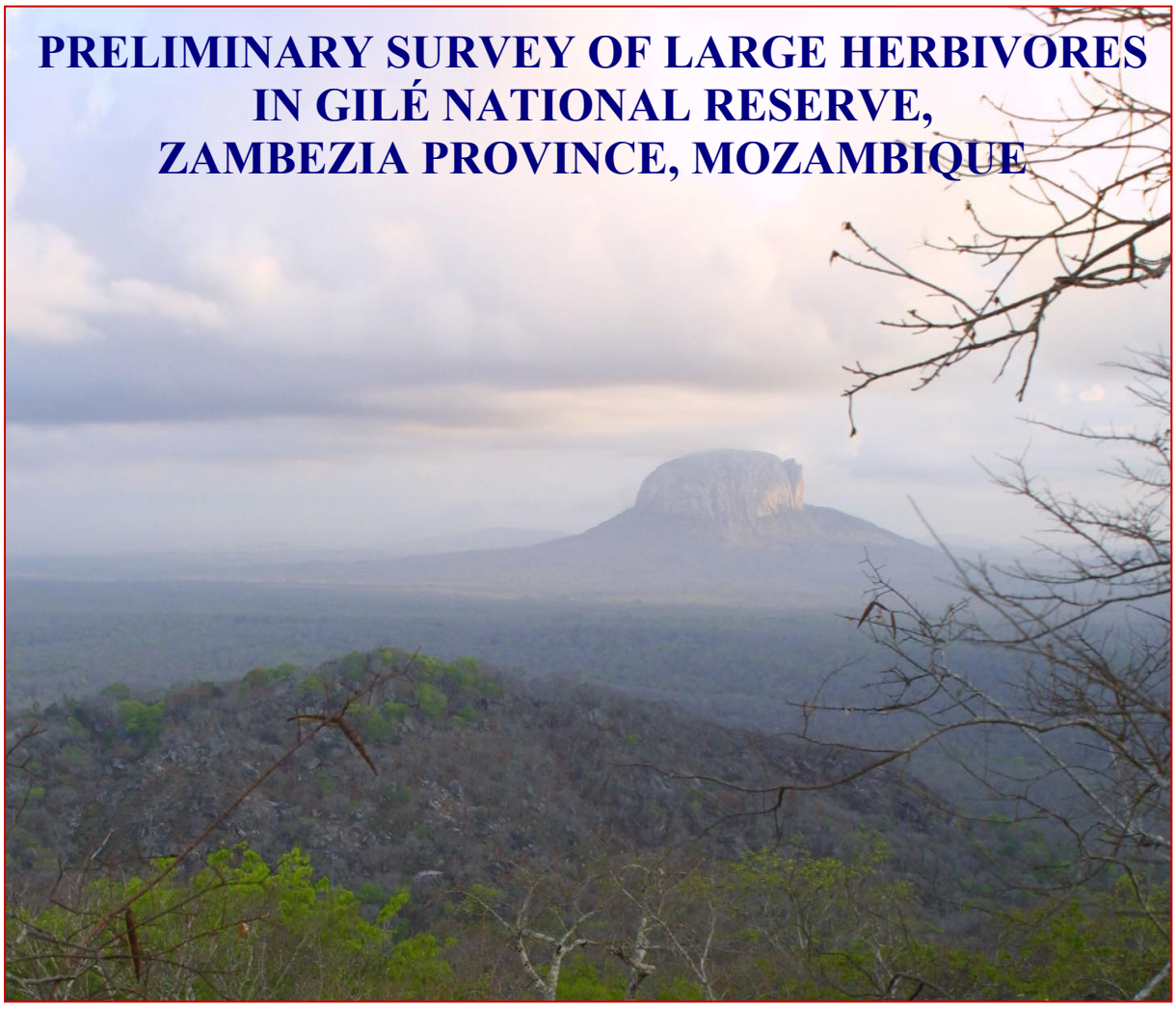
PRELIMINARY SURVEY OF LARGE HERBIVORES IN GILÉ NATIONAL RESERVE, ZAMBEZIA PROVINCE, MOZAMBIQUE



February 2008

TITLE:	PRELIMINARY SURVEY OF LARGE HERBIVORES IN GILÉ NATIONAL RESERVE, ZAMBEZIA PROVINCE, MOZAMBIQUE
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ABSTRACT:

This survey was carried out within the framework of the project between the Ministry of Tourism of the Republic of Mozambique and the IGF Foundation for the co-management of the Gilé National Reserve, Mozambique. The aim of this study was to conduct a preliminary ecological survey of the Gilé National Reserve, focused on large mammals, in order to: 1) update the mammal checklist of the reserve; 2) clear up the status of several key mammal species; 3) provide quantitative information about mammal distribution and relative abundance.

Wildlife survey to such scale had never been carried out in the Gilé National Reserve. A total distance of 586 km was covered by foot along transects, and 240 hours were spent recording biological data.

Forty mammal species were recorded. Large herbivores with particular interest for watching or hunting tourism included the elephant (*Loxodonta africana*), the African buffalo (*Syncerus caffer*), the Livingstone's eland (*Taurotragus oryx*), the bushbuck (*Tragelaphus scriptus*), the greater kudu (*Tragelaphus strepsiceros*), the bushpig (*Potamochoerus larvatus*), the waterbuck (*Kobus ellipsiprymnus*) and the sable antelope (*Hippotragus niger*). Signs of large carnivores were rarely observed, but the occurrence of the leopard (*Panthera pardus*), the side-striped jackal (*Canis adustus*) and serval (*Felis serval*) was confirmed.

The first quantitative data about large mammal distribution and relative abundance are provided. These data allow identifying the species that should benefit in priority from specific conservation measures like reintroduction or reinforcement (re-stocking). The effects of future management decisions on dynamic processes of mammal species would possibly be assessed should the survey hereby applied is repeated in the forthcoming years. Intensification of anti-poaching patrols is recommended to overcome the unsustainable poaching activities that threaten the reserve integrity.

***Cover picture**: View of Gilé Inselberg (©IGF Foundation)*

RESUMO

Este inventário foi realizado no âmbito do projecto entre o Ministério do turismo da República de Moçambique e a Fundação IGF para a co-gestão da Reserva Nacional do Gilé (RNG). O objectivo deste estudo era implementar um inventário preliminar da Reserva Nacional do Gilé com um enfoque sobre os mamíferos de grande porte, para: 1) actualizar a lista dos mamíferos da reserva; 2) esclarecer o estatuto de várias espécies chaves de mamíferos; 3) propiciar informação quantitativa sobre a distribuição dos mamíferos e a sua abundância relativa.

