by documented or suspected causes, including weeds, crop diseases, “small pest” species, elephants and other larger mammals between 1990 and 2000. During this period, large wildlife appeared to contribute only 0.04% of the total area recorded as damaged. Of this, elephants contributed 0.02%, hippo 0.008% and other ungulates 0.007% of the total area affected. However, the majority of crop damage (99.96%) appeared to be caused by weeds, diseases and “small pest” species. In relative terms, the effects caused by elephants and other large wild animals were small. However, such incidences may be of greater relevance to family food security, because of their ability to clean out the entire plot in one attack. Because of this, the government has implemented shooting as an acceptable method to control marauding individuals.

Throughout this period, 18 villages in Songea Rural (Namtumbo) District reported a total of 96 incidences of crop raiding by large wildlife species. These villages were broadly categorized into three zones:

- those within the buffer zones of the Selous Game Reserve
  (3 villages, 46 cases, 83.3 ha damaged);
- those within the Selous-Niassa Wildlife Corridor
  (5 villages, 33 cases, 53.0 ha damaged);
- those that were neither in the Corridor nor the buffer zones
  (9 villages, 18 cases, 35.6 ha damaged).

There were no reports on crop damage from many villages probably because of poor communication and reporting systems. It is likely that levels of reporting of cases of crop damage in villages surrounding the Selous Game Reserve were adequate, because of the presence of wildlife management committees that are responsible for all wildlife matters, including crop protection, in their respective wildlife management areas. Early reporting helped the village game scouts to act immediately in the event of crop raiding, and as a result killing of crop raiders is successful in these areas.

Table 6: Total area of mixed crops cultivated and the total damage in Songea Rural (Namtumbo) District caused by weeds, diseases, "small pest species" (rodents, birds), elephants and other large mammals as reported by the District Agriculture Office.

Year	Total area cultivated (ha)	Encroachment by weeds	"Damage" attributed to diseases	"Damage" attributed to "small pest" species	Total area "damaged" by encroachment of weeds, diseases, and "small pest" species (ha)	"Damage" attributed to elephant	"Damage" attributed to hippo	"Damage" attributed to other large ungulates	Total "damage" by large wildlife species (ha)	Total area "damaged" (ha)
1990	160,885	32,177	8,044	8,045	48,266	0.8	14.2	-	15.0	48,281
1991	163,780	32,756	8,189	8,889	49,134	1.9	2.8	0.2	4.9	49,139
1992	132,620	26,524	6,631	6,631	39,786	2.8	3.6	0.8	7.2	39,793
1993	127,072	25,414	6,354	6,353	38,121	29.2	-	-	29.2	38,150
1994	116,139	23,228	5,807	5,807	34,842	32.4	6.3	4.5	43.2	34,885
1995	123,394	24,679	6,170	6,170	37,019	3.2	1.6	-	4.8	37,024
1996	119,740	23,948	5,987	5,987	35,922	-	4.1	-	4.1	35,926
1997	126,124	25,225	6,306	6,310	37,838	3.6	-	-	3.6	37,842
1998	139,592	27,918	6,980	3,980	38,878	10.9	-	-	10.9	38,889
1999	132,873	26,575	6,644	6,644	39,863	2.8	-	25.5	28.3	39,891
2000	145,480	29,096	7,274	7,274	43,644	17.1	1.6	-	18.7	43,663
Total	1,487,699	297,540	74,386	71,387	443,313	104.7	34.2	31.0	169.9	443,483
Fraction of total "damages" (%)		67.1	16.8	16.1	99.96	0.02	0.008	0.007	0.04	100.00

3.4 Attacks on humans and livestock by wildlife

Respondents in interviews claimed that lion, leopard, spotted hyena, African wild cat and "jackal" (black-backed or side-striped jackal – two species that are not distinguished by name in local languages nor in Kiswahili, the official language) killed livestock. "Jackal" and African wild cat were reported to prey on poultry whereas leopard, spotted hyena and lion were reported to prey on sheep and goats. Occasionally, leopards apparently also took poultry and lions killed cattle. Predation was reported to occur sporadically at any time of the day, throughout the year. During the period 1990 to 2000, the Songea Rural (Namtumbo) District game office recorded a total of 75 incidences of predator attacks on livestock in 33 different villages. Ten of these cases were recorded from villages found within the SNWC. The total reported offtake comprised 753 livestock, including 18.3% (n = 138) of cases reported from villages in the southern section of the SNWC, in particular Ligunga, Lusewa, Magazini, Msisima, Milonji. and Mtelamwahi.

Lions accounted for 70.3% (n = 53) of all incidences and claimed 75.3% (n = 567) of the total offtake, followed by leopards that were responsible for 23% (n = 173) of the total offtake. The combined total livestock killed by spotted hyena, python, and African wild dog only represented 1.8 % (n = 13). No livestock death was reported from the northern section of the SNWC where a community-based conservation programme (CBC) is practised. Peak incidences of livestock offtake were confined to the months of January, February and August (Table 7). Few domestic animals were reported to have been injured by wild animals: Lions were responsible for injuring cattle, leopards for causing injuries to goats and dogs.

Elephants never killed any livestock, and there were no reported cases of humans being injured or killed by elephants. Lions were reported to be responsible for the deaths and injuries of three people, respectively.

Table 7: Monthly distribution of the number of livestock killed by wild animals in Songea Rural (Namtumbo) District for the period from 1990 to 2000.

Month	Livestock								Total
	Cattle	Goat	Sheep	Swine	Dog	Pigeon	Donkey	Poultry	
January	13	94	-	2	1	-	1	12	123
February	21	192	2	45	-	-	-	-	260
March	2	20	-	4	-	-	-	-	26
April	14	28	5	9	-	-	-	-	56
May	2	40	-	3	-	-	-	1	46
June	3	16	1	2	-	-	-	-	22
July	-	27	-	-	-	-	-	-	27
August	-	2	-	6	2	5	-	85	100
September	-	9	-	-	-	-	-	-	9
October	6	32	-	3	-	-	-	-	41
November	13	20	-	6	1	-	-	-	40
December	-	-	-	-	3	-	-	-	3
Total	74	480	8	80	7	5	1	98	753

3.5 Wildlife utilisation and poaching

Various forms of wildlife utilisation are practised in different areas of the SNWC. There is a CBC programme in the northern section of the Corridor that aims to use wildlife resources in accordance with Wildlife Management Area (WMA) regulations. These include the option, upon application by a village, of receiving hunting quotas for the WMA land from the Director of Wildlife at the Ministry of Natural Resources and Tourism of Tanzania.

During interviews, people were asked whether it was easy for them to obtain wildlife meat. Of the 88 people interviewed, 30% (n=27) initially responded with yes, 59% (n=52) said it was not easy and 10% (n=9) were not sure. Those who initially responded positively were mostly from the northern section of the SNWC. It appeared that many people from the southern section of the corridor did not initially respond positively for fear of legal action that may be brought against them if they admitted to having access to wildlife meat. As confidence built up during interviews, respondents from the southern section of the SNWC conceded that bush meat was widely utilised and pointed to a lack of alternatives, and the rarity of livestock in the area. This assessment was confirmed by field-work, when signs of poaching activities (Figure 7) were repeatedly observed, particularly in the southern section of the SNWC (Table 8).

Evidence of attempts to poach elephants in the Corridor was observed during field-work associated with elephant immobilisation. One elephant was observed with a shortened trunk evidently cut off by a snare. Two radio-collared study elephants were injured or killed by poachers. One large mature bull had been shot in 2002 and compromised but not killed outright. There were several muzzle-loader shells, which had entered the head but had not penetrated the bone. The elephant also had one soft-point .375 bullet lodged inside the heart muscle. This bullet created a large abscess, progressive weakness and ascites, and was likely to be responsible for a massive deterioration in condition that caused the bull to restrict his movements to a very small area compared with his previous movements and heart failure when the radio-collar was taken off. Secondly, a mature radio-collared breeding bull (Ndalala) was shot and killed by poachers in Mozambique, and personnel of the Niassa Game Reserve retrieved its radio-collar. The collar had been located by our tracking devices in the air

but initial efforts to find it on the ground had proved futile.
Respondents of interviews stated that professional poachers came from Mozambique and operated in the southern section of the Selous Niassa Wildlife Corridor, closely cooperating with the many fishermen who undertake illegal fishing activities along the Ruvuma River. As many as 63 non-licensed fishermen were counted in 31 camps found along the Ruvuma River.

