4 RESULTS

4.1 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 3). 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 fieldwork (Table 3).

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 (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 fieldwork 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 the year 2000 reported a clumped distribution of buffaloes (CIMU 2001). A few scattered small groups of buffaloes were seen during the dry season aerial

Table 3: Status and distribution of wildlife species as assessed by village group discussions, 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	Bush pig	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

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 fieldwork, yet a herd of about six individuals was observed by L. Siege (Personal comm. 2001) in the south eastern section of the Corridor near Mkasha Mountain. Bush meat from hartebeest, buffalo and duiker were recovered during fieldwork 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 fieldwork 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. Large numbers of sable antelope were reported to occur almost everywhere throughout the Corridor, an assessment confirmed by regular encounters during fieldwork, and an estimate of a minimum population size of 4,460 animals (Table 3).

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 wildcat and African civet seemed less widespread (Table 3). 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.

4.2 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 3). 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 NGR 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 fieldwork (Table 4) 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).

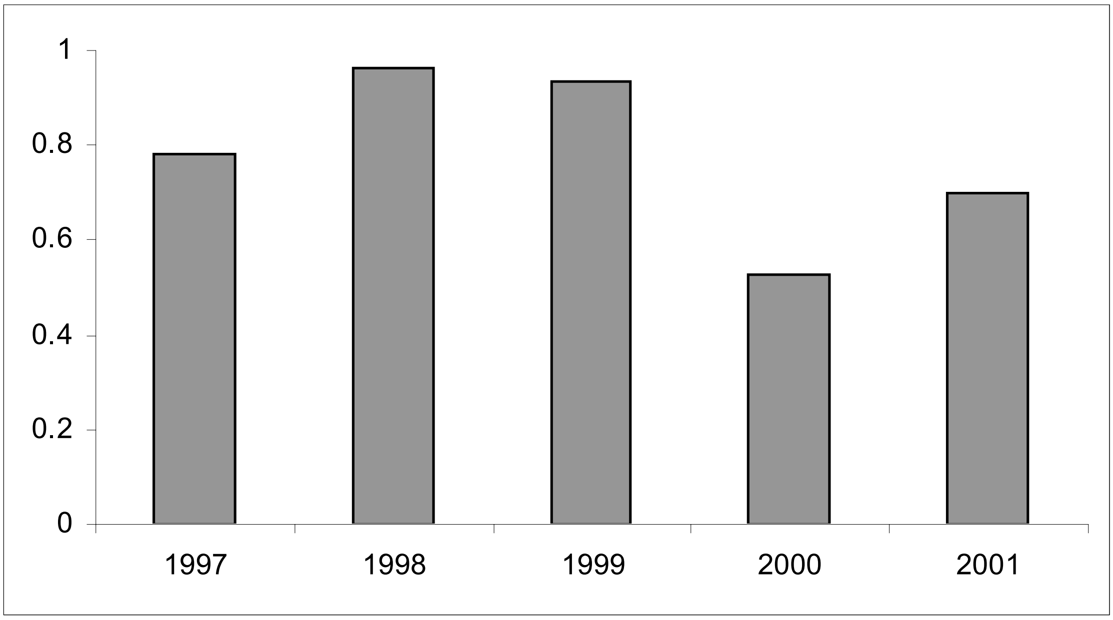

Figure 3: Mean elephant calf: female ratios in six different survey areas of the Selous-Niassa Wildlife Corridor

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

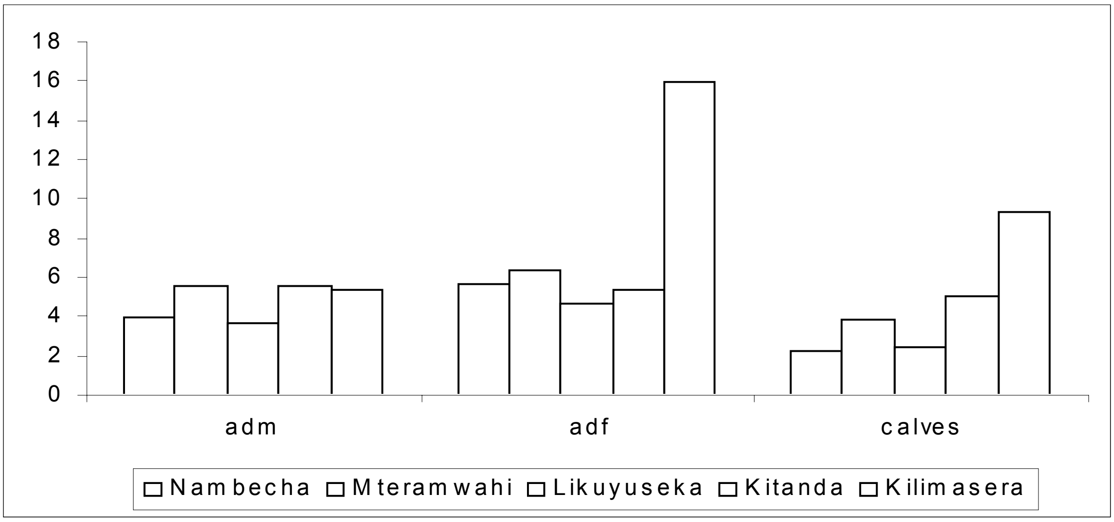

Figure 4: Sizes of different age-sex classes in elephant groups in five different survey areas in the northern and central section of the Selous-Niassa Wildlife Corridor averaged over 5 years between 1997 and 2001. Adm-Adult male, Adf-Adult female.

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).

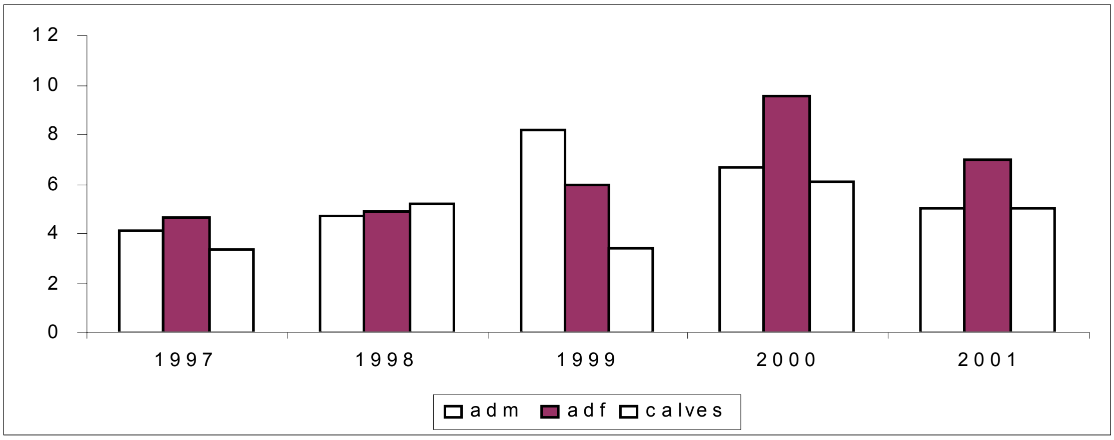

Figure 5: Sizes of different age-sex classes in elephant groups averaged across five different survey areas in the northern and central section of the Selous-Niassa Wildlife Corridor between 1997 and 2001. Adm-Adult male, Adf-Adult female.

Table 4: 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

4.3 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.

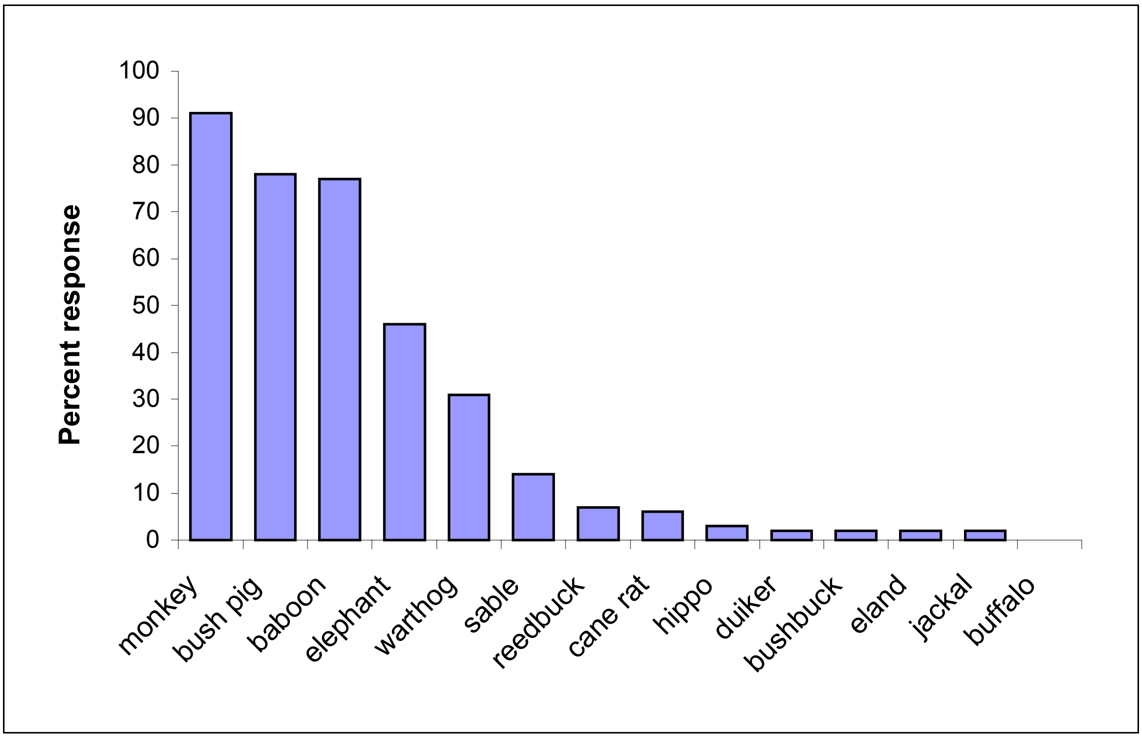

Figure 6: The relative frequency with which wildlife species were mentioned as being involved in crop raiding activities (n = 87).