Tamanho inventário nunca foi realizado na RNG. Uma distância total de 586 km foi percorrida seguindo transectos e 240 horas foram consagradas à colecção de dados biológicos. Quarenta espécies de mamíferos foram registadas. Herbívoros de grande porte apresentando um interesse particular para o turismo contemplativo o cinegético incluíram o elefante (*Loxodonta africana*), o búfalo africano (*Syncerus caffer*), o elande de Livingstone (*Taurotragus oryx*), o imbabala (*Tragelaphus scriptus*), o grande cudo (*Tragelaphus strepsiceros*), o porco do mato (*Potamochoerus larvatus*), o piva (*Kobus ellipsiprymnus*) e o pala-pala (*Hippotragus niger*). Indícios de grandes carnívoros foram raramente observados, mas a ocorrência do leopardo (*Panthera pardus*), do chacal listrado (*Canis adustus*) e do gato serval (*Felis serval*) foi confirmada.

Os primeiros dados quantitativos sobre a abundância relativa dos mamíferos de grande porte são propiciados. Por outro lado, estes dados permitiram identificar as espécies que deveriam beneficiar prioritariamente de medidas específicas de conservação como reintroduções ou reforçamento. Os efeitos das futuras decisões de maneio sobre a dinâmica das populações das espécies de mamíferos poderiam ser avaliados se o inventário assim realizado for repetido nos próximos anos. A intensificação das patrulhas de luta contra o caça furtiva é recomendada para erradicar as actividades de furtivismo insustentáveis que estão ameaçando a integridade da reserva.

"This report is dedicated to 'Doctor Pisteiro', Emilio Manuel Evili,
the first tracker involved in the survey, who suddenly died from hernia.
He did a fantastic job, passed me on part of his tracking skills, and
taught me the basics to survive in the bush."
Pascal Mésochina

CONTENTS

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I would like to thank Dr. Philippe Chardonnet, IGF Foundation director, Mr. Hubert Boulet, IGF Foundation deputy director, and Dr. François Lamarque, IGF Foundation field officer, for launching this survey and for supporting me throughout its duration, with their help and advices.

During the two and half months I spent in Mozambique, I have greatly appreciated the help and welcome of Mrs. Felismina Langa, head of the "Direcção Provincial do Turismo" (DPT; Provincial Bureau of Tourism), Zambézia Province. I have also enjoyed discussions and interactions with the staff of DPT during days spent in Quelimane. I especially like to thank Victorino who helped me in solving the hard disk failure of my computer, and spent so much time with me in endless discussions.

The survey could have not been accomplished without the help of Victor Guedes (DPT). Up to early December, we collaborated in a very efficient way to successfully complete our respective missions, and shared great moments in the bush.

I am grateful to José Cherecsanha, administrator of Gilé district and Antonío Santaré Duarte, administrator of Pebane district, for their keen interest in the survey and their willingness to help me. I specially express my appreciation to Alfredo José Vitorino, the canton's chief of Mulema Sede, for his warm hospitality.

The Gilé National Reserve Rangers' staff provided invaluable help. Abrão Rosário, Pedro Joaquim Sozinho, Zabura Amisse Ntubula, Calixto Vicente José and Juma Vasco Fernando Sualei were enthusiastic contributors to field work.

I express my thanks and appreciation to the guards of Musseia, involved in the survey as trackers. Carvalho Carlo Nabuino and Emilio Manuel Evili were essential contributors to the success of the survey. Community rangers provide invaluable support to anti-poaching patrols for free. I am full of admiration for their dedication to preserve the reserve, and specially thank those that joined the team to carry out the survey.

I also acknowledge the warm hospitality of anyone and thank them for the great moments I spent around fire camps.

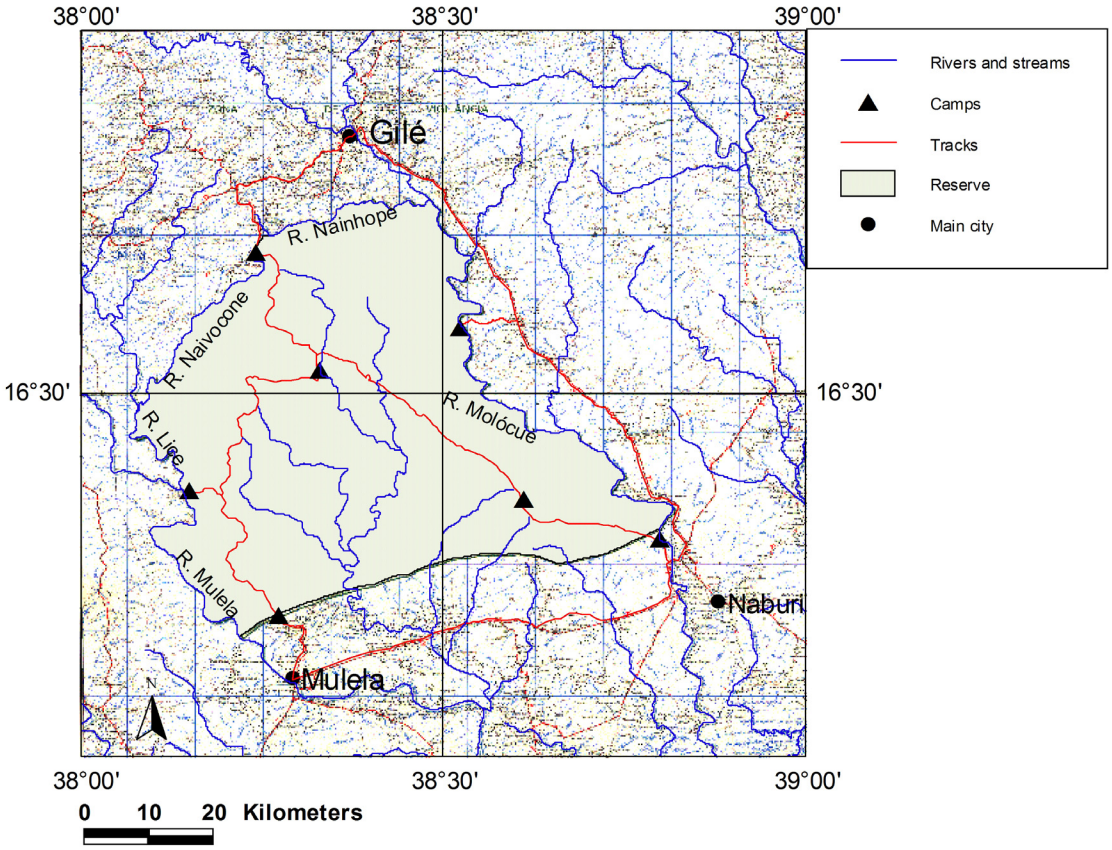
The contribution of each person does not imply their endorsement of the entire document as it is published.