Figure 7: A snare collected by the project field scientist

D.G. Mpanduji (on the right), in the southern section of the Selous-Niassa Wildlife Corridor.

Table 8:Signs of poaching activities observed during field observations in different village lands

Villages	Section of Corridor	Included in WMA scheme?	Signs of poaching activities observed during field observations									Total
			Pit trap	Snare line	Foot trap	Poacher camp	Honey collector	Bush fire	Fish Camp[†]	Logging pit	Elephant Carcass	
Mchomoro	North	SCP/CBC	-	-	-	-	-	-	-	-	-	0
Songambele	North	SCP/CBC	-	-	-	-	-	-	-	-	-	0
Hulia	North	SCP/CBC	-	-	-	-	-	-	-	-	-	0
Kilimasera	North	SCP/CBC	-	-	-	-	-	-	-	-	-	0
Namwinyu/Namakungwa/Darajambili/Ndenyende	North	SCP/CBC	9	12	43	-	1	-	1	-	-	66
Mtelamwahi	South	SCP/CBC	-	-	-	-	-	-	-	-	-	0
Ligunga	South	No	-	-	-	-	-	-	1	-	-	1
Amani	South	No	-	-	-	-	-	-	-	-	-	0
Magazini	South	No	-	24	16	4	1	7	21	-	6[*]	79
Lingusenguse	South	No	-	2	20	-	1	-	-	-	1	24
Marumba/Morandi	South	No	-	-	-	-	-	-	-	-	-	0
Misyaji	South	No	-	-	-	-	-	-	-	-	-	0
Lusewa/Milonji	South	No	-	-	-	-	-	-	-	-	-	0
Mbatamila	South	No	4	13	99	3	3	2	1	1	-	126
Nampungu	South	No		2	2	-	-	-	-	-	-	4
Matepwende	South	No	-	-	-	-	-	-	7	-	-	7
Msisima	South	No	-	-	-	-	-	-	-	-	-	0
Total			13	53	180	7	6	9	31	1	7	307

Note: [*]Three elephant carcases were observed by David Moyer of WCS.

[†]A total number of 63 people was found in fish camps along the Ruvuma River

3.6 Immobilisation and assessment of health status in elephants

In general, darting free-ranging elephants from the ground proved difficult and dangerous. The Selous ecosystem is thick miombo woodland, and the area has a history of ivory poaching and of licensed hunting, with up to 30 elephants sport-hunted every year. The first capture period illustrated that elephants tended to retreat into remote and extremely dense vegetation during the day and were very wary of people. The dense woodland and riverine vegetation made tracking elephants by car impossible and by foot difficult and time consuming in areas with steep terrain. Due to these obstacles, a helicopter was used for the second capture period, and the anaesthesia protocol was modified accordingly. With a helicopter, it was possible for the pilot to manipulate the entire herd during immobilisation by directing the movement of both darted and undarted animals into open areas within a short time, hence minimizing the amount of stress for the darted individual. With a helicopter, the recovery process was closely monitored from the air, thus minimizing the danger to people that were present on the ground. The helicopter was also used to guide revived animals in a safe direction.

Ten out of 12 immobilisations to fit radio-collars were uneventful. Immobilisation of one lactating female darted from the helicopter was soon reversed, because she was lying on her sternum and her approximately 6 year-old calf persistently refused to move away. One adult bull, severely compromised by a massive parasitic infection, died before the capture team could reach it. The remaining 10 elephants were successfully immobilised and radio-collared.

There was no serological or molecular evidence from elephants of infection with endotheliotropic herpes viruses. The blood chemistry values from immobilised elephants were within the clinically normal values for cholesterol, triglycerides, creatine, sodium, iron and total protein while slight increases were noted for alkaline phosphates (AP), lipase, urea, potassium and calcium and a slight decrease was noted for α-amylase, bilirubin and aspartate amino transferases (AST). Sperm count and sperm motility of the Likuyu male were excellent after collection by electro-ejaculation. The Ndalala bull was darted shortly after he had mated with the cow, which accompanied him. His well-developed accessory sex glands were found empty during the transrectal ultrasound examination. Based on this result he was classified as a mature breeding bull. Semen collections from free-living elephants followed by cryo-preservation may have substantial value for assisted reproduction programmes in captive African elephants in European and North American zoos (Hildebrandt et al. 1998).

3.7 Major elephant movement routes

Elephant movement routes were located and identified based on interviews, village discussions and own field-work Three major movement routes were identified along which elephants move from the Ruvuma River to the centre of SNWC (Figure 8). The first movement route started at Lukawanga, about 27 km east of Magazini village, at a junction between the Lukawanga River in Mozambique and the Ruvuma River. This route continued northwards along the Msanjesi, Majimahuu and Matepwende Rivers to the Changalanga and Mtungwe Mountain area in the centre of the corridor. The second route started with four separate crossing points at the Ruvuma River some 14 km west of Magazini village; the area included the Mkasha Mountains, and Lusanyando, Ajemsi and Rutukila along the

Ruvuma River. All these routes join at the Binti Uredi seasonal stream and proceeded north-east via the Namisegu River to join the Lukawanga route. The third route also started in four separate locations, which included a point near the Ndalala River in Mozambique, Binti Hasani, Msawisi and Kipembele Rivers southwest of Magazini village in Tanzania. This route runs north-west to the southern face of London Mountain near Msisima village and also northwards along the Msawisi River to Luyati and Tingilafu Mountains and their associated rivers and forests near Amani village. From here, some elephants were said to cross the Amani–Magazini road to join the Lukawanga route. However, those from the London Mountain and the associated forest were reported to proceed westwards via Nambwela Forest and the Lisugu and Kimbande Mountains and their associated forests to Lukimwa River and Ngoma Litako swamp. They were then reported to change their course northwards by the way of Lukimwa river to Mtelamwahi areas at the centre of the Corridor. Some movements between Ndalala and Mbumule mountains were also reported.

From the centre of the corridor, elephants appear to have four separate movement routes towards the northern end of the Corridor— Malimbani, Nampungu ya Chakame, Ritungula and Sasawala-Lukumbule — that ultimately connect the Ruvuma River in the south with the Selous Game Reserve in the north and Mwambesi Game Reserve in the southeast.