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 (not mentioned during interviews) are considered problem animal species.

Table 5: 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	Bush pig, baboon, vervet monkey.	Flowering / harvest	Eat 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	Bush pig, 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, bush pig	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
	Bush pig	Harvest	Eat 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

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 5). 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 5 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 Figure 7. 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. 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 6 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.

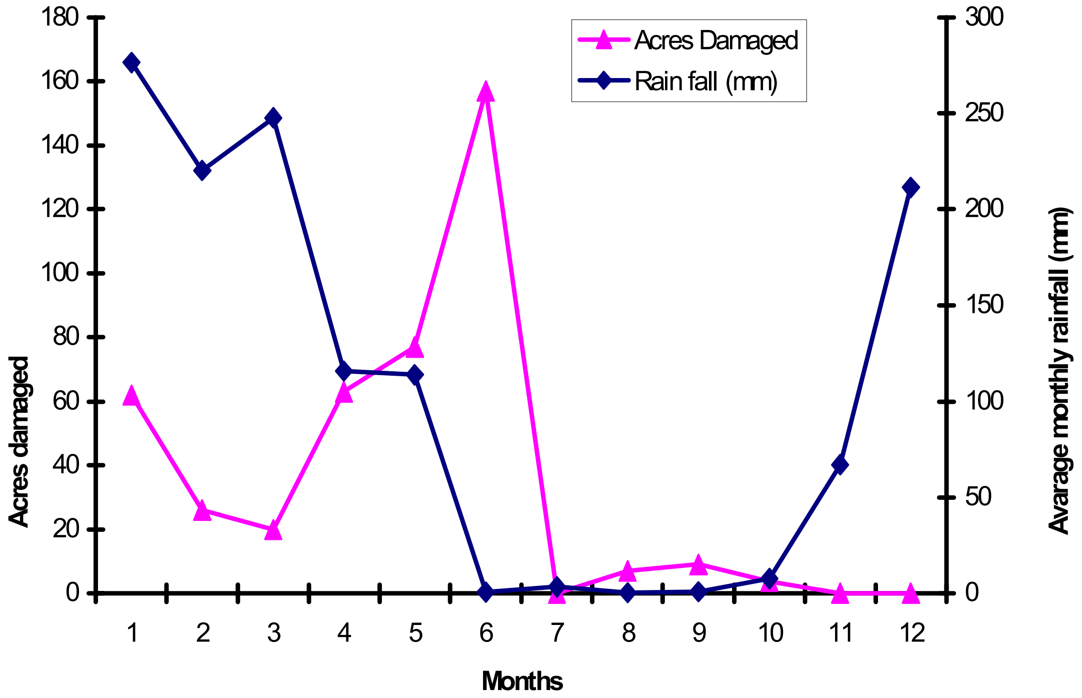

Figure 7: Shows the relationship between monthly crop damage by larger mammals and avarage rainfall pattern in Songea Rural District from 1990 to 2000.

Table 6: Report of hectares of cultivated crop "damaged" by larger wild animal species in Songea Rural (Namtumbo) District from 1990 to 2000.

Crop	"Damage" attributed to specific wildlife species						Total Hectare
	Elephant	Hippo	Eland	Buffalo	Waterbuck	Others	
Rice	45.0	10.8	-	1.2	-	9.6	66.6
Maize	16.1	15.5	1.2	1.8	0.1	8.5	43.2
Banana	4.0	0.4	-	-	-	-	4.4
Tabacco	1.6	6.5	-	-	-	-	8.1
Leguminous plants	1.6	0.2	0.8	1.2	0.3	3.3	7.4
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 Hectare	104.7	34.2	2.0	4.4	0.4	24.2	169.9

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 7 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 SGR (3 villages, 46 cases, and 83.3 ha damaged), those within the SNWC (5 villages, 33 cases, 53.0 ha damaged) and 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

4.4 Attacks on humans and livestock by wildlife

Respondents in interviews claimed that lion, leopard, spotted hyena, African wildcat 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 wildcat 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.

Table 7: Total hectares of mixed crops cultivated and the total hectares damaged by weeds, diseases, "small pest species" (rodents, birds), elephants and other large mammals in Songea Rural (Namtumbo) District 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

Note: ‡The sum of hectares encroached by weeds, diseases and small pest species. †The sum of hectares damaged by elephants, hippo and other large wild animal species.

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 8).

Table 8: Monthly distribution of the number of livestock and companion animals 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

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.

4.5 Wildlife utilization and poaching

Various forms of wildlife utilization 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 field patrol and informal discussions, 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 fieldwork, when signs of poaching activities (Figure 8) were repeatedly observed, particularly in the southern section of the SNWC (Table 9).

Evidence of attempts to poach elephants in the Corridor was observed during fieldwork associated with elephant immobilization. One elephant was observed with a shortened trunk evidently cut off by a snare (Figure 9). 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 NGR retrieved its radio-collar. The collar was located by tracking devices in the air but initial efforts to find it on the ground proved futile. Respondents of interviews stated that professional poachers came from Mozambique and operated in the southern section of the SNWC, 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 8: Bundles of snares collected from a single snare line by Game Assistant, Ally Msusa during fieldwork, in the southern section of the Selous Niassa Wildlife Corridor.

Figure 9: A trunk of a bull traumatized by snare on the southern section of the Selous-Niassa Wildlife Corridor. The wound was cleaned and treated by Oxytetracycline spray

Table 9: 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

4.6 Immobilization and assessment of physical conditions 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 immobilization 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. M99 was therefore used without Stresnil to decrease the recovery time. Four elephants were thus immobilized with a combination of M99 and Stresnil, and eight were successfully immobilized using M99 only (Table 10). Ten out of 12 immobilizations to fit radio-collars were uneventful. Immobilization 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.

Table 10: Date, time, location, sex, type of drug, dose and posture of elephants immobilised in different areas of the Selous-Niassa wildlife corridor in southern Tanzania

Date	Time	Location	HS	Sex	Type of drugs	Initial dose & route	Additional dose & route	Total dosage	Recumbency position	Reversing agent	Other observations
27 Aug 00	2.15 pm	Likuyu	1	M	M99 Stresnil	M 15 mg, S 40 mg IM	M, 1 mg IV	M 16 mg, S 40 mg		M5050 (diprenorphine), 5 ml	Immobilized near Likuyu, fields of the old refugee area.
28 Aug 00	3.07 pm	Mtilandambo	5	F	M99 stresnil	M 12 mg, S 40 mg IM	none	M 12 mg, S 40 mg	semi sternal	naltrexone, 50 mg	Herd a matriarch, one sub adult bull and two calves, found browsing on aquatic plants
03 Sep 00	9.14 am	Mkundi	12	M	M99 stresnil	M 12 mg, S 40 mg IM	M, 1 mg IV	M 13 mg, S, 40 mg	left lateral	Naltrexone, 6 ml	After being darted the animal went into recumbency at the foot of dry-river bank.
04 Sep 00	3.03 pm	Mbarangandu	16	F	M99 stresnil	M 12 mg, S 40 mg IM	3 mg	M 15 mg, S 40 mg	right lateral	M5050, 3 ml naltrexone 1 ml	Single-tusk female with 69 adult elephants and 4 calves were seen in the vicinity.
04 Nov 01	3.23 pm	Ndalala elephant route	5	M	M99	15 mg IM	Nil	M 13 mg	right lateral	Naltrexone 5 ml	Ultrasound examination showed empty ampullae, which signify recent breeding.
09 Nov 01	3.45 pm	Mkasha	1	M	M99	15 mg IM	M 1 mg IV	M 14 mg	right lateral	M5050, 1 ml , naltrexone 5 ml	A small suppurating wound on the lateral medial aspect of the neck on the right side was treated with oxytetracycline spray.
10 Nov 01	11.10 am	Msanjesi	2	M	M99	15 mg IM	M 1.8mg IV	M 16.8 mg	left lateral	M5050, 5 ml	Trunk traumatized by snare; wound was cleaned and treated with oxytetracycline spray
10 Nov 01	2.05 pm	Sasawala Forest	1	M	M99	15 mg IM	Nil	M 15 mg	left lateral	M5050, 5 ml	Animal was aggressive immediately after reversal but was scared by our shooting in the air.
11 Nov 01	11.00 am	Sasawala River	2	M	M99	15 mg IM	Nil	M15 mg	left lateral	M5050, 5 ml	Animal died, trunk partially obstructed by tree, PCV and Hb low.
12 Nov 01	11.00 am	Nampungu	1	M	M99	15 mg IM	2.8mg IV	M17.8 mg		M5050, 5 ml	
12 Nov 01	1.22 pm	Sasawala Forest	1	M	M99	15 mg IM	2.7mg IV	M 17.7 mg	right lateral	M5050, 4 ml	

HS – herd size

The shoulder height was used as index for age group definition (Table 11). The elephants were all categorized as matures (except Mbarangandu-D bull). Maturity was further confirmed by sperm production (Likuyu male) and mating evidence for some individuals e.g. Ndalala bull as manifested by empty accessory sex glands observed during transrectal ultrasound examination. The Ndalala bull was darted shortly after he had mated with the cow, which accompanied him. Based on this result, the Ndalala bull was classified as a mature breeding bull. The two females were accompanied by calves of different ages (Table 10).