Pascal Mésochina

ACRONYMS

AKI_e:	Abundance Kilometre Index of species e
AKI_m:	Abundance Kilometre Index of mammals (all species included)
DPT:	"Direcção Provincial do Turismo" (Provincial Bureau of Tourism), Zambezia Province
GPS:	Global Positioning System
IGF Foundation:	International Foundation for the Management of Wildlife
RNG:	"Reserva Nacional do Gilé" (Gilé National Reserve)

Map 1. Location of the study area



Map 2. Geographical limitations of the RNG

I. INTRODUCTION

In June 2007, the Honourable Fernando Sumbana, Minister of Tourism of the Republic of Mozambique and Dr. Philippe Chardonnet, Director of the International Foundation for the Conservation of Wildlife (IGF Foundation) signed an agreement for the co-management of the "Reserva Nacional do Gilé" (RNG: Gilé National Reserve), Zambézia, Mozambique. The preparation of the project had to be completed by further activities before the formal launching of the project in 2008.

Among these activities, a biodiversity study was required to improve the level of knowledge on the macrofauna of the RNG. The IGF Foundation has established a database of the wildlife species known to occur in the RNG. In its first stage, the database encompassed a number of observations carried out in RNG, particularly those published in former studies: Dutton *et al*., 1973; Chande *et al*., 1997; Carpaneto, 2001; Gallego Lizon, 2002; Fusari & Cumbane, 2002; República de Moçambique, 2004; Chardonnet & Dobremez, 2005; Boulet & Lamarque, 2007. However, the database needed to be developed and elaborated with more information on wildlife diversity, relative abundance, and range use. Therefore, IGF Foundation and DPT ("Direcção Provincial do Turismo": Provincial Bureau of Tourism, Zambezia Province) have decided to carry out an intensive field survey of the RNG's large mammal species, between October and December 2007.

A global environmental study cannot be developed by a single expert and needs the participation of several specialists. The aim of this study was therefore to conduct a preliminary ecological survey of the RNG, focused on large mammals, in order to update the mammal checklist of the reserve, to clear up the status of several key mammal species, and to provide some quantitative information about mammal distribution and relative abundance. Since, in forested areas, the selected survey methodology, transects on foot, is more appropriate to monitor large herbivores compared to large carnivores (Gittleman *et al.*, 2001), the main focus of the survey was large herbivores. Information about birds and reptiles were also opportunistically recorded to update checklists.