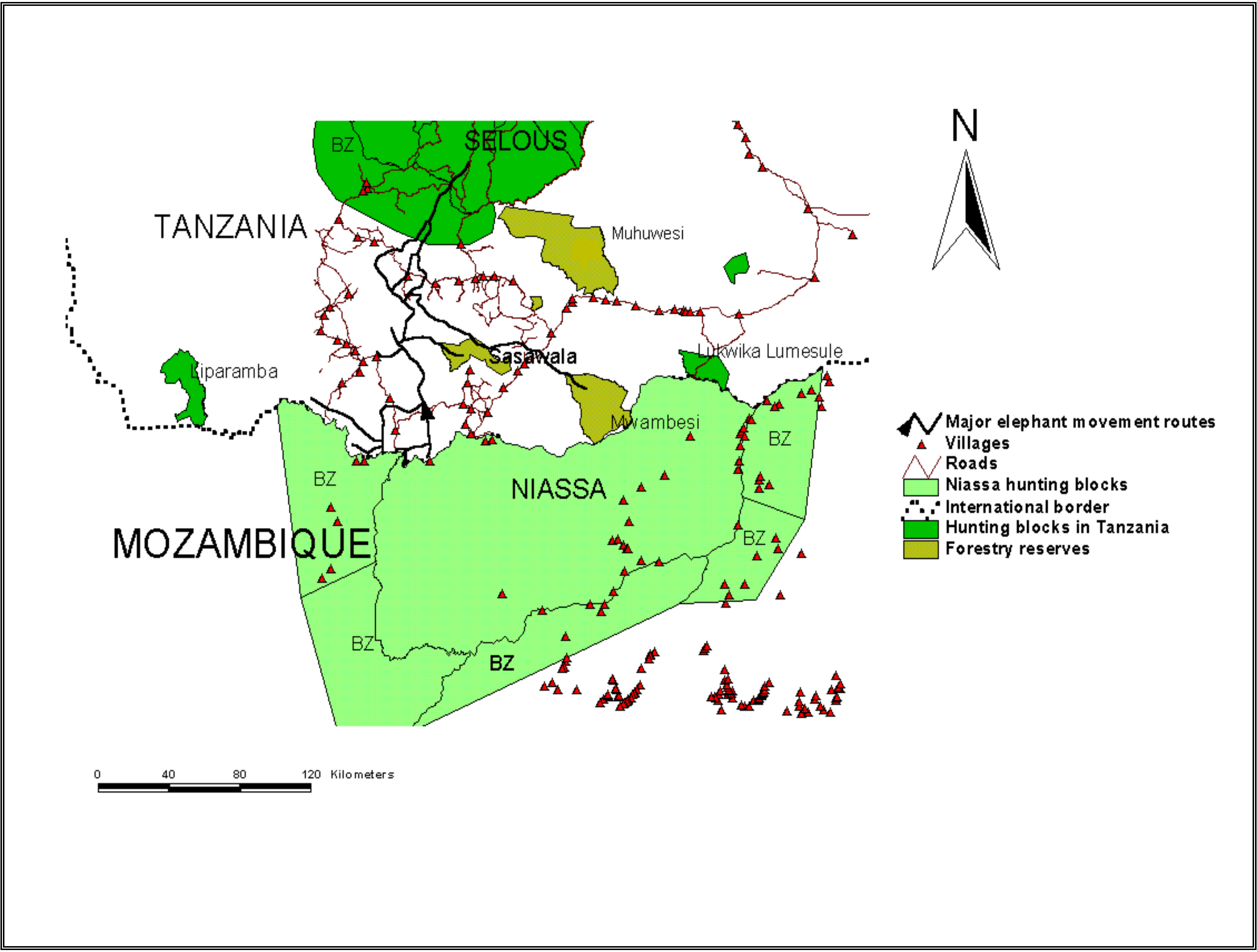

Figure 8: The major elephant movement routes in the Selous-Niassa Wildlife Corridor in southern Tanzania

in relation to the location of roads, villages and local protected areas. Arrows indicate likely continuation of known route, but do not imply direction of movements by elephants.

BZ : bufferzones around Selous are separate from the Game Reserve, around Niassa are part of the Game Reserves.

3.8 Seasonal elephant movements

In all villages, the season when elephants were most likely to appear on village land was reported to be between March and April, at the height of the wet season and the time of peak crop damage. This is the same period during which elephants were also reported to migrate from south to north. North-to-south migratory movements were reported to occur during the dry season between June and December. Key factors responsible for these movements were thought to be the availability of resources such as water, food and, in some places, increased disturbance by people. From early March to the end of April, elephants were thought to be likely to move northwards (upstream) to avoid swollen rivers and flooded wetlands after heavy rain. North-to-south movements were probably triggered by a decline in availability of forage and water. At this time of the year, most trees shed their leaves and the seasonal streams run dry. The major sources of tree foliage and water would then be permanent water sources such as the Ruvuma River, permanent swamps, and some smaller permanent streams. Thus, elephants are expected to concentrate their movements in riverine forests during the dry season.

Interviews also revealed that in Mozambique, elephants were expected to move towards the Tanzanian border during the dry season between June and December. This movement was also linked to a lack of water and food plants, and the frequent occurrence of bushfires in Mozambique. During this time the elephants were expected to cross the Ruvuma River and its associated islands to Tanzania in search of riverine food plants.

Table 9: Major river systems in the centre of the Selous-Niassa Wildlife Corridor associated with elephant presence

River system	Location	Seasonal status	Movement route	Wildlife
Kitwanjati	Western side of Mtungwe Mountain to south and slightly to the eastern side where it joins Lijumu river before entering Msanjesi	Permanent	Between Mtungwe and Msanjesi or Litemela forest and its associated river	Resident and migratory elephant groups of variable size
Litemela	Tributaries start from Ligunga village then run eastwards through a dense forest until it meets the Msanjesi river	Completely dries up during dry season		Resident/migratory elephants and buffaloes stay during rainy season
Nakamu	Along the eastern side of Mtungwe Mountain towards Mtumbitumbi	Permanent in upper parts, dries seasonally downstream	Forms an important link between route from Msawisi to Mtungwe Mountain	Elephants and buffaloes found throughout the year
Msanjesi	In the centre of the Corridor between Mtungwe and Sasawala river	Permanent throughout the year	Forms important link between the elephants from Ruvuma to Kitwanjati, Lihumu, Naluwale, Milia and Litemela	Both resident and migratory elephants are found here. Other animals found here are sable, bushbuck and waterbuck
Luchilikulu	Small tributary originating from Nkalele thicket and draining to Miwawa, which drains into Lukimwa. Situated south of Songea-Tunduru road near Kilimasera on the north, Mtungwe mountain on the far south	Permanent stream, provide permanent food and water to a number of wildlife	Forms a link between Malimbani, Ritungula and Nampungu ya Chakame elephant routes	Migratory and resident elephants are found here. Other species known to be resident are sable, Reedbuck, waterbuck, Buffalo and zebra
Nampungu	Important elephant area is the Kwakundungu swamp and its associated riverine forest	Permanent river	Forms a link between Sasawala, Msanjesi and elephants from Selous and Mwambesi Game Reserve.	Permanent and migratory elephants. Other residents include crocodiles, bush pigs, sable, warthog and migratory groups of buffalo

Both interviews and own field-work suggested that large, permanent river systems are the key habitat for all major elephant movement routes and thus of particular conservation value. Table 9 describes in greater detail several of these river systems in the centre of the Corridor. In addition, one river system in the southern section is worth mentioning, the Msawisi River system. Msawisi river forms an important elephant movement route to Mbumule and London mountains. From here the elephants are reported to continue westwards to Lisogo and Kimbande mountains and its associated forests. It is further reported that, elephants do continue further west to Msanjesi minor, Ditiwi river and Ngoma litako dam.

3.9 Common food plants of elephants

During this study, 31 plant species reported to be consumed by elephants were subsequently identified during field-work. Elephants were reported to forage on leaves, bark, tubers, or whole plants of 20 tree species, fruit of 10 tree species and in one species on both leaves and fruit. Table 10 summarizes details on edible parts, habitat and time of maturation of these plants and their fruits. Apparently, the peak fruiting period of marula (*Sclerocarya birrea*) was associated with seasonal congregations of elephants along those major rivers where the tree is found. Other fruits and plants did not obviously attract elephants in larger congregations.

3.10 Elephant home ranges

Of ten radio-collared elephants, one radio-collar failed but nine animals were tracked for periods varying between 8 and 24 months, covering several natural seasons. Estimated total home range sizes for these elephants in different areas of the Corridor as calculated by different methods are summarized in Table 11. The following guidelines may be helpful in interpreting the advantages and disadvantages of the different methods (Harris et al. 1990):

Table 10: Trees, shrubs and grass species eaten by elephants as food in the Selous-Niassa Wildlife Corridor
as reported by local people.

Scientific name	Common name *	Part consumed by elephant	Habitat	Time of maturity
Acacia brevispica	mtonya (Y)	soft young tips	swamps, rivers	throughout year
Acacia polyacantha (Acacia campylacantha)	mkwanga (Y)	soft young tips	swamps, rivers	throughout year
Acacia robusta	mchongwe (Y)	bark, leaves, preferably the growing tips	swamps, rivers	throughout year
Acacia xanthophloea	mchonge (Y)	bark, leaves, preferably the growing tips	swamps, rivers	throughout year
Bauhinia petersiana	camel foot (E), kitabu ndogo (S)	bark and leaves	open savannah	throughout year
Boscia albitrunca	chiguluka (Y)	whole tree	open savannah, bushland	throughout year
Borassus spp.	mkonda (Y)	Fruit	swamps, rivers	June –November
Brachystegia longiforia	mpapa (Y)	tree bark	widely distributed	throughout year
Brachystegia utilis	miombo (S)	tree bark	widely distributed	throughout year
Burkea africana	mjini (S), mnyongandembo (Y)	bark and leaves, often by old males	widely distributed	throughout year
Catune regum spinosa (Xeromphis obovata)	chisondoka (Y)	fruit	forests, rivers	June –November
Cussonia arborea	mtumbitumbi (Y)	bark	widely distributed	throughout year
Cussonis ssp.	mbutibuti (Y)	bark	widely distributed	throughout year
Diospyros spp.	Msakala (Y)	fruit	along rivers	July – September
Diplorhynchus condylocarpon	mtomoni (S)	tree bark	widely distributed	throughout year
Esente ventricosum	ndizi pori (S)	leaves &fruit	swamps, rivers	March – April
Jurbernadia globiflora	mchenga (S)	leaves & bark	hilly areas	throughout year
Margaritaria discoides	mserechete (Y)	leaves	widely distributed	throughout year
Oxytenanthera abyssinica	mianzi (S)	whole plant, early stage of growth		
Parinari curatellifolia	mbuni (S, Y)	fruits	widely distributed	June –September
Penisetum purpureum	elephant grass (E), matete or mabingobingo (S)	whole plant	swamps, riverbanks	throughout year
Phoenix recliata	mkindu (S)	fruits & leaves	swamps, rivers	throughout year
Piliostigma thonningii	camel foot (E), kitabu kubwa (S)	leaves & bark	widely distributed	throughout year
Sclerocarya birrea	marula (S), nNtondowoko (Y)	fruit	along rivers	March – June
Strychnos cocculoides	madonga (S)	fruits	Everywhere	May
Swartzia madacascariens	mng'eng'e (S, Y)	fruits	scattered	June – October
Tamarindus indica	mkwaju (S,Y)	leaves	scattered	throughout year
Vangueria spp.	mavillo (S, Y), mburugutu (Y)	fruits	along rivers	March – April
Ziziphus pubescens	mpenjere (Y), mraba tatu (N)	fruits	along rivers	March
	kitupa (S)	tuber	swamps	wet season
Artocapus heterophylus	jackfruit (E), maya (Y)	fruits	along rivers	February – April