Table 11: The shoulder height, sex and age group definition from eleven elephants darted in the Selous-Niassa wildlife corridor in southern Tanzania

Elephant Identification	Sex	Shoulder Height (Metres)	∗Age Group Definition
Sasawala_A	M	2.92	AM
Mbarangandu_B	F	2.32	AF
Nampungu_C	M	3.04	AM
Mbarangandu_D	M	1.90	SAM
Mtilandembo_E	F	2.30	AF
Likuyu_F	M	2.80	AM
Mkasha_G	M	2.59	AM
Ndalala_H	M	2.88	AM
Sasawala_I	M	2.89	AM
Msanjesi_J	M	2.68	AM
Dead Elephant	M	3.00	AM

∗After Du Toit (2001); Shoulder height > 2.3 metre = Adult Male (AM), Shoulder height > 2.0 metre = Adult Female (AF), Shoulder height 1.5-2.3 metres = Sub Adult Male (SAM).

Immobilization and physiological data are presented in Table 12. 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). There was no serological or molecular evidence from elephants of infection with endotheliotropic herpes viruses and foot and mouth diseases.

Table 12: Immobilization, haematology and blood chemistry values in elephants from different areas of the Selous–Niassa Wildlife Corridor in southern Tanzania

	M99, Stresnil (*n* = 3)			M99 (*n* = 6)	Literature values
Immobilization parameters					
Time to first effect (min)	Not detectable, done from the bushy ground			8 (3-20)	
Induction time (min)	10.3 (7–15)			11.2 (5–22)	31 ± 9.1[a]
Recovery time (min)	6.3 (4–9)			4.2 (1–10)	2–5[b]
Total down time (min)	77 (61–106)			72 (50–109)	
Mean heart rate (per min)	64 (50–78)			58.2 (53–65)	72–98[b]
Mean respiration rate (per min)	(4–8)			6.25 (6–7)	4–6[b]
Haematology and blood chemistry	Values from M99 anaesthesia (*n* = 6)	Values from dead elephant	Literature values		Remarks
			Brown and White (1980)[c]	ISIS (1999)[d]	
PCV (%)	45.7 (41-50)	25 ↓	44 (38.2–49)	38.1 (25.7 –52.2)	
Hb (g/dl)	11.7 (9.4–14.4)	8 ↓	14.3 (10.2–17.2)	13 (9.6 –17.8)	
Total RBC (cells/l) $\times 10^{12}$	2.4 (1.6–3.04)	haemolysed	3.6 (2.96–5.02)	3.11 (2.05–4.8)	haemolysed in transit from field
Total WBC (cells/l) $\times 10^{9}$	11.4 (10.1–12.6)	14.4↑	10.2 (9–11)	11.03 (5.6 –19.3)	
Glucose (mmol/l)	4.22 (3.74–5.5)	4.79	-	4.72 (2.28–8.44)	
Alkaline phosphatase (IU/l)	163.2 (103–213)	272	48	186 (64–411)	age & sex variations[c]
Gamma glutamyl transferase (IU/l)	6.8 (4–9)	8	-	13 (3–29)	
Glutamyl oxalo-transferase (AST) (IU/l)	9 (8–14)	10		22 (10–80)	
Glutamyl phosphotransferase (ALT) (IU/l)	3.2 (2–5)	3	3	8 (0–26)	
Lipase (IU/l)	4.5 (4–6)	5	-	0.83 (0.28–1.67)	
Alpha amylase (IU/l)	1473 (1272–1895)	1704	2650	307.1 (68.64–1380)	seasonal variations[c]
Bilirubin (μmol/l)	1.25 (0.51–2.22)	1.03	5	3 (0–9)	seasonal variations[c]
Cholesterol (mmol/l)	1.61(1.24–1.81)	1.45	1.58–2.99	1.99 (0.0–6.06)	
Triglyceride (mmol/l)	0.77 (0.50–0.85)	0.3	0.34–0.59	0.49 (0.19–1.08)	
Creatine (μmol/l)	167.96 (130.83–190.95)	169.73	131	159 (71–513)	seasonal & age variations[c]
Total protein (g/l)	82 (64–97)	79	87	77 (62–96)	
Uric acid (mg/dl)	0.13 (0.1–0.2)	0.1	0.05	0.02 (0.0–0.06)	
Urea (mmol/l)	7.86 (6.43–10)	5.72	3.4–9.5		seasonal & regional variations[c]
Sodium (mmol/l)	129 (94–134)	133	125–137	127 (107–145)	seasonal variations[c]
Pottassium (mmol/l	5.6 (3.7–8.9)	7.6	5.3–6.4	4.9 (3.3–7.9)	seasonal & age variations[c]
Calcium (mmol/l)	2.6 (2.2–2.9)	2.96	2.19–2.91	2.75 (2.38–4.45)	
Iron (μmol/l)	12.66 (8.06–16.66)	14.51		13 (6.265–23.27)	

[a] Douglas (1994), [b] Kock RA et al (1993), [c] Brown and White (1980) references for free-ranging African elephants; [d] (ISIS 1999) reference for captive African elephants. IU/l = international units per litre

4.7 Major elephant movement routes

Elephant movement routes were located and identified based on interviews, village discussions and own fieldwork. Three major movement routes were identified along which elephants move from the Ruvuma River to the centre of SNWC (Figure 10).

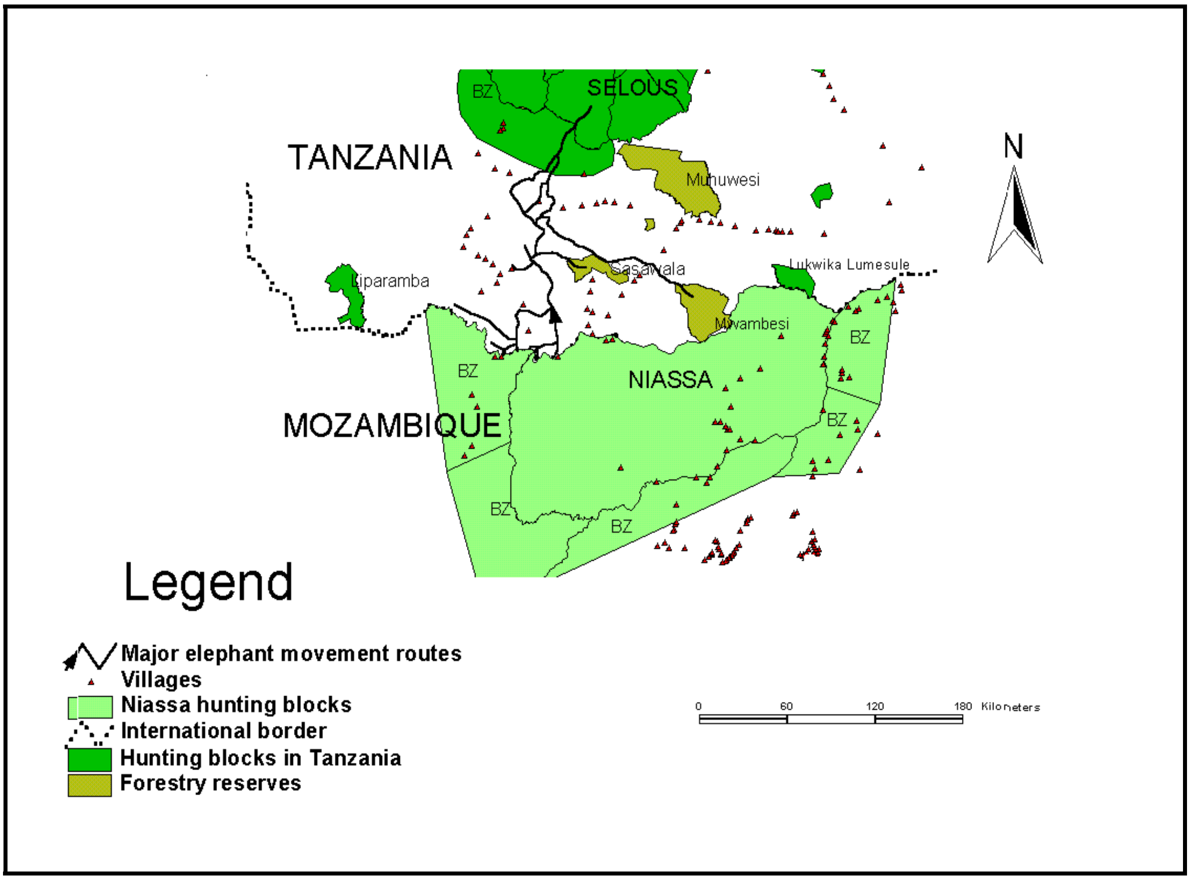

Figure 10: The major elephant movement routes in the Selous-Niassa Wildlife Corridor in southern Tanzania, in relation to the location of roads, villages and local protected areas. Arrows indicate likely continuation of known route, but do not imply direction of movements by elephants. BZ: bufferzones around Selous are separate from the Game Reserve, around Niassa are part of the Game Reserves.

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 east 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 northeast 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 northwest 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 on the southwest portion of the SNWC 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.