II. MATERIAL AND METHODS

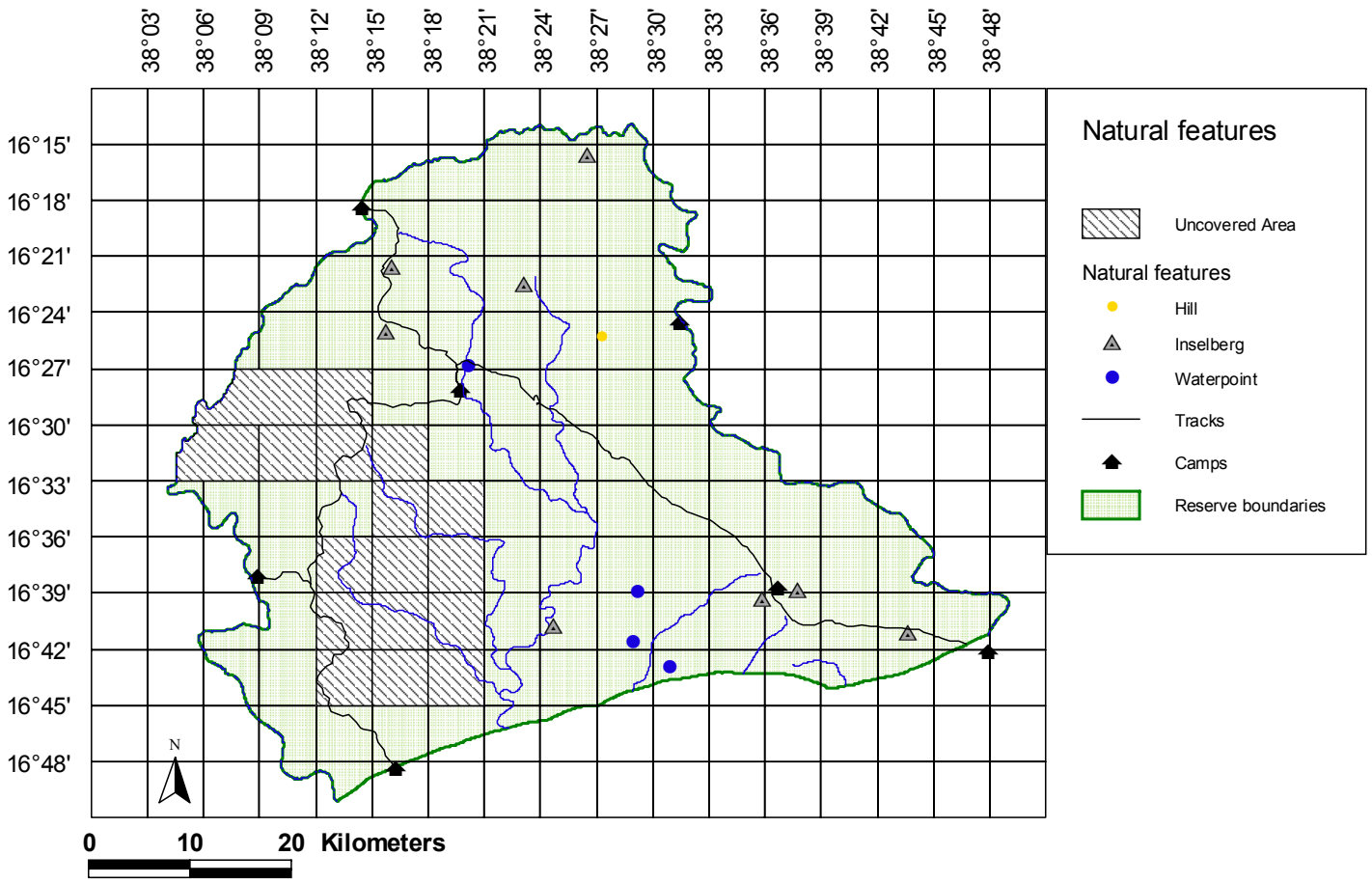
1. RESOURCES DESCRIPTION

1.1. Geographical location

The RNG is the only protected area of the Province of Zambézia. It extends some 2 100 km² (210 000 ha) between Gilé and Pebane Districts in the north-eastern part of Zambézia Province and is comprised between 16°14'45" and 16°50'30'' south and between 38°05'38'' and 38°48°45'' east (Map 1 & 2). The following watercourses bound the RNG on its northern, eastern and western parts: Nanhope (northern sector), Molocué (eastern sector), Naivocone, Lice and Mulela (western sector). There is no geographic delimitation in the southern sector of the reserve: the southern border is legally defined as a line parallel to the road that connects the Mualama and Nova Naburi localities (Map 2).

1.2. Geology and soil

The geology of the area comprises two Precambrian series, highly metamorphosed and deformed, locally invaded by granite intrusions and small bodies and dikes of basic rocks.



Map 3: Natural features observed within the RNG

The first series, called “Regional Greises” represents the oldest one and is associated with white, yellowish or green magnetite bearing quartzite. The second series, called “Meta-sedimentary series” is composed of schists comprising paragreises, sandstones and quartzite (Dutton *et al.*, 1973).

There are two different types of soil in the RNG: (1) a light sandy soil and (2) a red clayed soil, whose distribution is quite irregular within the reserve (INIA, 1994). Both soils have a low degree of fertility and are quite susceptible to hydrological erosion.

1.3. Climate

The RNG climate lies within the Walter’s tropical summer-rainfall climatic zone (White, 1983), with a well-defined wet period between November and April and a dry period for the others six months (May-October). The annual average rainfall is around 800-1 000 mm. The temperature varies substantially during the dry season, from 13°C (mean minimum in June) to 35.7°C (mean maximum in October). The variation of the temperature during the rainy season is less marked.

1.4. Landscape

The landscape of the RNG is characterized by a gently sloping plain declining southwards from 200 to 100m above sea level, and by granite inselbergs emerging from the woodland.

The RNG is drained by three major watercourses and by numerous small streams, some with permanent water and others simply seasonal. The three major watercourses are the Molocué river, which flows along the eastern boundary, the Mulela river, which flows along the south-western border and the Malema river, which flows in the core sector of the RNG. Other permanent watercourses have a much reduced flow during the dry season (e.g. Naivocone in the northern area, Muipige in the south-eastern sector and Nakololo in the core sector). Several water-pools have been noticed (Map 3), but it has to be checked whether they are permanent or seasonal.

1.5. Vegetation

As defined by White (1983), the RNG falls within the Zambezian Regional Centre of Endemism phytogeographic unit, and within the Vegetation Type 26: ‘Dry Zambezian Miombo Woodland’.

The landscape of the RNG consists of a miombo woodland / dambo grassland mosaic where deciduous miombo woodland is dominant in terms of cover percentage. The dambos are small to medium size (maximum 5 hectares) edaphic grasslands that are often flooded during the rainy season. The miombo woodland is heterogeneous and varies according to several biotic characteristics: height of the trees, shape of the tree canopy (vertical or horizontal), density of undergrowth (shrubs and herbs) and ratio between deciduous and evergreen tree species. A forestry survey conducted by a team from the Mozambican Ministry in charge of Environment (MICOA, 1999) in the RNG defined four woodland types based on the degree of canopy coverage and tree height: a) Open forest, b), Woodland c) Closed forest, and d) Riverine vegetation (Table I).

Table I: Characteristics used to determine the type of vegetation

	Characteristics	
	Canopy cover	**Tree height**
Closed forest	> 70%	> 7m
Riverine forest	40% - 70%	> 7m
Open forest	40% - 70%	< 7m
Woodland	10 % - 40%	< 7m
Dambo	< 10%	< 7m

• Open forest

This vegetation type covers the largest part of the RNG, extending from the northern boundary to more than half surface southwards (Fusari & Cumbane, 2002).

Canopy cover varies between 40 and 70%; the tree density is around 1 100/ha. Although no obvious dominant species emerge in this vegetation type, several trees are common: the wild custard apple (*Annona senegalensis*), the monkey pod (*Senna petersiana*), the snake bean (*Swartzia madagascariensis*) and a species of bride's bush (*Pavetta* sp.).

The grass layer has a phytomass around 2 150 kg/ha and presents a high forage score, indicating its capacity to support grazers (Fusari & Cumbane, 2002).

• Woodland

Woodland is the second larger vegetation type in terms of extension, covering less than half of RNG southern sector (Fusari & Cumbane, 2002).

The canopy cover is less than 40%; the tree density is around 1 200/ha. The dominant tree species include the munondo (*Julbernardia globiflora*), the mobola plum (*Parinari curatellifolia*), the parsley tree (*Heteromorpha trifoliata*) and the heart tree (*Hymenocardia acida*).

The grass layer has a phytomass around 3 220 kg/ha and presents a high forage score (Fusari & Cumbane, 2002).

• Closed forest

Closed forest is the third larger vegetation type in terms of extension. It is always enclosed within the open forest vegetation type (Fusari & Cumbane, 2002).

The canopy cover is higher than 70%, with a tree density of around 1 300/ha. There is no clear-defined tree species dominance within the closed forest vegetation type, however species like the Pride of De Kaap tree (*Bauhinia galpinii*), the panga-panga (*Millettia stuhlmannii*), the mobola plum (*Parinari curatellifolia*), the munondo (*Julbernardia globiflora*), the glossy flat-bean (*Dalbergia nitidula*), the wild seringa (*Burkea africana*) and the variable bushwillow (*Combretum apiculatum*) are common.

The grass layer has a phytomass around 1 200 kg/ha and presents a high forage score (Fusari & Cumbane, 2002).