* Language of common names: Kindendeule, E-English, N-Kingoni, S-Kiswahili, Y-Kiyao.

- The minimum convex polygon method, the oldest and best known method, includes all tracking locations and is defined as the area bounded by the outermost locations linked in a convex way. The MCP method can produce an exaggerated estimate if a few points are well beyond the usual centres of activity.

- The Jennrich-Turner algorithm assumes that animal home ranges generally have an elliptic shape and calculates the size based on an ellipse defined as the area including 95% of data points. Home range sizes may be overestimated if the true shape of the range area differs substantially from an elliptic shape.

- The kernel algorithm does not make an initial assumption about the likely shape of the home range but emphasizes the centres of activity as the basis of the size calculations. When there are large deviations between sizes calculated with different proportions of data points, then comparatively small areas where intense activities take place are scattered over a rather larger area visited much more sparsely.

Home range sizes as calculated by the MCP method varied from 328 to 6,905 km^2. Elephants that were radio-collared in the northern section of the Selous-Niassa wildlife corridor (the Mbarangandu-B and D, and the Likuyu-F) had smaller home ranges than the elephants radio-collared in the central and southern sections of the Corridor. The Msanjesi-J bull (radio-collared in the central area), the Ndalala-H and the Mkasha-G bulls (radio-collared in the southern section) along the Ruvuma River had the largest home ranges.

Table 11: Home range sizes of radio-tracked elephants in the Selous-Niassa Wildlife Corridor

as calculated with the minimum convex polygon, kernel and Jennrich-Turner methods.

Elephant Identification	Total home range by various estimation methods (size in km^2)				
	MCP	Kernel Home Range			Jennrich-Turner
	100%	95%	75%	50%	95% ellipse
Sasawala-A	2369.4	1485.3	390.3	81.5	2495.9
Mbarangandu-B	328.0	238.5	99.6	35.6	309.9
Nampungu-C	1493.8	1098.0	277.3	106.3	1889.9
Mbarangandu-D	548.8	201.1	54.5	20.8	316.6
Likuyu-F	576.3	1197.6	591.1	290.2	1192.8
Mkasha-G	4420.8	2449.4	750.0	165.3	3985.1
Ndalala-H	4610.1	4057.0	1427.2	698.6	5610.1
Sasawala-I	3134.9	1553.2	333.3	79.6	3773.3
Msanjesi-J	6905.1	2663.2	419.4	180.7	7728.8
Means ± SE	2709.5±753	1660.4±410	482.5±13ɛ	184.3±70	3033.6±833

Figure 9 shows the distribution of the home ranges as defined by the MCP method in relation to the major movement routes defined and explained earlier, and the location of villages, roads and all the protected areas in the vicinity of or within the Selous-Niassa Wildlife Corridor. Several conclusions may be derived from the results on the location and size of elephant home ranges in the Corridor:

- Some elephants (both males and females) maintained small or small to medium-sized home ranges throughout the year and should be classified as truly resident, non-migratory animals.
- Home ranges were oriented in both north-southerly direction, expected if animals use the Corridor principally as a transit area or simply follow the main drainage patterns, and in east-westerly direction, more compatible with the idea of a resident existence.

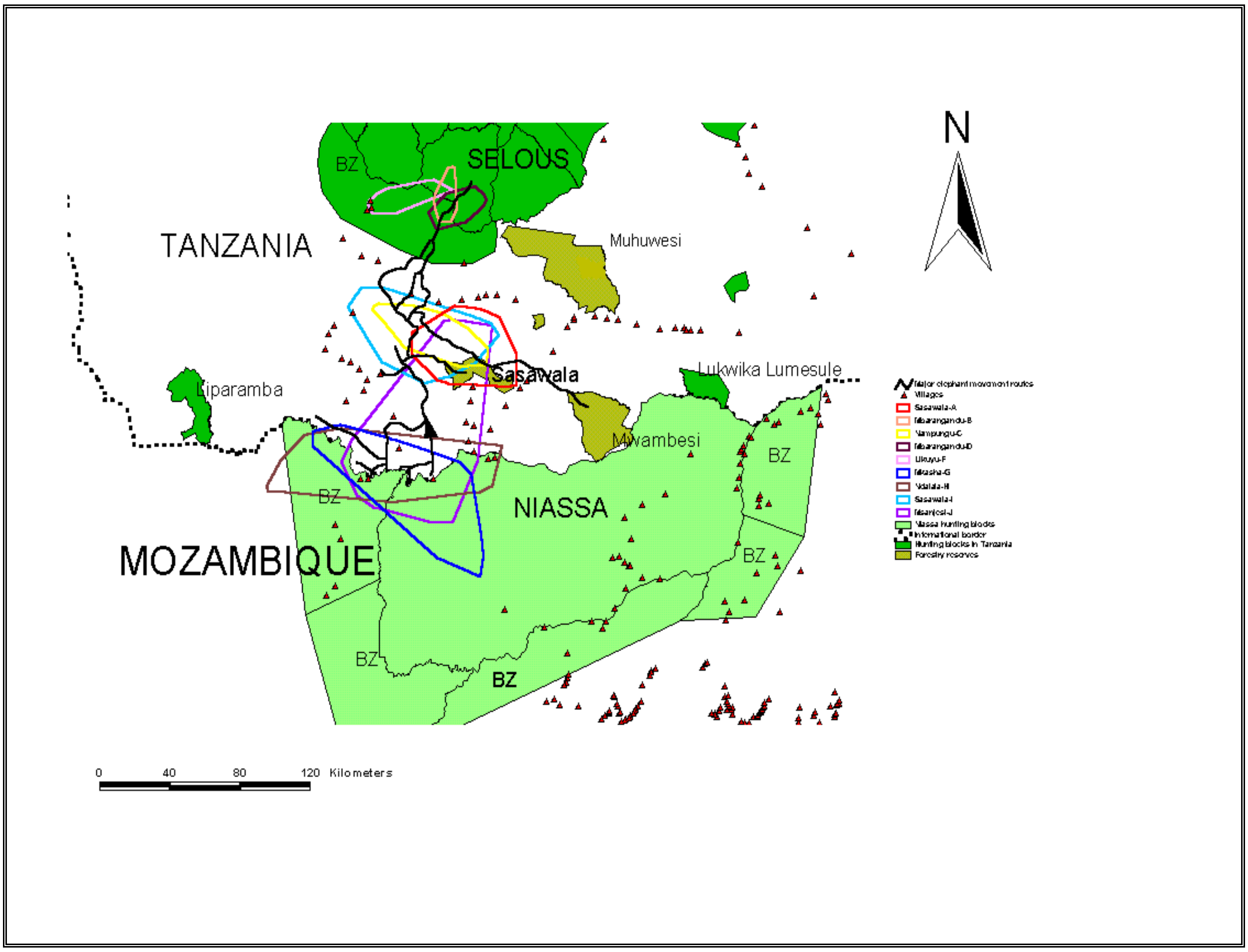

Figure 9: Home ranges of nine radio-tracked elephants in relation to the locations of major elephant movement routes, villages and protected area boundaries in the Selous-Niassa Wildlife Corridor

BZ: bufferzones around Selous are separate from the Game Reserve, around Niassa are part of the Game Reserves.