The Malimbani elephant route links Mbarangandu in the north and Kitwanjati in the south near Mtungwe (Figure 11). The elephants use nine small tributaries that drain into the Lukimwa River, but they do not follow the main river course. The route crosses the Songea–Tunduru main road between Mchomoro and Kilimasera, about 16 km from Kilimasera.

The Nampungu ya Chakame elephant route, which has its origins on Mbarangandu River catchments, crosses the Songea–Tunduru main road at Mt Kilimasera. It continues south via three important tributaries: Nampungu ya Chakame, Nampungu ya Kalwembe and Nampungu ya Wazee, to the Mbawa River, which drains into the Nampungu River (Figure 12). From here, the route continues via the Luchilikulu River and Nkalela Forest to the upper banks of the Msanjesi River.

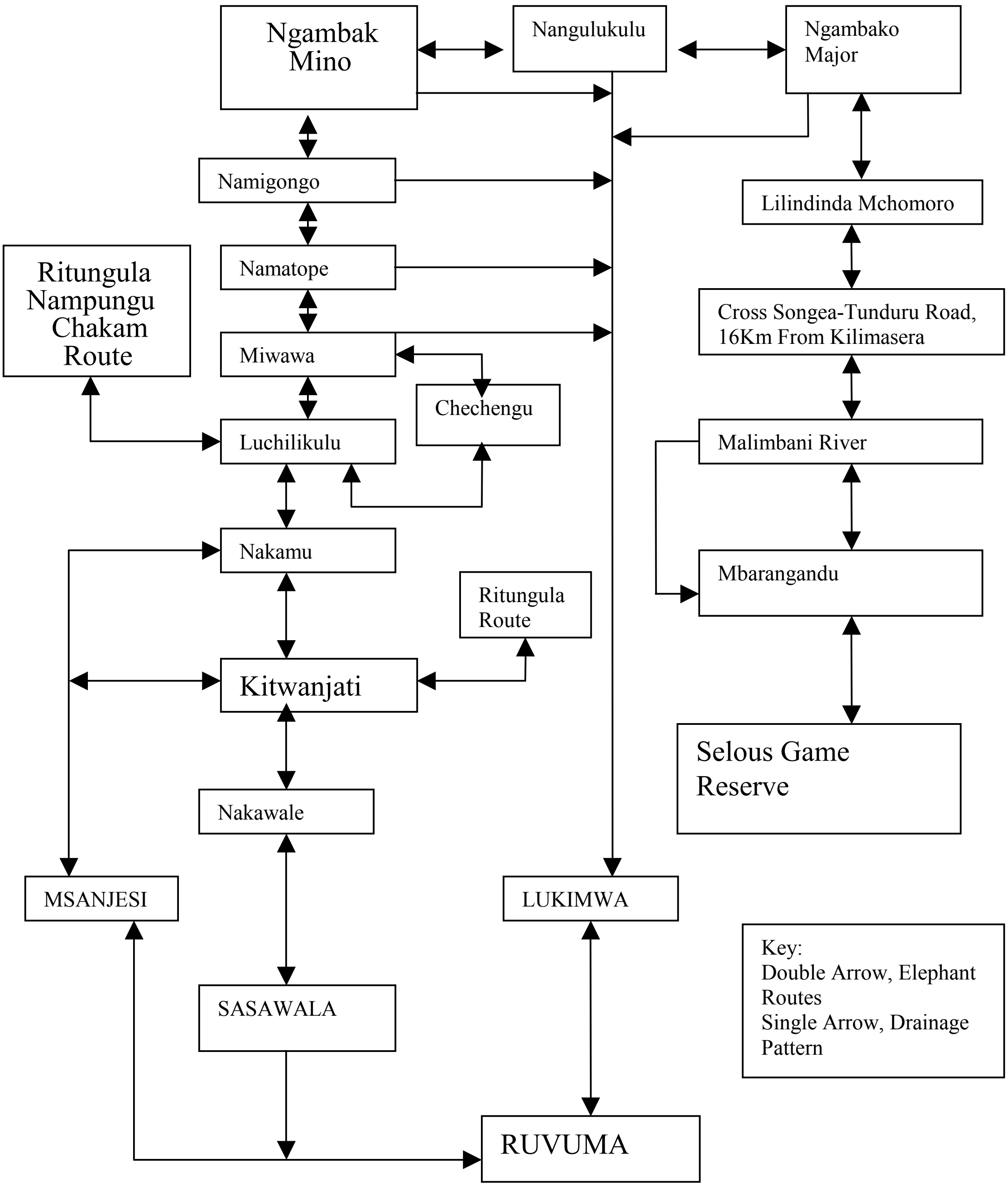

Figure 11: Tree diagram showing the Malimbani elephant route

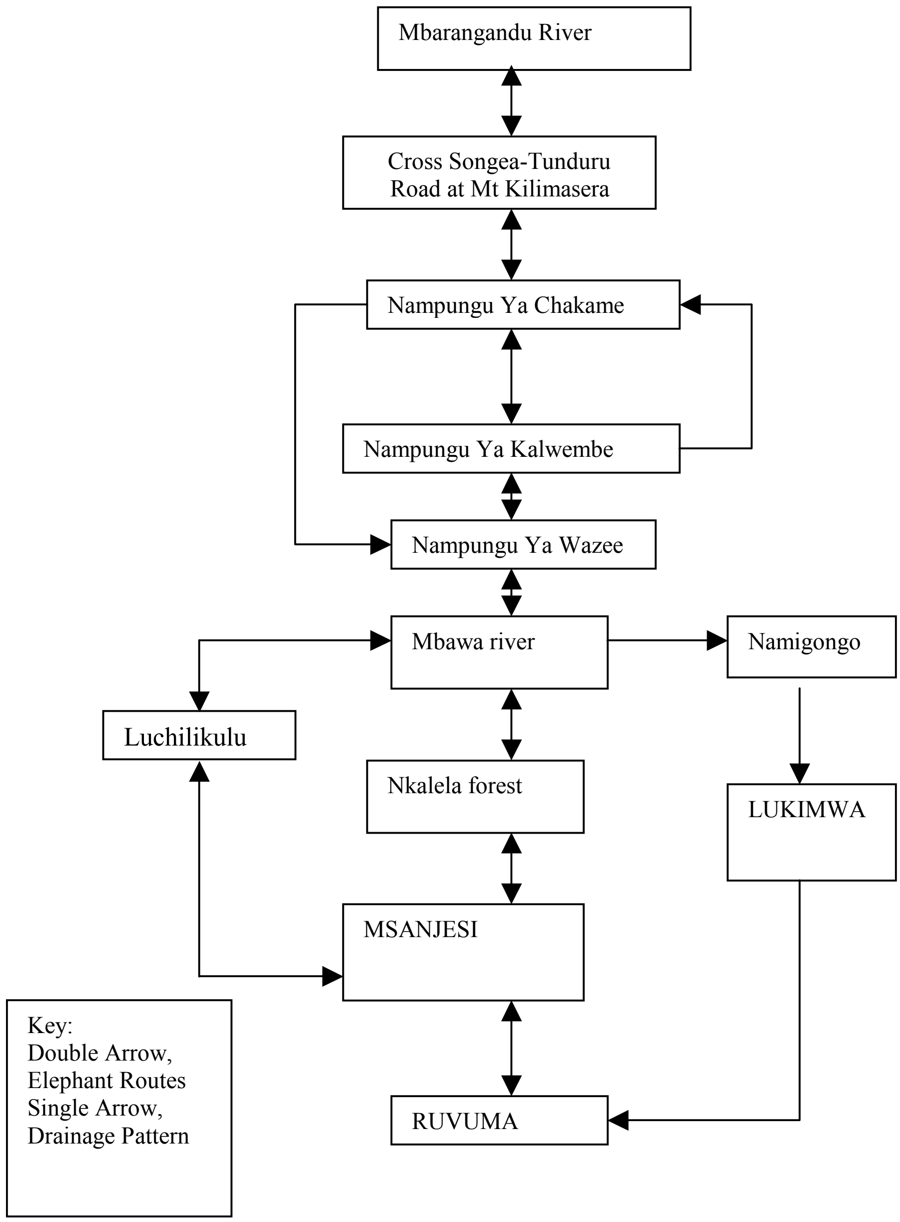

Figure 12: Tree diagram showing the Nampungu ya Chakame elephant route

The Ritungula elephant route broadens as it emerges from SGR. The elephants are reported to follow the Ritungula River or the Muhuwesi River via a series of small tributaries: Manoni, which drains into Mbarangandu, or Miwawa, which drains into Muhuwesi, to Kumbuja (which itself drains into Miwawa). The elephants then enter the Kapesula River and thereafter to Muhuwesi before proceeding to the Ritungula River (Figure 13). The route crosses the Songea–Tunduru main road at Mlima Simba and the former Mwembenyani village near Hulia. The elephants then proceed southwards via a series of three small tributaries draining into the Nakapeye before it enters the Nampungu River.

From Nampungu the elephants raid crops in the nearby villages of Changalawe, Hulia, Nampungu, Namwinyu, Mbatamila and Mnenje. The route continues farther south through Nkalela Forest and Mtumbitumbi and Malisafi Rivers to the upper banks of the Msanjesi River. Nkalela Forest links the Ritungula elephant route with the Malimbani and Nampungu ya Chakame routes via the Luchilikulu River and its associated forest. Another link is reported to exist between Ritungula and Malimbani routes via Kitwanjati River (Figure 11, 12). The elephants are also reported to traverse between Msanjesi and Sasawala Rivers via Nakawale and Namakong streams. Namakong is a small permanent stream draining into Msanjesi. It is known to provide good shelter and grazing ground for elephants and other herbivores year round.