• Riverine vegetation

Riverine vegetation occurs along the numerous watercourses running in the RNG (Fusari & Cumbane, 2002). Numerical data about tree density and grass phytomass are not available for this vegetation type.

Canopy cover varies between 40 and 70%. While the screw pine (*Pandanus livingstonianus*) dominates this vegetation type in the southern sectors of the RNG, no clear species dominance is noticeable elsewhere. Common tree species include the red-heart tree (*Hymenocardia ulmoides*), the munondo (*Julbernardia globiflora*) and the mobola plum (*Parinari curatellifolia*).

• Dambo

Dambo is the vegetation type less represented in the RNG (Fusari & Cumbane, 2002). Dambos occur where the underground water comes near to the surface and hampers tree growth. Most of the dambo soil becomes dry and compact during the dry season (Dutton *et al.*, 1973; Carpaneto, 2001).

The canopy cover is less than 10% with a very low tree density, while the grass phytomass is very large (i.e. around 5 550 kg/ha). However, because of the very poor quality (coarse and unpalatable for grazers) of the grass species, the grass layer of dambos has a low forage score, indicating its low capacity to support grazers.

1.6. Fauna

• Mammals

The first wildlife data in the RNG were provided by Dutton *et al.* (1973) who conducted a preliminary ecological survey mainly focused on large mammals. This first checklist of mammals has been updated thereafter through various more or less intensive field surveys and/or ethnozoological interview of local population (Chande *et al.*, 1997; Carpaneto, 2001; Chardonnet & Dobremez, 2005; Boulet & Lamarque, 2007). The last three studies were not focused on wildlife survey, so only a few days was devoted to this task.

Fifty nine species of mammals were considered as occurring in the RNG according to the last effective survey (Carpaneto, 2001): 5 primates (3 monkeys and 2 galagos), 2 elephant shrews, 2 hares, 12 rodents, 17 carnivores, 19 ungulates (except 2 species considered as extinct: black rhinoceros [*Diceros bicornis*] and blue wildebeest [*Connochaetes taurinus*]), 1 pangolin and antbear (Appendix 2). Conservation status was unclear for the African buffalo (*Syncerus caffer*), the Livingstone's eland (*Taurotragus oryx*), the Lichtenstein hartebeest (*Alcelaphus lichtensteinii*) and the Burchell's zebra (*Equus burchelli*). Among the most remarkable species occurring in the reserve, it is worth to quote the Lord Derby's anomalure (*Anomalurus derbianus*), the African wild dog (*Lycaon pictus*), the lion (*Panthera leo*), the elephant (*Loxodonta africana*), and the sable antelope (*Hippotragus niger*).

• Birds and reptiles

The last checklist of the RNG's birds, updated in 2001 (Carpaneto, 2001), included 113 species (72 non-passerines and 41 passerines). However, the author considered that the avifauna of the RNG was far to be totally known and that many species, mainly passerine, still had to be added to the checklist.

The checklist of reptiles, established in 2001 (Carpaneto, 2001), included 27 species: 3 chelonians, 12 snakes (out of which two unidentified), 2 monitor lizards, 3 geckoes, 2 unidentified plated lizard, 1 agama, 1 chameleon, 1 crocodile, 1 unidentified flat lizard and 1 skink.

2. SURVEY

2.1. Survey framework

The RNG has been cut out according to a grid made of 90 cells of three minutes both in latitude and longitude (Map 4). The central cells extended to ca. 32 km², while the smaller ones on the outskirts were joined to adjacent cells. As a result, RNG boundary cells had a surface varying between 16 km² and 76 km².

The objective was to perform a systematic sampling of the RNG by carrying out survey along transects of at least 5 km per cell. We recorded all mammals seen as well as their signs of presence. Since the systematic sampling along transects is not appropriate to assess relative abundance of carnivores in forested areas (Gittleman *et al.*, 2001), large herbivores were more likely to be observed than carnivores. The data collected have been used to draw information on macrofauna diversity, distribution and relative abundance.