- Some individual home ranges cover a large section of the Corridor, covering an area from the Songea-Tunduru road that divides the Corridor into the smaller northern and larger southern section to areas south of the Ruvuma River.
- Several animals spent time regularly inside the Corridor and the adjacent Game Reserve, the Selous in the north and the Niassa in the south.
- Particularly large breeding bulls frequently switched between the southern sections of the Corridor and large parts of the Niassa Game Reserve inside Mozambique.

During the wet season, home range sizes as calculated by the MCP method varied from 181 to 4,562 km^2 ($n = 8$). Home range sizes for the dry season varied from 312.5 to 6,784 km^2 ($n = 8$). There were no apparent significant differences between wet and dry season home range sizes. For bull D who was tracked across two full wet seasons, the inclusion of locations from the second wet season led to a modest increase of total range size by 2.2%, suggesting that the animal was truly resident and that there was little change in home range use between subsequent wet seasons.

Home ranges overlapped amongst some individuals in the northern (B, D, and F), central (A, C, I, J) and southern (G, H, J) section of the Corridor. There was little overlap between the core areas of the home ranges of the three elephants in the northern section. For instance, although the overlap of the home ranges between B and D was substantial, the overlap of the core areas comprised only 0.2 km^2 or 1%. There was also no overlap of the core areas of the home ranges of the four individuals in the central section of the Corridor.

3.11 Elephant travelling distances

The summary of the total distances travelled by individual elephants throughout the study period, the maximum distance and the average distance moved between successive locations are summarised in Table 12.

Table 12: Total distance travelled, maximum and average distance moved between successive tracking locations for elephants radio-collared in different areas of the Selous-Niassa wildlife corridor.

Individual identification	Total distance travelled (km)	Maximum distance moved between successive locations (km)	Average distances moved between successive locations (km)
Sasawala-A	2763.0	41.1	3.2
Mbarangandu-B	869.8	10.6	1.4
Nampungu-C	685.0	37.7	3.1
Mbarangandu-D	2115.5	25.7	2.6
Likuyu-F	345.0	33.5	14.4
Mkasha-G	3918.8	57.4	4.1
Ndalala-H	1459.0	56.6	7.5
Sasawala-I	2525.2	35.2	3.4
Msanjesi-J	2403.7	103.0	5.2
Mean±SE	1898.3±385	44.5±9	5±1.3

The three individuals in the northern section of the Corridor did not move extensively. They utilised areas in and around the Selous Game Reserve and the adjacent buffer zone. Three of the four individuals in the central section showed extensive movements along mostly east-west directions covering the Sasawala Forest Reserve, some parts of Nampungu river and areas adjacent to Mtelamwahi village. One bull showed extensive southward movements to Mozambique. Similarly, the two bulls in the southern section exhibited extensive cross border movements between Tanzania and Mozambique (Figure 10). All these movements appeared to tally well with the previously described major elephant movement routes.

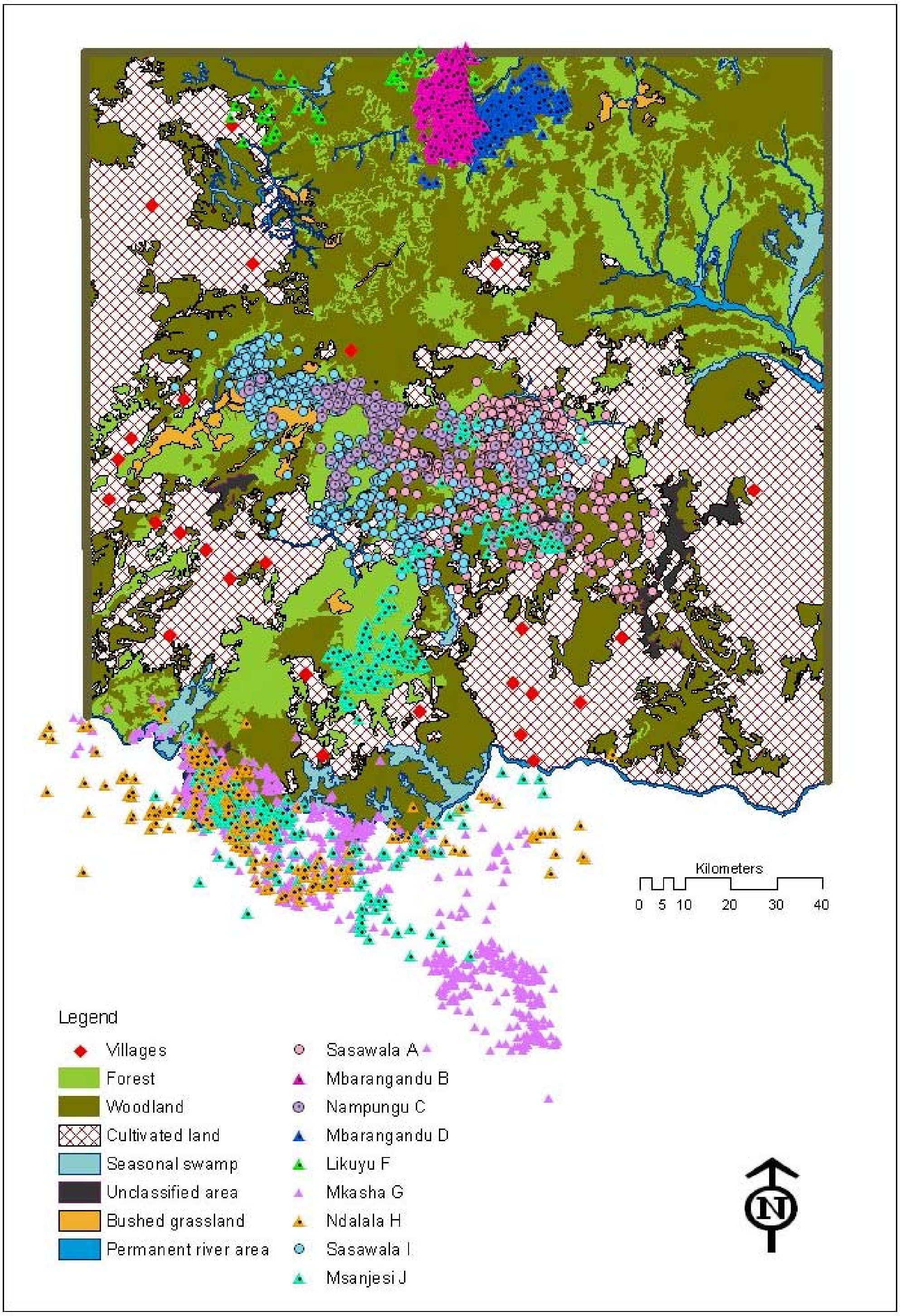

Figure 10: All tracking locations of 8 radio-collared elephants in the Selous-Niassa Wildlife Corridor

3.12 Habitat selection and utilisation by elephants

During the present study, an area of 26,687 km^2 was considered as available habitat to the radio-collared elephants on the Tanzanian side of the Corridor, to which the analysis of habitat preferences was restricted. The most dominant component (42%) was miombo woodland. Cultivation covered the second largest area (34%), forests constituted 18%, swamps covered 2.4% and bushed grassland and riverine environments each comprised 1.7%. Approximately 1.2% of the area belonged to other habitat categories ("unclassified").

Habitat preferences were analysed separately for wet and dry season. During the dry season, elephants significantly preferred river, bushed grassland, forest and woodland. They also significantly avoided cultivated land. Swamps were used in accordance with their availability. During the wet season, elephants expressed a strong preference for bushed grassland; other preferred habitats included forests and rivers. They also significantly avoided swamps and cultivated land, whereas woodland was used as expected from its availability.

Did elephants change their habitat preferences between dry and wet season? Preference for both miombo woodland and swamps declined in the wet season: miombo ceased to be a preferred habitat, being used according to its availability, and swamps were actively avoided. Preference for bushed grassland, already a preferred habitat, increased. Although still a preferred habitat, use of riverine environment declined, and cultivated land; already a significantly underselected habitat was even more strongly avoided.