The Sasawala-Lukumbule elephant route uses a series of eight small tributaries draining into Sasawala before it enters Kiumbe Forest, Lukumbule River and the Mwambesi Game Reserve (Figure 14). The Ruvuma River separates Mwambesi Game Reserve from NGR. This route suggests a link between the centre of the SNWC and the eastern territories besides the corridor. Elephants from Mwambesi Game Reserve were reported to have killed one person during April 2001. These animals (a cow and two calves of different age groups) were followed and reported to have gone as far as Nampungu village in the central portion of the corridor.

4.8 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.

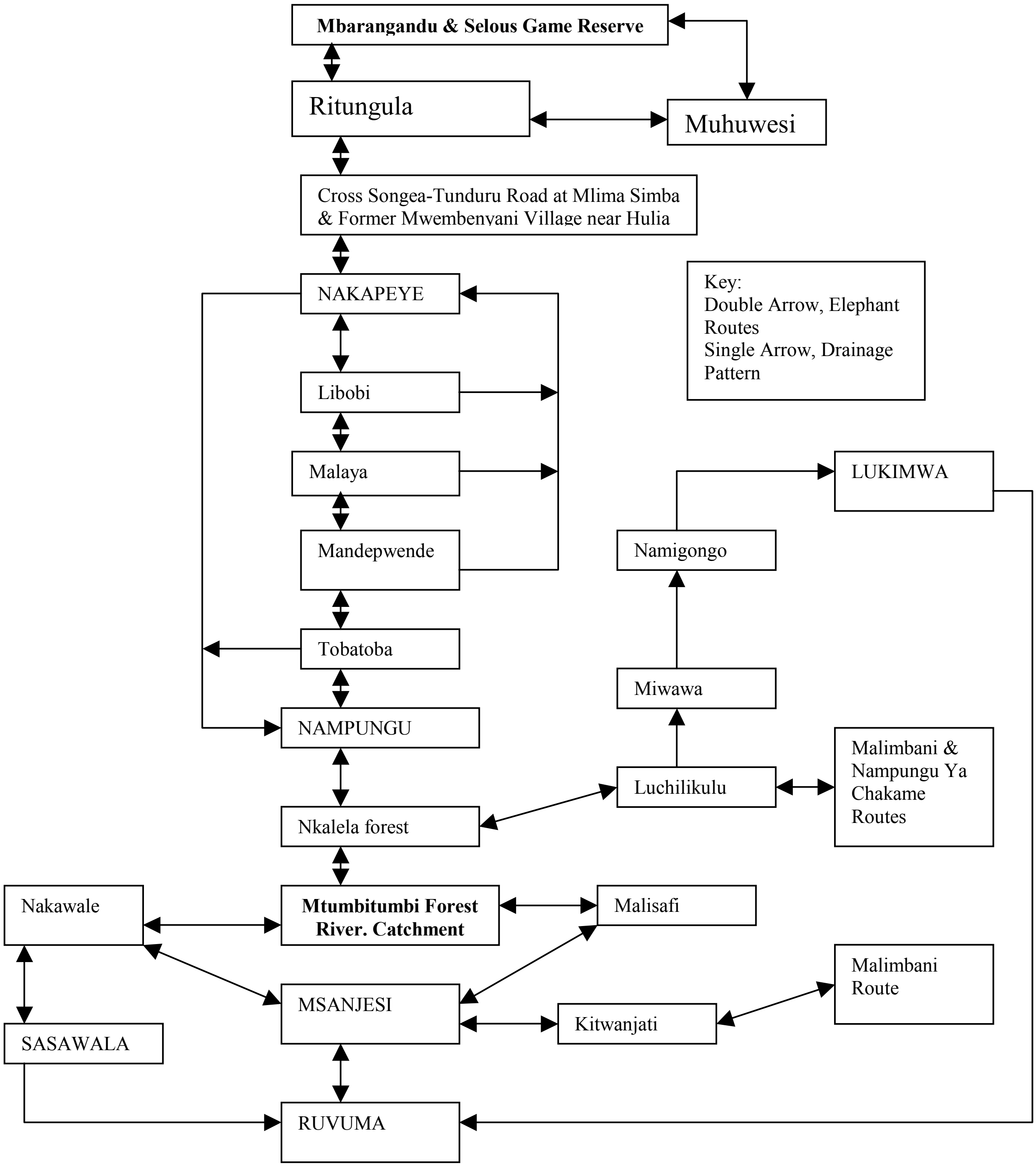

Figure 13: Tree diagram showing the Ritungula elephant route.

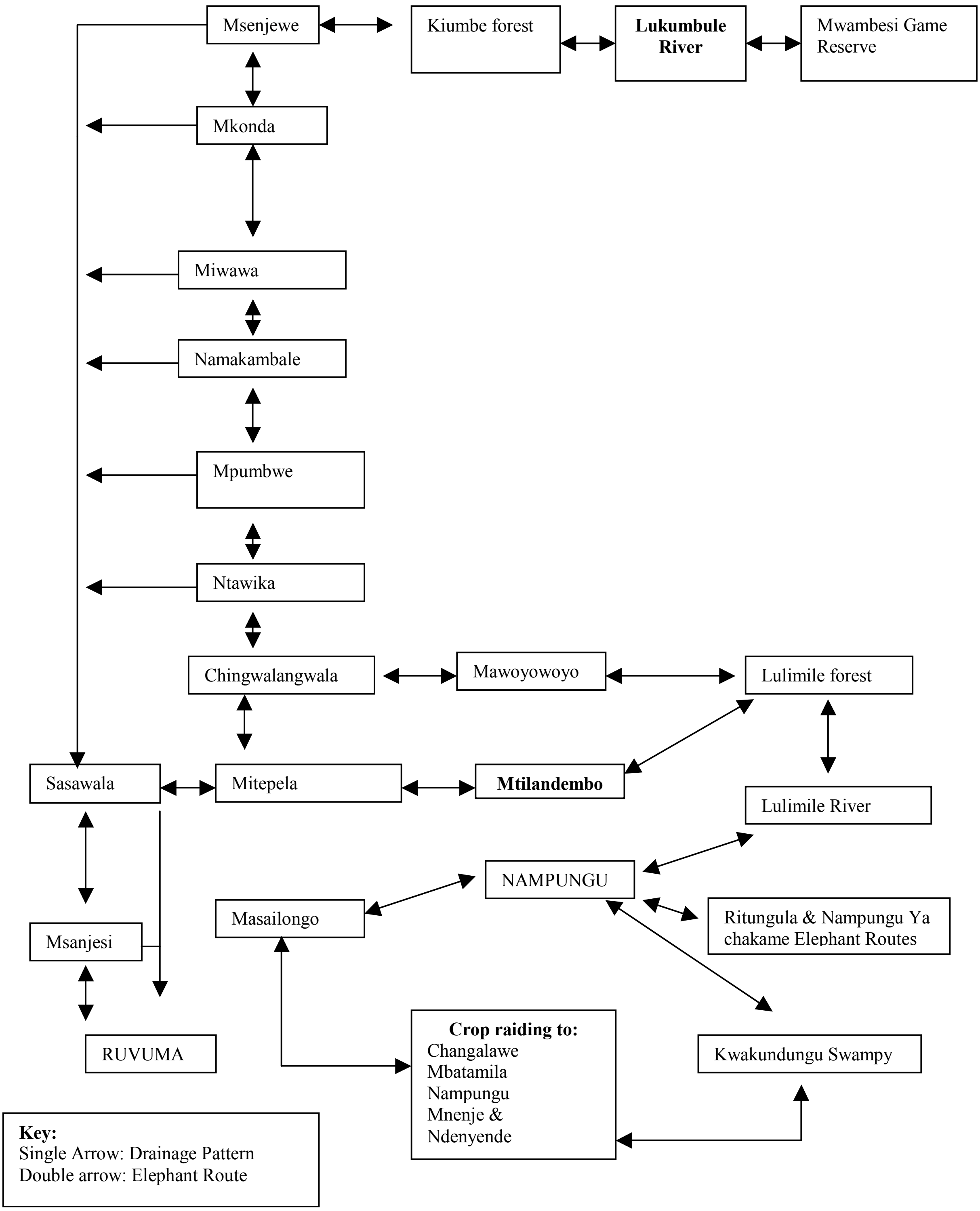

Figure 14: Tree diagram showing the Sasawala-Lukumbule elephant route

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.

Both interviews and own fieldwork suggested that large, permanent river systems are the key habitat for all major elephant movement routes and thus of particular conservation value. Table 13 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.

4.9 Common food plants of elephants

During this study, 31 plant species reported to be consumed by elephants were subsequently identified during fieldwork. 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 14 summarises details on edible parts, habitat and time of maturation of these plants and their fruits.

Table 13: 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 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

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.

4.10 Comparing the GPS and Argos satellite location data

The tracking programme lasted from September 2000 to November 2002. Throughout this time 10 elephants were tracked. Four of them were tracked for two years and six elephants were tracked for one year. The summary of the number of location fixes acquired from the GPS and Argos system and the duration of monitoring period are summarized in (Table 15). The minimum duration of which the GPS functioned was 4 months while the longest duration was 19 months. During this time, a total of 3511 position fixes were acquired from 8 individuals.