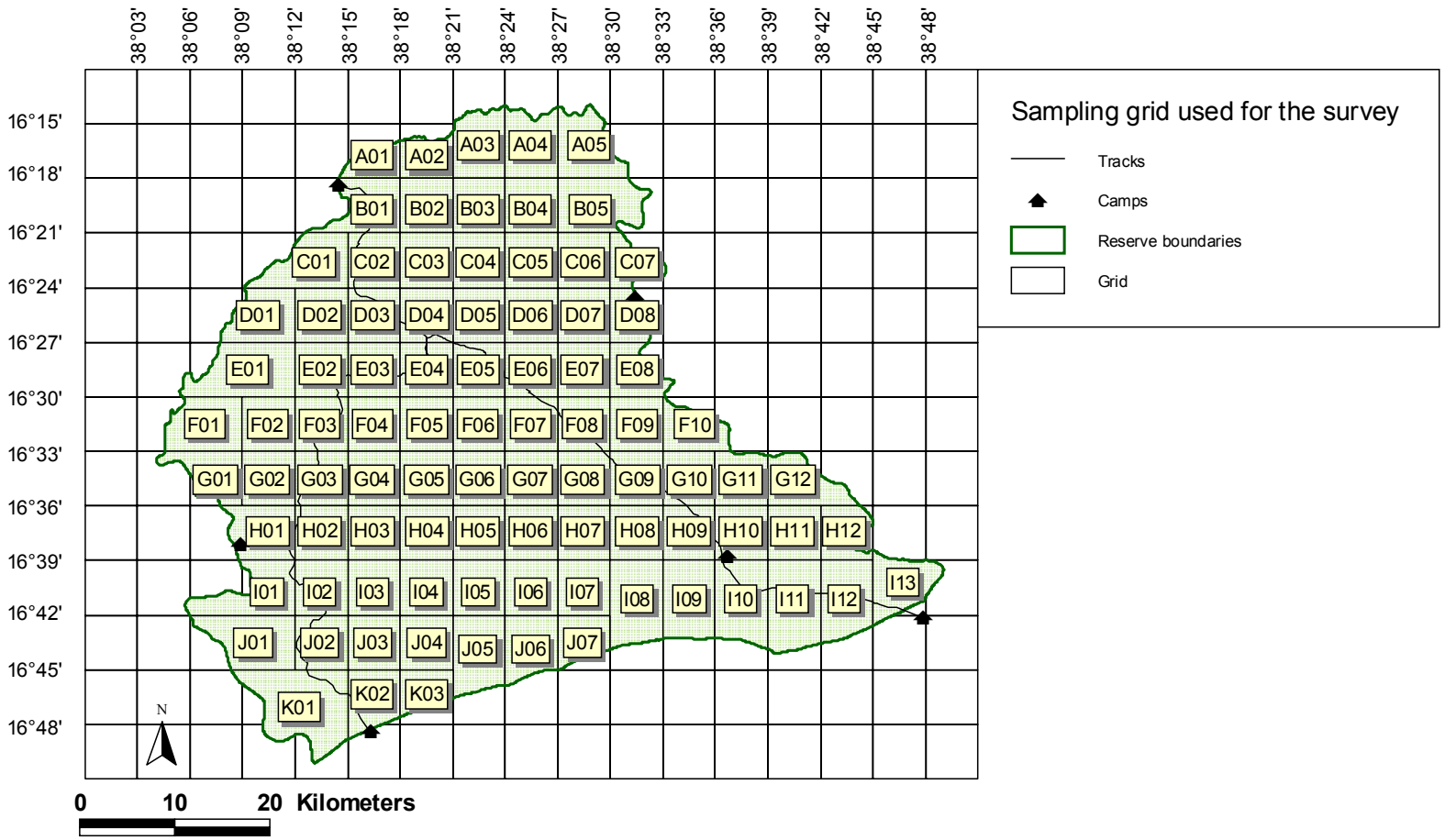
2.2. Survey organization

Considering the large surface of the reserve (2 100 km²) and its limited track network (around 170 km), we carried out the survey on foot. The field work was organized into field sessions lasting between two and four days and covering two to three cells per day (Appendix 1). The wildlife survey team, made of three key persons (one skilled tracker, one ranger and one observer), was living in full autonomy during a given field session. All RNG's rangers but one have been included at least once in the team to receive in-service training. We also regularly switched between two trackers, both being guards at the Musseia Camp. A carrier joined the team from the third field session onwards.

The field session starting and ending points were determined according to logistical constraints. Transect itineraries were designed in order to survey special habitats (mostly inselbergs) and maximize the probability of encounter with animals, without focusing on a given species. A theoretical transect was consequently prepared, taking into account these information and the main directions to follow to complete the field session. During the survey, the tracker led the team and chose the areas to prospect, despite the main direction of walk was adjusted from time to time.

2.3. Data collection and analysis

A Global Positioning System unit (GPS Garmin III+) was used to geo-reference transects as well as any wildlife observation or interesting natural features and to estimate the length of the covered transects.



Map 4: Sampling grid of the survey

Different types of information were collected depending on the nature of the observation. When animals were directly seen, we recorded the time of observation, the species, the group size and composition. Should we detect animal's presence sign ('indirect observation' like spoors, feces, feeding sites, dens…), we additively assessed the dating of the sign (Day; Recent: between 1 and 2 day old; Old: older than 2 days). Observations were not recorded when we suspected that individuals had already been recorded according to this set of information and the tracker skills.

We also recorded the survey duration, the habitat type at the transect's starting point and any change of habitat along transects (mileage on GPS unit). Using the vegetation types occurring within the RNG (cf. § II.1.5.) and the distance between transect and watercourse, the following habitats were defined:

- transect along watercourse (up to few hundred meters from watercourse): 'watered' closed forest; 'watered' open forest; 'watered' woodland; 'watered' dambo;
- transect far way from watercourse: 'dry' closed forest; 'dry' open forest; 'dry' woodland; 'dry' dambo;

The specific habitat represented by inselbergs was also considered.

Data collected were used to draw the following information:

• Cell coverage

To assess the cell coverage, the following ratio was calculated:

$$CC_i = \frac{TS_i \times 100}{CS_i} \qquad \text{(Equation 1)}$$

Where: -CC_i: Coverage of $Cell_i$ (%)
-TS_i: Transect Surface within cell i (km²)
-CS_i: Surface of $Cell_i$ (km²)

Wildlife signs were readily detected within a strip of 10 meters (5 meters on both sides). As a result:

$$TS_i = TL_i \times TW \qquad \text{(Equation 2)}$$

Where: -TS_i: Transect Surface within $Cell_i$ (km²)
-TL_i: Transect Length within $Cell_i$ (km)
-TW: Transect Width (km)

The cell surfaces were determined using GIS software (Arcview 3.2).

• Mammal distribution

The distribution of mammal species was assessed at both the cell and the habitat scales.

To assess the species' distribution, each observation (direct and indirect) of a given species in a given cell (or habitat) was recorded as a 'presence'. Obviously, the species was recorded as absent from the sampling unit when it was not observed. From the presence/absence data recorded at the cells' scale, the percentage of cells where each species occurred was determined.

Species with less than 20 observations were excluded from the analysis performed at the habitat scale.

• Mammal relative abundance

The relative abundance of a mammal species was assessed by calculating the Abundance Kilometre Index (AKI_e), as follows:

$$AKI_e = \frac{N_e}{TL} \qquad \text{(Equation 3)}$$

Where: -AKI_e: Abundance Kilometre Index of species$_e$
-N_e: Number of contacts with species$_e$
-TL: Transect Length (km)

Rainfalls were recorded 15 times during the survey period (Table II). Rains erased signs like spoors and feeding sites and made difficult the dating of feces deposits. To reduce this bias regarding signs' detection, only direct observations and signs dated the day of observation were considered as contacts. AKI_e were only determined for species with more than 10 contacts. A mammal AKI (AKI_m) was calculated by cumulating all mammal species contacts.

Table II: Rainfall occurrence during the survey

Date	Period of the day
20-oct	morning
26-oct	evening
03-nov	evening
04-nov	evening
18-nov	night
18-nov	evening
28-nov	evening
29-nov	afternoon
30-nov	morning
01-déc	afternoon
02-déc	evening
11-déc	afternoon
12-déc	evening
13-déc	evening
14-déc	afternoon

Relative abundances were assessed at reserve, cell and habitat scales:

- Reserve scale

  AKI_e and AKI_m were calculated by dividing the number of contacts by 586, the total distance covered along transects (Equation 3).