4 Discussion and Recommendations

4.1 Status and distribution of elephants

The wider Selous ecosystem is one of the strongholds of elephants in Tanzania, where over half of the country's elephant population is found (Blanc et al. 2002). Like many other elephant populations in Africa, the Selous population has suffered from severe poaching in the 1970s and 1980s. For example, from 1976 to 1986, the Selous elephant population was reduced from 110,000 to 55,000 individuals. By 1989, the population was reduced to about 30,000 individuals (TWCM 1998, Siege 1999). Population size in the Selous-Niassa Wildlife Corridor (SNWC) was unknown until recently (TWCM 1998, CIMU 2001). Given the previous general trend for the wider Selous ecosystem, the strong tradition of elephant hunting in the Corridor, and the wary behaviour of elephants towards people as reported by respondents during interviews and observed during field-work, it is likely that the elephant population in the Corridor also severely suffered. Furthermore, the civil war and political instability in neighbouring Mozambique were certainly not conducive to anti-poaching law enforcement until recently.

This study used several complementary approaches to establish a detailed picture of the current status of the elephant population in the Corridor. The responses from individual questionnaire-based interviews, village discussions, field-work, patrol records of village game scouts, assessment of elephant health status and satellite-based radio-tracking of radio-collared elephants provided a detailed and altogether encouraging picture of the current status:

- At least some elephants in the Corridor, both males and females, are truly resident, non-migratory animals. The Corridor is therefore not just an area of transit for elephants between the two Game Reserves in the north and in the south but it also sustains its own sizable resident population. There are at least 2,400 elephants that are resident or use the Corridor part-time, and the population appears to be currently expanding, with a healthy calf: female ratio and excellent values in terms of the reproductive quality of semen of breeding bulls.

- As the details of radio-tracked movements of individuals particularly in the centre of the Corridor indicated, the biological corridor stretches further in east-westerly direction than initially expected.

- Some elephants make use of large sections of the Corridor by virtue of maintaining very large home ranges. The fact that there are conspicuous and well-established major elephant movement routes that cross the entire Corridor also suggests that some elephants may be entirely transient and use the Corridor to move between the adjacent Game Reserves. Hence, any fragmentation of elephant habitat in the Corridor would be a grave disadvantage.

- Regular movements of animals between the Corridor and the adjacent Game Reserves, the Selous in the north and the Niassa in the south, emphasise the contiguousness of the habitat in terms of its conservation value, and underscores the value of the Corridor for the adjacent Game Reserves.

- Large breeding bulls frequently move between the southern sections of the Corridor in Tanzania and large parts of the Niassa Game Reserve inside Mozambique. Not only does this emphasise the status of the Corridor as a true trans-boundary ecosystem, it also pinpoints the value of the Corridor as a link between the Selous and the Niassa elephant populations in terms of breeding and genetic exchange.

4.2 Surveying wildlife: comparing low tech and high tech approaches

Conventional field surveys of wild animal populations are expensive, time consuming and require a high degree of technical expertise. In this study a low technology approach to assess the status and distribution of wildlife of the SNWC was compared with the results of a conventional aerial survey. The low-tech approach consisted of interviewing people and using indigenous knowledge to score the presence or absence of wildlife on village lands. The results showed that elephant, sable antelope, warthog, eland and duiker appeared to be abundant and widespread whereas species such as reedbuck, bushbuck, hippo, Liechtenstein's hartebeest and zebra seemed to be rare and restricted in their distribution. Buffalo and greater kudu were reported to occur in specific parts in both the northern and southern sections of the Corridor. The interviews also suggested that the SNWC supports a large population of Roosevelt's sable antelope, consistent with the general distribution of this species in the greater Selous ecosystem as derived from repeated aerial surveys, where they were present in over 60% of the southern part of the ecosystem (TWCM 1995, 1998).

The qualitative agreement of both "censusing methods" was sufficient to suggest that a preliminary survey using common indigenous knowledge enhanced by additional field-work may quickly reveal the wildlife potential of a particular area. Repeated and sophisticated survey methods may be needed if a quantitative estimate and the tracing of quantitative changes in the status state of wildlife populations is required.
The interviewing technique employed in the present study also had the advantage of identifying the presence of secretive, nocturnal or migratory species that are difficult to record during aerial surveys. For instance, the presence of endangered species such as the African wild dog and large carnivores such as lions, leopards or spotted hyenas were publicly reported and their presence subsequently confirmed from signs encountered during field-work but were absent from aerial census records.

Wildlife monitoring involves a number of different methods including regular game counts and habitat evaluation. A comprehensive assessment of a wildlife population and its status requires the application of several methods to estimate total population size, number of groups, group sizes, male:female ratios, approximate age structure, apparent health status of individuals, reproductive success, home range, movement patterns within the home range, emigration or colonisation of new areas. To achieve this objective, a truly comprehensive commitment in terms of time and resource is inevitable. This has been a limiting factor in many places. Like many other important wildlife corridors in Tanzania, the SNWC is outside the core of protected areas and thus not part of a priority census zone. It is therefore essential to develop a simpler, yet sustainable and effective monitoring method that will enable a reasonable long-term understanding of the population dynamics of key wildlife species and provide the basis for informed management decisions.

Presently, the villages in the northern section of the SNWC near the Selous Game Reserve practise community-based wildlife management. These villages trained groups of village game scouts (VGS) in basic anti-poaching (Mahundi 2001). The game scouts were also trained to collect basic ecological data during routine monthly anti-poaching patrols. Continuous data collection as a basis for wildlife management was therefore feasible in principle. This study was therefore also interested in assessing how valuable such patrol records can be in terms of ecological information.

The patrol records provided reasonable information on average group sizes and basic information on population structure (age-sex classes) in highly conspicuous species such as elephants. However, some of the VGS elephant sighting data lacked consistency and were difficult to interpret. This was because the initial training emphasised anti-poaching activities. Records can be improved by designing a protocol that combines the direct observation of encounters with elephant groups with indirect methods (dung count) of elephant monitoring, as suggested by Burnham et al. (1985) and Kangwana (1996). Such data can be regularly collected throughout the year by the village game scouts.

The patrol records also do not constitute a comprehensive survey of the relevant habitats, since the likelihood of patrolling an area depends on accessibility in terms of terrain topography and the distances involved, as acknowledged by the scouts themselves. In that sense, patrols can be considered transects in some but not all habitats, and are unlikely to provide a reliable estimate of total wildlife species diversity.

4.3 Elephant home ranges and movements

Previous status survey of African elephants by Said et al. (1995) and Barnes et al. (1998) mentioned the possibility of cross-border movements of elephants between Tanzania and Mozambique. The ground observations and the satellite-based tracking confirmed nine such crossing points at which elephants from either side were observed to cross the Ruvuma River.

The three groups of elephants radio-collared in the northern, central and southern sections of the Corridor showed distinct and different home range characteristics. The northern individuals had predominantly small home ranges, showed substantial degree of home range overlap and a modest overlap of their home range core areas. The central group had medium-sized home ranges, overlapped substantially but showed no overlap of the core areas of their home ranges. None of the four bulls radio-collared in the central section of the SNWC had its core area within the Sasawala Forest Reserve (SFR). The southern individuals had the largest home ranges, and yet showed the greatest overlap of their core areas.

Previously recorded home range sizes of African elephants varied from 15 to 8,700 km^2, a 600-fold difference, recorded in a wide variety of habitats by several methods across a range of African countries (Table 13). Discussions on explaining such variation considered differences in methodology, the absence or presence of what were considered migratory movements as a consequence of marked seasonal environmental changes, differences in the productivity of habitats, and the protected status of some of the areas where elephants were tracked. For instance, all elephants previously reported to have small home ranges were only found in protected areas. In comparison, the results from this study demonstrate substantial range variation within the same study population, namely a 20-fold variation in range size, from fairly small (328 km^2) to large ranges (6,905 km^2), in one habitat, and that was a habitat – miombo woodland – not previously studied. Whether such variation in one study area was a consequence of improved technology, studying elephants in a novel habitat type or an increased sample size remains presently unclear. Alternatively, it may reflect differences in space use strategies between individuals that by the standards of other studies would be classified as resident and migratory, respectively.

In terms of movement patterns, elephants in the present study might be classified as residents (in the northern and central sections of the SNWC), and partially migratory in the case of individuals moving extensively between Tanzania and Mozambique in the southern section. The results from satellite-based telemetry demonstrated extensive movement of elephants towards the end of dry season and limited mobility during the wet season. During this time, elephants appeared to stay at specific locations. For example, the core areas of the wet season home ranges of some individuals were localized near agricultural fields, suggesting an interest in crop raiding in these animals.

The extensive movements of elephants during the late dry season have previously been associated with a search for new growth and fruiting plants (Haltenorth and Diller 1986).