Table 14: 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 madacascariensis	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: E – English, N – Kingoni, S – Kiswahili, Y – Kiyao

The minimum duration of which the Argos system functioned was one day while the longest duration was 24 months. During this time, a total of 1419 position fixes were acquired from same 8 individuals. Two elephants had either GPS or the Argos system not functioning while one individual had its radio-collar totally failed. Attempts were made to trace this individual using the VHF radio. Few radio locations and one sighting report was available (Table 15). For each individual elephant, all location fixes acquired from the GPS and Argos system were processed and overlaid separately on GIS where they were inspected for obvious discrepancies. Only two location fixes obtained from the Argos system were considered to be outliers. One position fix was from the Sasawala-A elephant whose point was offset by 45km.

Table 15: The characteristic of the GPS and ARGOS Satellite data acquired from the second generation Telonic radio-collars used on 10 elephants in the SNWC from 2000-2002.

Initial Location and animal identification	Sex	Monitoring period		Months with GPS data	Months with Argos data	Number of location fixes		Total Location Fixes
		Start	End			GPS system	Argos system	
Sasawala-A	M	10112001	21062002	11	11	552	308	860
Mbarangandu-B	F	04092000	26092001	13	1	612	2	614
Nampungu-C	M	12112001	05062002	8	NA	222	NA	222
Mbarangandu-D	M	03092000	08102002	19	24	623	181	804
Mtilandembo-E‡	F	28082000	NA	NA	NA	NA	NA	NA
Likuyu-F	M	27082000	15092002	NA	13	NA	25	25
Mkasha-G	M	10112001	15102002	12	12	608	347	955
Ndalala-H	M	04112001	14092002	4	11	80	163	244
Sasawala-I	M	12112001	15092002	8	11	417	327	744
Msanjesi-J	M	10112001	18092002	11	11	397	64	461

‡Some VHF and citing data available

MCP calculation including this point yielded a home range of 2992.2km2. However, when this point was excluded, the new home range was 2137.7km2. Only this single point caused the massive increase of about 40% of the total home range. The second position fix was from the Sasawala-I elephant and was offset by 76km. Home range calculation including this point yielded a MCP area of 4947.2km2. When this location was excluded, the new home range was 2798km2. This point therefore contributed to about 77% increase to the total home range. These two points were therefore considered as outlier and was deleted. Table 16 shows the duration in months where comparisons were performed within individuals on the number of location fixes and the monthly home range size. One way ANOVA test statistic showed no significant difference (P>0.05) between the monthly home ranges calculated from the GPS and Argos satellite data. The data were therefore pooled and the new total home ranges summarized in Table 17.

Table 16: Comparison between the number of position fixes and the mean monthly home range between the Argos and GPS system from months where both data were available for the elephants radio-collared in the Selous-Niassa wildlife corridor, southern Tanzania.

Elephant Identification	Duration of observation in Months comparison done	Number of position fixes		Mean monthly MCP home range size (Km^2)	
		ARGOS Data	GPS Data	ARGOS Data	GPS Data
Sasawala-A	11	308	552^{***}	487	606.03^{ns}
Mbarangandu-D	19	181	623^{***}	94.33	68.28^{ns}
Mkasha-G	12	347	608^{***}	557.43	563.09^{ns}
Msanjesi-J	11	66	397^{***}	348.80	303.77^{ns}
Sasawala-I	8	248	417^{***}	368.39	360.32^{ns}
Ndalala-H	4	60	100^{ns}	626.21	692.17^{ns}

Note: Highly significant (P<0.001)*** and non-significant (P>0.05) ^{ns} results are indicated

4.11 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 17).

The following guidelines may be helpful in interpreting the advantages and disadvantages of the different methods (Harris et al. 1990):

- 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.

Table 17: 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±138	184.3±70	3033.6±833

*The home range estimate for this animal should be treated with caution because of the small sample size (n= 25). Both MCP and KHR are sensitive to sample sizes (Arthur and Schwartz, 1999, Seaman et al., 1999).

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 km2. 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.

Figure 15 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.

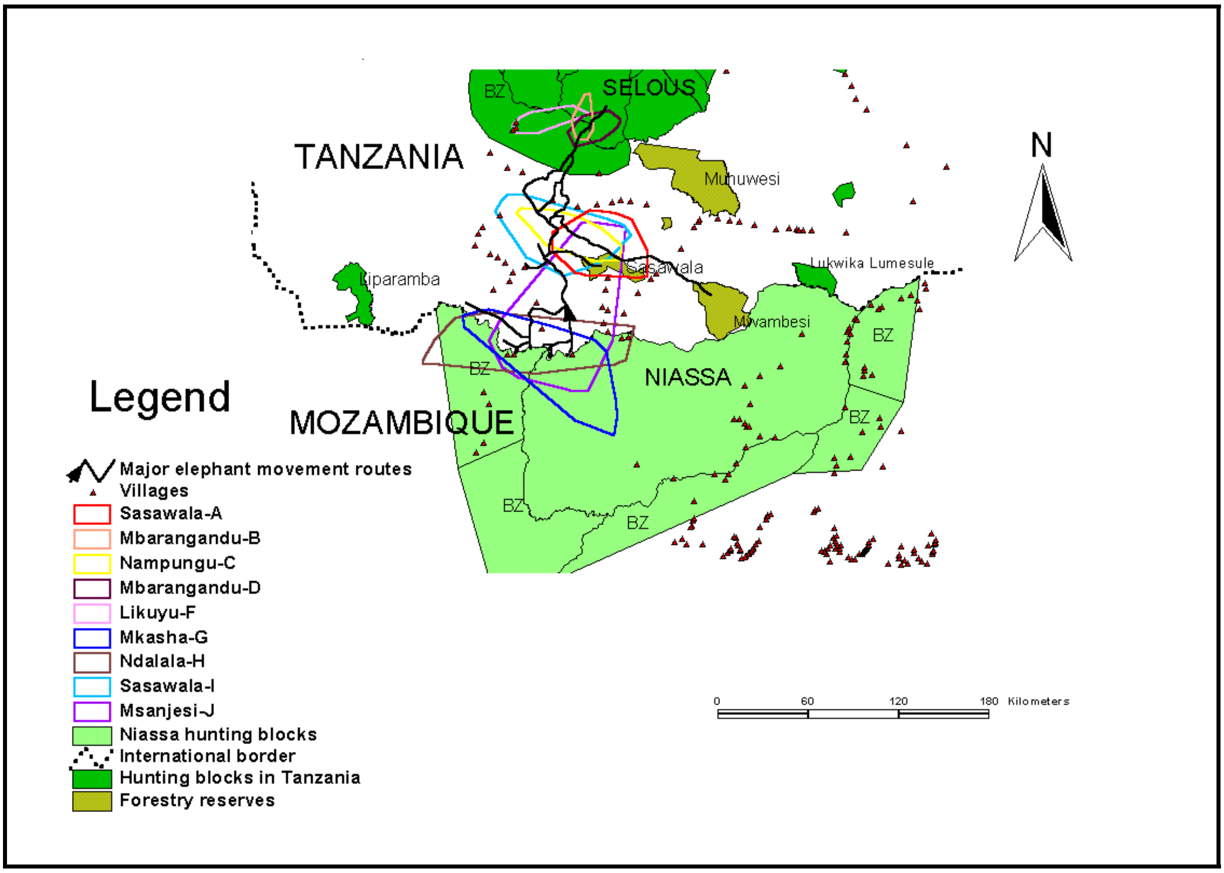

Figure 15: Home ranges of nine radio-tracked elephants in relation to the locations of major elephant movement routes, villages and protected area boundaries in the Selous-Niassa Wildlife Corridor. BZ: bufferzones around Selous are separate from the Game Reserve, around Niassa are part of the Game Reserves.

Several informations 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.

- 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 (F1,4=0.001, P>0.05). 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 home 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 (Table 18).

4.11.1 Cumulative home range characteristics

In order to determine the home range boundaries, the cumulative position fixes were analysed in a chronological sequence and the resultant home ranges were plotted against time. Figures 16 and 17 illustrate these relationships to the period of observation for the elephants radio-collared from the southern and northern sections of the SNWC. These data illustrates that the duration of attaining an asymptote varied considerably between individuals. For example, the B elephant cow maintained stable asymptote right from the first month of observation and continued for considerable time period (Figures 17).

Table 18: Percentage of the total home range overlap of each radio-collared elephant with all other radio-collared elephants from the Selous-Niassa wildlife.

Individual	Home range overlap (%) with other elephants								
Identification	Sasa-A	Mbara-B	Namp-C	Mbara-D	Lik-F	Mka-G	Ndala-H	Sasa-I	Msanj-J
Sasawala-A	100	0	64.2	0	0	0	0	45.2	19.3
Mbarangandu-B	0	100	0	32.4	5.6	0	0	0	0
Nampungu-C	40.5	0	100	0	0	0	0	46.1	10.7
Mbarangandu-D	0	54.2	0	100	0.01	0	0	0	0
Likuyu-F	0	9.8	0	0.01	100	0	0	0	0
Mkasha-G	0	0	0	0	0	100	56	0	30.7
Ndalala-H	0	0	0	0	0	58.4	100	0	39.7
Sasawala-I	59.8	0	96.7	0	0	0	0	100	17.1
Msanjesi-J	56.4	0	49.4	0	0	47.9	59.4	37.7	100

The elephants (A, C, H and I) bulls showed relatively stable home ranges attained within three months of observations and maintained it almost throughout the study period. The elephants (D, G and J) bulls kept on changing their home ranges. The cumulative home range for the elephant E cow and the F bull were not determined because of the poor performance of their radio collars and inconsistency of data acquisition.