- Cell scale

  Relative AKI_e and AKI_m were calculated as follows:

$$\mathrm{Re}lativeAKI_{ei} = \frac{AKI_{ei} \times 100}{\sum_{i=1}^{i=90} AKI_{ei}} \quad \text{(Equation 4)}$$

  Where: -RelativeAKI_{ei} is expressed as a percentage
  -AKI_{ei}: Abundance Kilometre Index of species e in $Cell_i$

  Relative AKI_e and AKI_m data were regrouped into three classes of values with different limits depending on species. A fourth class ('Present') was created for cells where only old signs were recorded and AKIe could not be calculated. The derived information was mapped using a GIS software (Arcview 3.2). This allowed the localization of putative hotspots for a given species or the mammal community.

- Habitat scale

  AKI_e and AKI_m were calculated for each habitat types (Equation 3) but inselbergs, where only few contacts were realized. Species with less than 20 observations were excluded from the analysis.

• Group size and composition

For each species, we assessed the number of individuals encountered, the median group size, the interval of variation of the group sizes, the ratio of solitary animals, the adult sex ratio and the ratio of immatures. Only direct and spoors' observations which allowed for individualization, were used. Species with less than seven observations were excluded from the analysis. Since several different observations might come from the same individuals, the data are possibly biased and should be considered as indicative.

The population of elephants was the only one for which recent number estimates were available (Martins & Ntumi, 2002). Elephant observations were therefore compared to withdraw possible doubloons. The criteria used to discriminate the observations were: (i) group size and composition, (ii) day of observation, (iii) sign dating, (iv) distance between observations. Consequently, estimates are unbiased for elephants, so the number of individuals reflects the minimal population size.

III. RESULTS

1. EXTENT OF THE SURVEY

We walked a total distance of 645 km, out of which 586 km were along transects (Map 5; Appendix 1), and 59 km were liaison walks to or from transects. We walked 202 km along watercourses, 375 km away from watercourse and 3 km on inselbergs. We spent nearly 240 hours recording biological data along transects.

Because of a lack of logistical support in December, the survey was not completed. We did not cover 17 cells out of the 90 defined (i.e. 19%), while 2 cells were only partially covered. In the 71 fully surveyed cells, the coverage ratio varied from 0.12 to 0.70%, with a mean value of 0.24 % [95% CI: 0.22-0.26].

2. MAMMALS

2.1. Check list

During the survey, 40 mammal species were recorded, out of which two were not previously listed (dwarf mongoose [*Helogale parvula*] and a rodent yet to be determined). We directly observed 27 species, while we recorded signs of presence (spoors, feces, feeding sites, and dens) for the 13 other species (Appendix 2).

The occurrence of the African buffalo (*Syncerus caffer*) and the Livingstone's eland (*Taurotragus oryx*) whose statuses were formerly unclear, was confirmed as well as the presence of other large herbivores with particular interest for wildlife viewing or hunting tourism like: the elephant (*Loxodonta africana*), the sable antelope (*Hippotragus niger*), the greater kudu (*Tragelaphus strepsiceros*), the waterbuck (*Kobus ellipsiprymnus*), the bushbuck (*Tragelaphus scriptus*) and the bushpig (*Potamochoerus larvatus*). Signs of large carnivores were rarely observed, but the occurrence of the leopard (*Panthera pardus*), the side-striped jackal (*Canis adustus*) and the serval (*Felis serval*) was confirmed. The primates observed were the yellow baboon (*Papio cynocephalus*) and the vervet monkey (*Chlorocebus pygerythrus*).

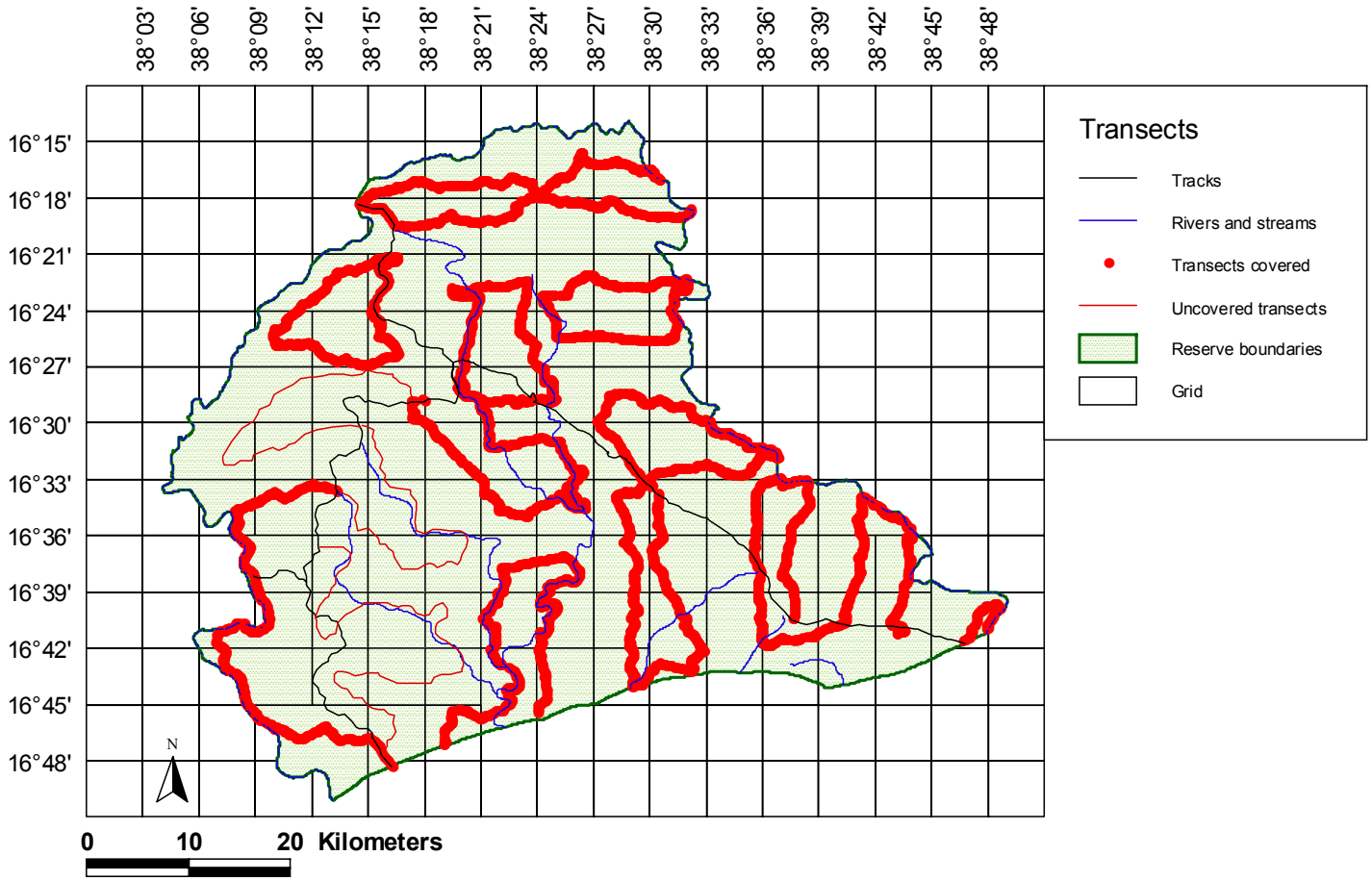
The presence of some reputably rare species could not be confirmed; this regards mostly the Carnivores like the African wild dog (*Lycaon pictus*), the spotted hyena (*Crocuta crocuta*) and the lion (*Panthera leo*), but also the Lichtenstein hartebeest (*Alcelaphus lichtensteini*). Finally, we did not find evidence of occurrence for the common zebra (*Equus burchelli*) and the blue wildebeest (*Connochaetes taurinus*), both considered as extinct in the RNG.