Table 13: Home range sizes of African elephants

Study area	Country	Study method	Home range size (km^2)	Reference
Lake Manyara NP	Tanzania	Individual recognition	15-52	Douglas-Hamilton (1971, 1973)
Tarangire NP	Tanzania	Individual recognition	330	Douglas-Hamilton (1971)
Serengeti NP	Tanzania	Individual recognition	> 330	Douglas-Hamilton (1971)
Tsavo West NP	Kenya	Individual recognition	350	Leuthold & Sale (1973)
Kruger NP	South Africa	Individual recognition	436	Hall-Martin (1984)
Tsavo NP	Kenya	Individual recognition	1,532	Leuthold (1977)
Tsavo East NP	Kenya	Individual recognition	1,580	Leuthold & Sale (1973)
Northern Namib Desert	Namibia	Individual recognition	1,763-2,944	Viljoen (1989)
Laikipia Samburu	Kenya	VHF radio collars	102 – 5,527	Thouless (1996)
Amboseli NP	Kenya	VHF radio collars, aerial surveys	2,756; 3042; combined 3,588	Western & Lindsay (1984)
Waza NP	Cameroon	Argos satellite collars, VHF radio and visual observations	785-2,534	Tchamba et al. (1994)
Etosha NP	Namibia	Argos satellite collars	5,800-8,700	Lindeque & Lindeque (1991)
Tarangire NP	Tanzania	GPS satellite collars	159-660 (N) 2,104-3,314 (S)	Galanti et al. (2000), TMCP (2002)
Selous-Niassa Wildlife Corridor	Tanzania	GPS/ARGOS satellite collars	328 – 6905	This study

NP – National Park; N – north; S – south.

During interview and village meetings, elephants were reported to proceed from south to north between March and April and from north to south between June and December. However, this idea did not conform with the results of the satellite-based tracking where southward movements of elephants were observed during March. Movements were also reported to be influenced by the peak fruiting period of major stands of marula (*Screlocarya birrea*) trees along the Ruvuma River between March and June. Again, the satellite-based tracking did not reveal the predicted large-scale movements during this period.

Movements towards marula stands by local groups of elephants were, however, repeatedly confirmed by ground observations and frequent sightings by village game scouts, officials from the SGR and the district game office (Nakambale & Madatta, pers. comm.).

4.4 Habitat use by and preference of elephants

The Selous-Niassa Wildlife Corridor is characterised by the presence of many permanent rivers and streams that provide food, water and shelter during the dry season. During the wet season, water and forage were available ad libitum and elephants do not depend on rivers or riverine vegetation, and favour instead the nutrient-rich plants in bushed grassland. Interestingly, radio-collared elephants avoided cultivated areas. Three reasons might explain this phenomenon:

- During the peak harvesting season (March to May), many people stay on guard on their farms and fields. This may stop elephants potentially interested in agricultural crops.
- The bushed grassland highly preferred by elephants is not used by people and occurs at long distances from villages, thus reducing the chance of encounters with people and increasing the cost for elephants to move to cultivated areas.
- The presence of natural river barriers close to the villages in the southern section of the Corridor reduces the chance that elephants cross during the wet season, as water levels are high. For instance, three bulls (Ndalala, Mkasha and Msanjesi) crossed the Ruvuma River to Mozambique only during dry season when the water level was low, whereas during the rainy season at high water levels they remained on the Tanzanian side.

These factors are consistent with the sporadic nature of crop raiding incidences by elephants reported during questionnaire surveys and village discussions and the low incidence of apparent crop damage caused by elephants.

The results suggest that bushed grassland, rivers and riverine vegetation, seasonally also woodland, forests and swamps are likely to be habitats crucial for the continued existence of elephants in the Corridor. Conservation effort should therefore be focused towards protecting these habitats as core protected areas supported by surrounding buffer zones or dispersal areas of woodland and forest habitats (Sarunday & Ruzika 2000). Bushed grassland and riverine habitats constituted only 3.4% of the total habitat available to elephants in the Corridor, yet their highly preferred nature makes it likely that encroachment of these areas by human settlement, cultivation or other development activities may result in intensified human-elephant conflict in future.

4.5 Corridors and population persistence

Where critical areas for survival of wild animals outside protected areas such as breeding sites, movement corridors, dispersal areas and foraging grounds have been neglected, land-use conflicts have intensified and considerable loss of biodiversity has occurred (Kideghesho 2000). Degradation within and around protected areas may therefore affect the rate of extinction of some populations and species, particularly large mammals and other animals that require habitats beyond protected areas (Wilfred & Ruzika 2000). In Tanzania, the areas of Serengeti, Ngorongoro, Lake Manyara, Tarangire, Arusha and Kilimanjaro are reported to have lost most of their wildlife movement corridors and dispersal areas (Mwalyosi 1991, Kideghesho 2001a-c, 2002), and as a result a number of large mammal species have been reported to become locally extinct in some places (Newmark 1996, Gamasa 1998, Silkiluwasha 1998).

Many human development activities are reported to be detrimental to elephant habitats. Construction of roads, railways and human settlements are activities that are likely to impede the movements of elephants (Johnsingh & Christy-Williams 1999). Already the Songea–Tunduru main road crosses the SNWC. Its impact, however, is currently minimal as elephants traverse the road at different sites. Human habitation and expanded agricultural activities between Mchomoro and Kilimasera and between Kilimasera and Hulia have already increased the number of incidents of conflict between people and elephants (Hahn 2001, N. Madatta pers. comm.). Similar phenomena are very likely to occur between Magazini and Amani, Magazini and Likusanguse and between Ligunga and Amani at the southern end of the corridor. Uncontrolled wildfires, poaching, fishing and encroachment along the Ruvuma River will ultimately prevent the movement of elephants and other wild animals between Tanzania and Mozambique. The long-term effects will include genetic isolation, habitat degradation within reserves by large herbivores such as elephants and intensify the conflicts between people and wild animals in adjoining areas. Genetic isolation of wildlife populations may also increase the likelihood of inbreeding and reduce the chance of population persistence (Soulé et al. 1979, Hudson 1991, Burkey 1994, Newmark 1996, Hanski & Gilpin 1997), even for wide ranging species such as the African wild dog and elephants that live at comparatively low densities (Cross & Beissinger 2001).

4.6 People and wildlife

The results from this study provide a sketch of the extent and likely development of human- elephant conflict (HEC) in Songea Rural (Namtumbo) District, including the western section of the SNWC. However, it should be noted that the data presented here were not systematically collected and may underestimate the real problem of HEC. Recently, a comprehensive and standardized protocol for collecting HEC data and analysis has been developed (Hoare 1999) that is currently being tested in some areas of the Selous Game Reserve in Tanzania (Dublin 2003). It is therefore appropriate to adopt a similar protocol to permit an in-depth analysis of the HEC situation in future work. Such a protocol has the advantage that it provides a basis for comparison with other data collected elsewhere and eventually may be integrated with a GIS (Hoare 1999).

In the present study, the major causes of reductions in crop yield were weeds, crop diseases and "small animal" pests (rodents and birds). Damage by elephants and other larger mammals appeared to be minimal. However, elephants were feared because of their principal ability to sweep an entire farm in one attack and because they were not deterred by most traditional methods of deterrence. This appeared to be the reason for regular reports of elephant raiding to the district game office. Crop damage by small mammals appeared to be tolerated partly because the farmers themselves easily managed them and partly because when small mammals were caught they served as a source of protein in an area where livestock is rarely kept.

Presently, a large proportion of villages appear to have no clear guidelines on how people may acquire land for subsistence farming. Land is typically acquired by bush clearing or inheritance.

People are also increasingly returning to their old hamlets (mavunduni) from where they were moved away during the villagisation process (ujamaa) between 1973 and 1974 (Malocho 1997). As a result, management of crop raiding mammals in mosaics of isolated plots is often uncoordinated and complicated.

Previous wildlife censuses (TWMC 1995, 1998, CIMU 2001) reported large numbers of wildlife outside the Selous Game Reserve (SGR). This increase might be due to the recent strengthening of anti-poaching surveillance inside the SGR by the SCP programme and outside the SGR by the village game scouts in their respective Wildlife Management Area (WMA) pilot projects in the buffer zone. As a result, animal populations (1) may be expanding and (2) individual animals may have lost some of their fear of people and thus move more freely into areas where they have not been sighted for many years (SCP/GTZ 1999, Siege 1999, Siege and Baldus 2000). At the same time the human population expands (Mwamfupe 1998, SDDP 1998) and thus the demand for land for development activities at the expense of wildlife habitats may increase. If wildlife populations are currently expanding in size and moving into new habitats and the human population does the same, competition for resources between people and wildlife will undoubtedly increase, and thus we are more likely to see cases of human wildlife conflicts in the future.