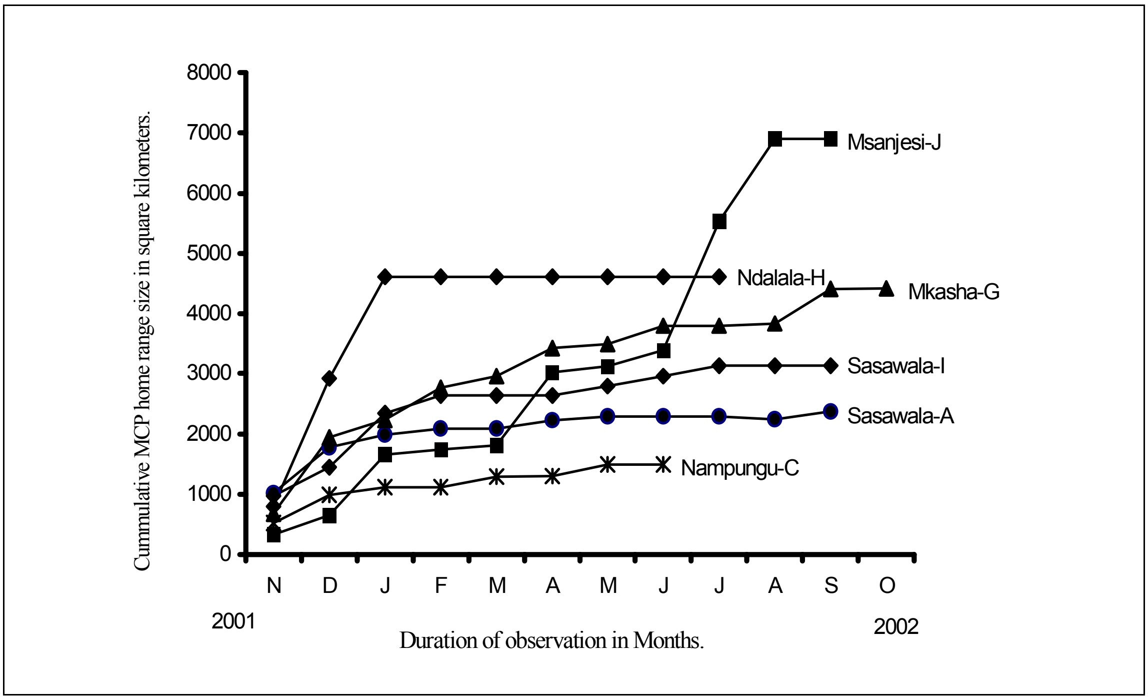

Figure 16: Cummulative observation area curve, illustrating the relationship between home range size and period of observation for six bull elephants radio-collared in the southern section of the Selous-Niassa Wildlife Corridor, Southern Tanzania.

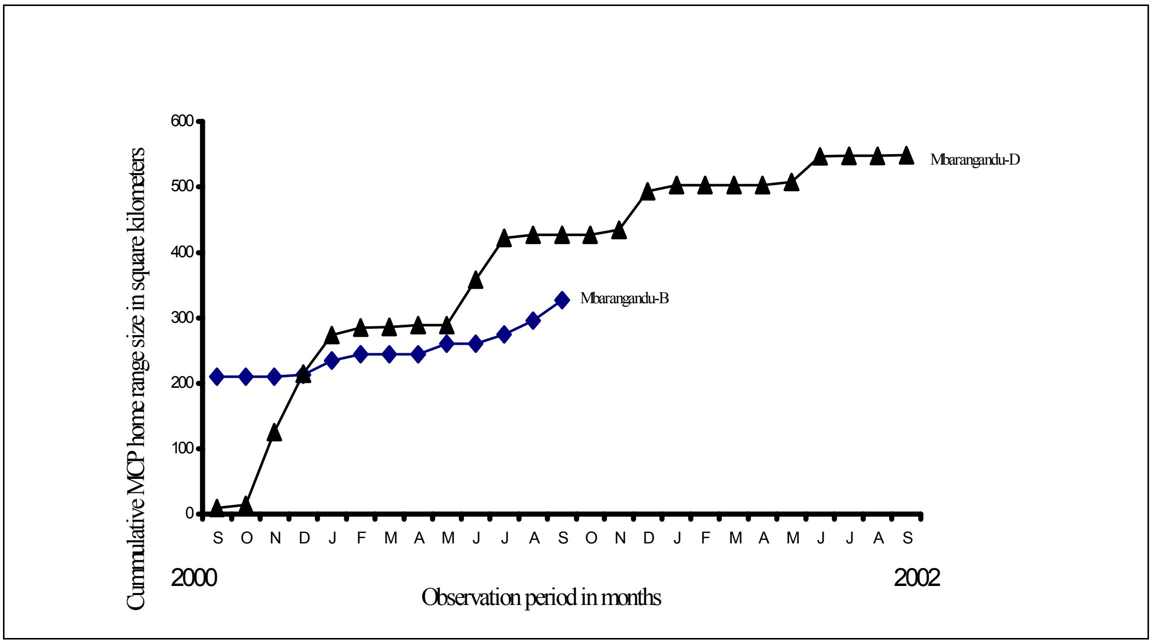

Figure 17: Cummulative observation area curves illustrating the relationship between home range size and period of observation in two elephants radio-collared in the northern section of the Selous-Niassa Wildlife Corridor, Southern Tanzania.

4.12 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 19. It should be noted that, the distances calculations were considered only when location fixes available were ≥ 75% of the total days during that particular month.

Table 19: 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 SGR and the adjacent buffer zone (Figure 18).

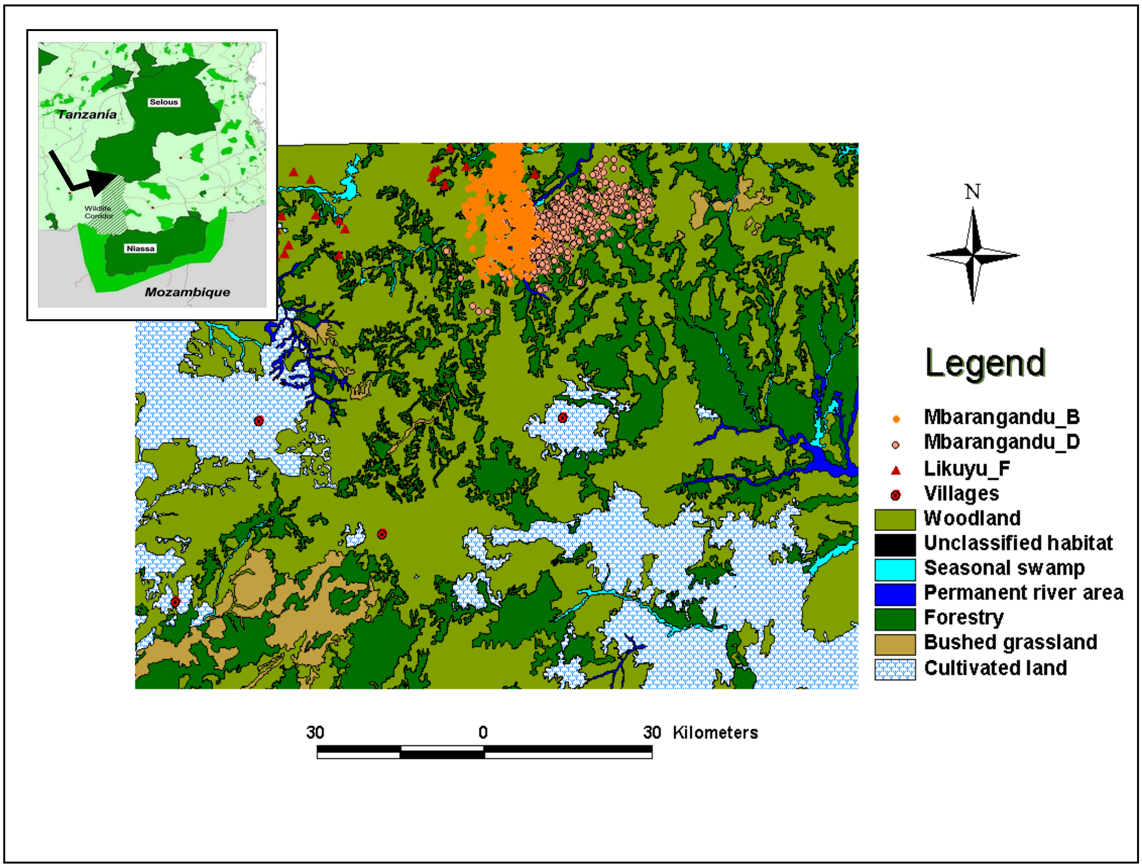

Figure 18: Tracking locations of three radio-collared elephants in the northern section of the Selous-Niassa Wildlife Corridor (Arrow on the small map insert)

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 (Figure 19). 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 20). All these movements appeared to tally well with the previously described major elephant movement routes.

4.13 Habitat selection and utilization 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%, swamp 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").

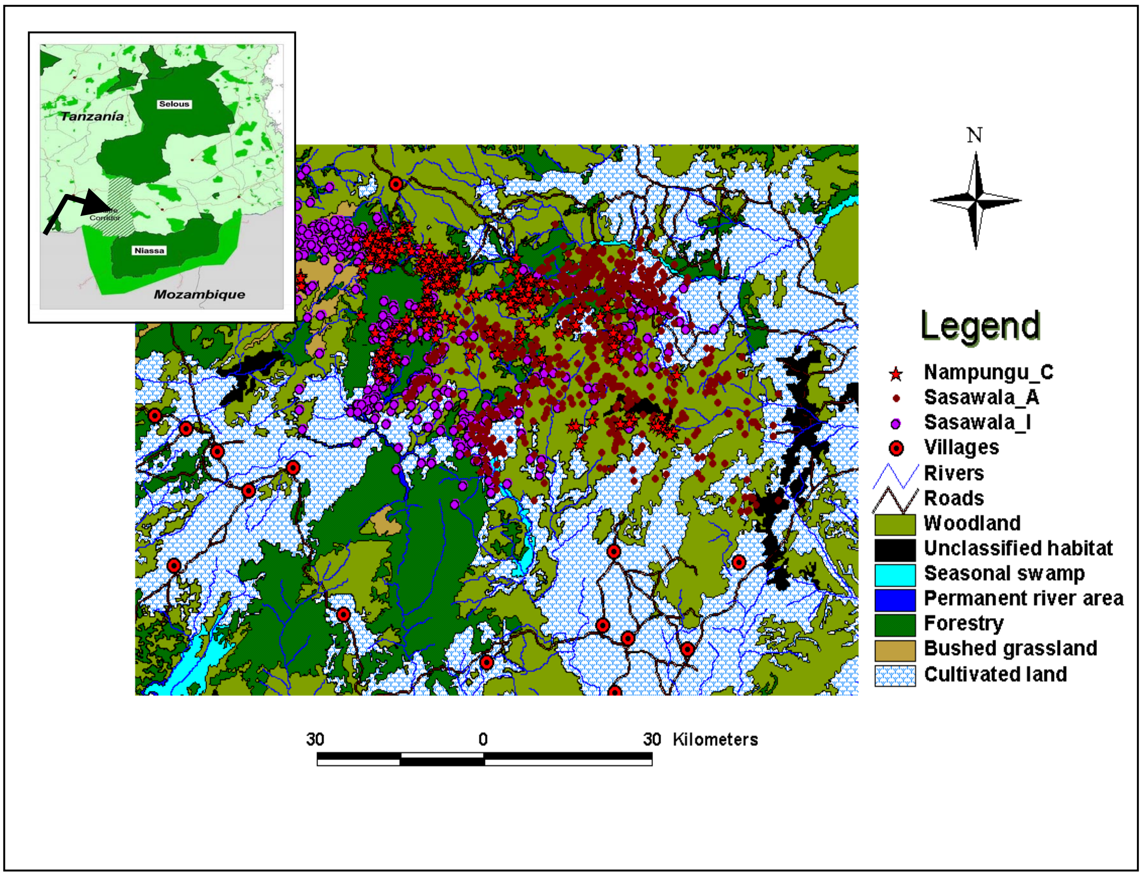

Figure 19: Tracking locations of three radio-collared elephants in the central section of the Selous-Niassa Wildlife Corridor (Arrow on the small map insert)

Habitat preferences were analysed separately for wet and dry season (Table 20). 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 under selected habitat was even more strongly avoided (Table 21).

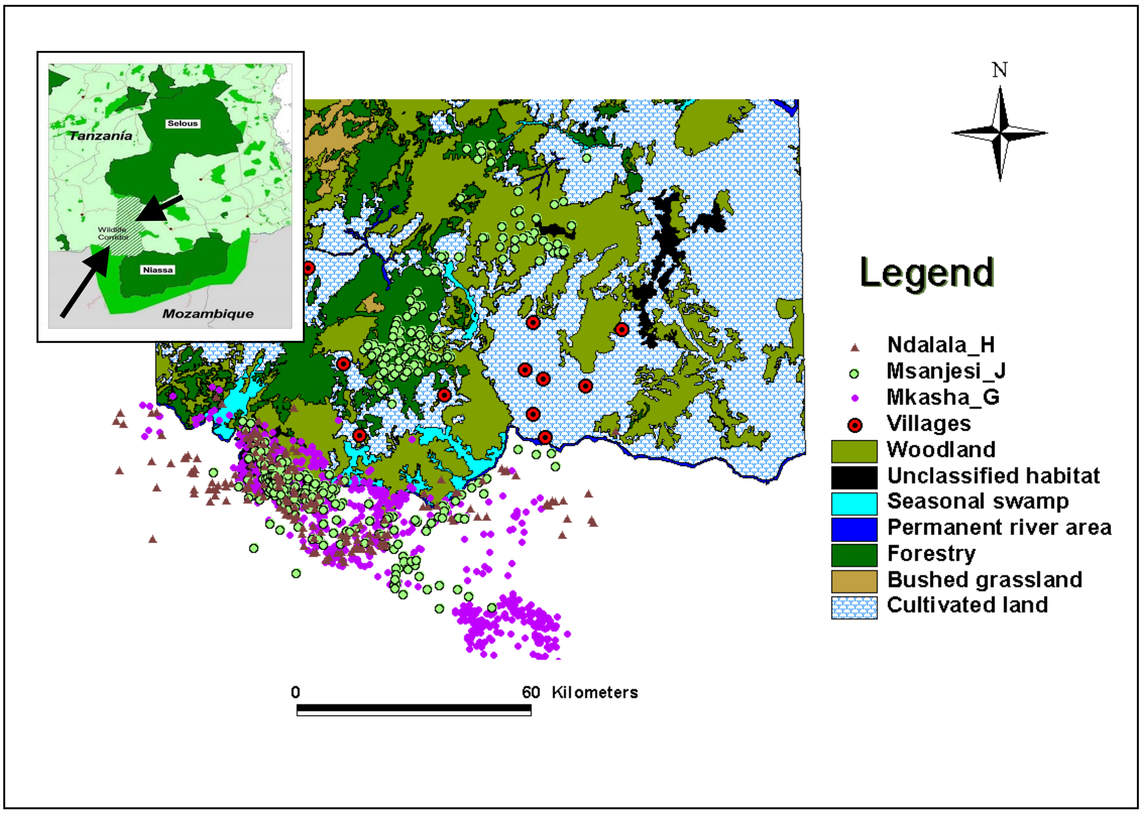

Figure 20: Tracking locations of three radio-collared elephants in the central and southern section of the Selous-Niassa Wildlife Corridor (Arrows on the small map insert)

Table 20: Seasonal habitat preference of elephants in the Selous-Niassa wildlife corridor in southern Tanzania between December 2000 and September 2002.

Habitat	Area Available (Km^2)	Proportion available π_i	Used sample μ_i	Used sample Proportion o_i	Selection ratio $\hat{w}_i$	SE ($\hat{w}_i$)	Standardized selection ratio α_i	X^2_M	P	Preference
Dry Season										
Woodland	11139	0.417	542	0.486	1.164	0.035	0.102	21.653	<0.001	+
Bushed grassland	443	0.017	48	0.043	2.593	0.231	0.225	47.787	<0.001	+
Cultivated land	8974	0.336	113	0.101	0.301	0.042	0.026	275.683	<0.001	-
Swamp	629	0.024	34	0.030	1.294	0.193	0.112	2.323	ns	0
Forest	4721	0.177	296	0.266	1.501	0.065	0.132	60.079	<0.001	+
River	452	0.017	69	0.062	3.654	0.228	0.319	135.292	<0.001	+
Unclassified area	330	0.012	13	0.012	0.943	0.268	0.083	0.045	Ns	0
Total	26687		1113		11.450					
Wet Season										
Woodland	11139	0.417	936	0.432	1.035	0.025	0.061	1.888	Ns	0
Bushed grassland	443	0.017	313	0.145	8.729	0.165	0.513	2185.267	<0.001	+
Cultivated land	8974	0.336	167	0.077	0.229	0.030	0.013	652.271	<0.001	-
Swamp	629	0.024	36	0.017	0.705	0.138	0.041	4.556	<0.05	-
Forest	4721	0.177	567	0.262	1.482	0.046	0.087	108.08	<0.001	+
River	452	0.017	60	0.028	1.635	0.164	0.096	15.045	<0.001	+
Unclassified areas	330	0.012	86	0.040	3.209	0.192	0.188	132.453	<0.001	+
Total	26687		2165		17.024					

Note: π_i -the proportion of the size in square kilometres in the í i^{th} habitat type, μ_i -the number of used sample units in category í in the population, o_i -the proportion of the used sample units in the category í, $\hat{w}_i$ -the proportion of habitat used (o_i) to its proportion (π_i), SE ($\hat{w}_i$) –the standard error of $\hat{w}_i$, α_i – the proportion of selection ratio in the category í to its total ($\Sigma\hat{W}_i$). Sign of preference: + Over selected,

- Under selected, 0 selected according to expectation based on proportion available, and X^2M Chi square test statistic.

Table 21: Changes in habitat preference of elephants in the Selous-Niassa wildlife corridor in southern Tanzania between the wet and dry season.

Habitat	Difference between Selection ratio ($\hat{w}_{i\ wet} - \hat{w}_{i\ dry}$)	Variance	χ^2_M	p	Direction of change in Preference
Woodland	-0.130	0.002	8.700	<0.01	+ to 0
Bushed grassland	6.136	0.342	110.222	<0.01	+ to +
Cultivated land	-0.072	0.001	5.147	<0.05	- to -
Swamp	-0.589	0.061	5.659	<0.05	0 to -
Forest	-0.019	0.008	0.043	Ns	No change
River	-2.019	0.225	18.140	<0.001	+ to +
Unclassified area	2.267	0.182	28.152	<0.001	0 to -

+ Direction of change in preference: + Over selected, - under selected, 0 selected according to expectation based on proportion available.