Recently, the Wildlife Policy of Tanzania (WPT) published by the Government of Tanzania in 1998 presented elaborate strategies for community participation in the management and utilisation of wildlife resources outside core protected areas (Severre 2000).

The objectives of the WPT for community participation included the promotion of conservation of wildlife and its habitats outside core protected areas by establishing WMAs, transfer of management responsibility of WMAs to local communities, thus taking care of corridors, movement routes and buffer zones, and to ensure that local communities obtain substantial and tangible benefits from wildlife conservation. Concerning the problem of conflicts between people and wildlife, the WPT stated that the responsibility of solving such conflicts should be devolved to local communities. The WPT (1998) also committed itself to encourage alternative strategies that reduce conflicts between people and wildlife, thereby opening avenues for research and the implementation of other methods deemed appropriate for Tanzanian conditions.

Such methods could include:

- incorporating the numbers of animals shot on problem animal control into hunting quotas for the communities so that they provide a greater economical benefit to the community;
- ensuring that the individuals most affected by the problem animal are the main beneficiaries of the revenue earned from wildlife, as suggested by the current CBC statutes since equitable distribution of costs and benefits (including revenue) should be clearly defined by the village constitution (Severre 2000);
- exploring the use of control methods, which rely on mechanical and electrical deterrents and are non-lethal, including, where practical, capturing and translocation of high value wild mammals.

In line with the WPT (1998), the Ministry of Natural Resources and Tourism launched Wildlife Management Area (WMA) regulations in 2003 to enable participation by local communities in the conservation of wildlife. These regulations prescribe the procedures and criteria for the establishment of WMAs. An important element to ameliorate possible conflicts between people and wildlife is a land use plan, since a key factor promoting conflict between people and wildlife is improper land use. Shifting cultivation and unplanned settlements may become a major problem where there is no such land use planning. Therefore a land use plan is a requisite component for the establishment of a WMA; it makes it binding for communities to carry out development activities only in areas set aside for that particular purpose. Proper land use planning should also encourage the establishment of buffer zones in areas adjacent to already existing core protected areas and that set aside appropriate wildlife corridors and dispersal areas will greatly reduce the likely contacts between people and wildlife and thus contribute to a decrease in human-elephant conflicts and other forms of conflicts with wildlife. If properly implemented, WMA schemes have the potential to make communities important partners in conservation, and communities will likely benefit when they declare wildlife conservation as a form of land use of their designated village land.

4.7 The future conservation status of the SNWC in southern Tanzania

The SNWC is an important biological area and has great potential for wildlife and its conservation. One line of evidence is that the SNWC harbours important populations of two species on the IUCN Red List, the African elephant (Vulnerable) and the African wild dog (Endangered). At present, the Selous Game Reserve and the adjoining village wildlife management areas protect the northern section of the SNWC. The larger, southern section of the SNWC currently lacks any kind of official protection, and hence may be vulnerable to all sorts of unsustainable use of wildlife. In recent years, human activities such as cultivation and tree felling have expanded in the central and southern part of the SNWC (personal observations; CIMU 2001). New villages also emerge in some important sections of the Corridor and close to elephant ranges and movement routes and human activities along the Ruvuma River are on the increase (personal observations). These are mainly unlicensed fishermen and illegal hunters that are thought to operate freely in the area. The same apparently also applies in some parts on the Mozambiquan side despite law enforcement efforts and the protected area network there. These activities are likely to continue to exert constant pressure on elephant groups, which range in the central and southern sections of the SNWC. There is also some evidence that elephants and key movement routes are affected by the continuous and nearby presence of people in the central and southern sections of the SNWC.

Despite these worrying signs, the current situation in this corridor is considered to be much better than in many other corridors in Tanzania (Noe 2003). At the end of this study, most recognised movement routes and important elephant crossing points in key locations are still intact and frequently used by elephants. If, however, the utilisation of wildlife resources continues unhindered and perhaps even expands in some areas in the southern and central sections of the Corridor, that use must be considered unsustainable and may in the long run jeopardize the continued existence of the SNWC as an intact ecological system.

The current initiative of the WPT (1998) is to encourage all stakeholders, particularly local communities, in the conservation and management of wildlife resources, by establishing wildlife management areas as a new category of protected area, where local people have a full mandate of managing and benefiting from conservation efforts. The WPT also emphasised trans-boundary cooperation with neighbouring countries in conserving migratory species and trans-boundary ecosystems. During this study, all critical elephant movement routes along the Songea–Tunduru main road were identified. Through the efforts made by the Selous Conservation Programme, a workshop including all stakeholders was conducted in Ruvuma Region to include the two districts falling within the SNWC.

The district commissioners of Songea and Tunduru, and the district game, forestry, bee, fishery, agriculture and livestock officials and the councillors, village chairpersons and other district and village officials from villages in the SNWC attended the workshop. Other delegates came from the United Nations Development Programme (UNDP), its Global Environment Facility (GEF) and the Niassa Game Reserve in Mozambique.

During this meeting it was agreed that areas already identified as important elephant movement routes should be protected and kept free from human development activities. It was further agreed to incorporate this decision in village bylaws. Through this decision, the Litungula elephant route was saved from total obstruction, as encroachment was already severe, and inhabitants of Mwembenyani village shifted voluntarily to the nearby villages of Hulia, Kilimasera, Pachani near Milonde, and Matemanga.

This study was part of a wider assessment of the SNWC to provide baseline data for planning and implementing a conservation and development project for the SNWC with the aim to protect and manage the southern part of the corridor through a network of village Wildlife Management Areas. A project by the Wildlife Division of the Ministry of Natural Resources and Tourism, GTZ, the Global Environmental Facility (GEF) and UNDP has been jointly planned. The project has recently been agreed and accepted, and implementation is envisaged to start in May 2004. This study has been instrumental for the preparation of this corridor project. Insofar, the research has been directly useful for the long-term conservation and management of elephants and other wild animals in the SNWC.

The goal of the conservation and development project is to protect the wildlife corridor by having the local communities participate and benefit from sustainable utilisation, and to combat trans-boundary elephant poaching. Benefits could include

- a legal supply of game meat obtained through annual hunting quotas for each participating village;
- the empowerment of participating villages to protect themselves and their property against problem and crop-raiding wild animals;
- generating cash income for community projects from sustainable use of wildlife through photographic or hunting tourism;
- the provision of employment for youths as village game scouts.

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Appendix

SCIENTIFIC NAMES OF WILDLIFE SPECIES

Common name	**Scientific name**
Aardvark	*Orycteropus afer*
Baboon, Yellow	*Papio cynocephalus*
[Cape] buffalo	*Syncerus caffer*
Bushbuck	*Tragelaphus scriptus*
Bushpig	*Potamochoerus porcus*
Cane rat	*Thyronomys swinderianus*
Civet, African	*Civettictis civetta*
Crocodile	*Crocodylus niloticus*
Duiker, Common	*Sylvicapra grimmia*
Eland	*Taurotragus oryx*
Elephant, African	*Loxodonta africana*
Francolin	*Francolinus* spp.
Guineafowl, Helmeted	*Numida meleagris*
Hare, African	*Lepus capensis*
Hartebeest, Liechtenstein's	*Alcelaphus buselaphus lichtensteinii*
Hippo	*Hippopotamus amphibius*
Hyena, Spotted	*Crocuta crocuta*
Impala	*Aepyceros melampus*
"Jackal" [black-backed or side-striped]	*Canis mesomelas* and/or *adustus*
Klipspringer	*Oreotragus oreotragus*
Kudu, Greater	*Tragelaphus strepsiceros*
Leopard	*Panthera pardus*
Lion	*Panthera leo*
Parrot, Brown-headed	*Poicephalus cryptoxanthus*
Porcupine, Crested	*Hystrix cristata*
Reedbuck, Common	*Redunca redunca*
Rhinoceros, Black	*Diceros bicornis*
Sable antelope, Roosevelt's	*Hippotragus niger roosevelti*
Vervet monkey	*Cercopithecus aethiops*
Warthog	*Phacochoerus aethiopicus*
Waterbuck	*Kobus ellipsiprymnus*
Wild cat, African	*Felis lybica*
Wild dog, African	*Lycaon pictus*
Wildebeest, Nyassa	*Connochaetes taurinus johnstoni*
Zebra	*Equus burchelli*