2.2. Distribution

• By cells

The different mammal species recorded during the survey had various levels of cell occupancy (Table III; Appendix 3)

The common duiker was the only species with ubiquitous distribution; we recorded evidence of its occurrence in each of the cells prospected. Most of the artiodactyls (greater kudu, sable antelope, bushbuck, southern reedbuck, and bushpig) had a widespread distribution, occurring in more than 60% of the cells surveyed. The striped polecat, the most widespread species of carnivore, fell within the same category.



Map 5: Transects covered during the wildlife survey and planned uncovered transects

Table III: Distribution of mammal species encountered during the survey: percentage of cells where the species were recorded

Species	Cell coverage (%)	Distribution class
Common Duiker	100.0	Ubiquitous
Striped Polecat	88.7	Widespread
Greater Kudu	84.5	
Spiny Mouse	74.6	
Bushpig	73.2	
Bushbuck	69.0	
Southern Reedbuck	64.8	
Sable Antelope	63.4	
Waterbuck	50.7	Medium
Yellow Baboon	47.9	
Scrub Hare	35.2	
Wild Cat	29.6	
Giant Pouched Rat	25.4	Restricted
Natal Duiker	19.7	
Cane Rat	18.3	
Aardvark	16.9	
Warthog	16.9	
Four-Toed Elephant Shrew	12.7	
Elephant	8.5	Localized
Vervet Monkey	8.5	
Mongoose sp.	8.5	
Side-Striped Jackal	8.5	
Suni	7.0	
Leopard	7.0	
Klipspringer	4.2	
Banded Mongoose	4.2	
Hyrax sp.	4.2	
Chequered Elephant Shrew	2.8	
Rock Hare	2.8	
African Civet	1.4	
Dwarf Mongoose	1.4	
Honey Badger	1.4	
Serval	1.4	
Rodent sp.	1.4	
Smith's Bush Squirrel	1.4	
Livingstone's Eland	1.4	
Ground Pangolin	1.4	
South African Porcupine	1.4	
African Buffalo	1.4	
Miombo Genet	1.4	

Among the species with a medium range of occupancy (from 30 to 50% of the cells covered), were the waterbuck, and the wild cat which therefore appeared to be the most widespread Felid. Species like the Natal duiker, the warthog, the aardvark and the cane rat had a more restricted range, with a cell occupancy varying from 13 to 25%.

Finally, 22 species had a localized range (present in less than 10% of the cells). All species falling within this category are globally rare in the RNG, but could be locally abundant (e.g. the elephant in the south-western part of RNG; the suni along the Molocué River) or confined to specific scarce habitat (e.g. the klipspringer or the hyraxes only occurring on inselbergs).

• By habitats

The bushbuck and the spiny mouse (Table IV) were the only mammals recorded in the RNG which were observed in all of the defined habitats (closed forest, open forest, woodland, and dambo, along or far away from watercourses; inselberg). The common duiker, the waterbuck and the bushpig were recorded in all habitat types but inselberg, while the striped polecat was only absent from dambo.

The kudu, the yellow baboon and the aardvark also used most of the habitat types found in the RNG, being only absent from inselberg and a few other types of habitat ('watered' closed forest for the kudu and yellow baboon; 'dry' dambo for the aardvark). The reedbuck and the sable antelope were not met on inselberg and in closed forest, while we did not observe the Natal duiker in dambo and 'dry' woodland.

The remaining species were absent from most of the defined habitat types. The elephant, the giant pouched rat, the scrub hare and the wild cat were only observed in woodland and open forest. Finally, we only recorded the suni in open forest and 'watered' closed forest.

Although we did not considered species for which sample size was below 20, it appeared that the klipspringer (n=7), and hyraxes (n=4) only occurred on inselberg.

2.3 Relative abundance

• Global

Along all the transects, we observed mammals 165 times and recorded signs of their occurrence 6,133 times; 3,980 mammal contacts were recorded, giving a global AKI_m of 6.9.

The common duiker was by far the species most often recorded (Table V); it represented more than half of the mammal observations. The corresponding AKI_e (3.73) was consequently more than three times greater than the value calculated for the second most observed species, the bushbuck ($AKI_e = 0.825$).

Far behind these two species, the spiny mouse and the striped polecat were recorded at the same rate ($AKI_e \approx 0.350$). The greater kudu, the waterbuck and the southern reedbuck had a slightly lower value, with AKI_e values varying from 0.264 to 0.288. We found fewer evidences of bushpig and sable antelope occurrence, with respective AKI_e values of 0.193 and 0.145. All the remaining mammal species were rarely recorded, with less than a record per 10 km (e.g. elephant, suni, wild cat etc…).

• By cells

The main mammal hotspot was located in the south-western part of the RNG, along the Mulela river, where AKI_m exceeded 10 contacts/km and species diversity varied between 10 and 15 species per cell.

On the contrary, the northern part of the RNG gathered the cells with the lowest AKI_m and species diversities (Map 6).

Most of mammal species were absent from the north of the reserve or only survived at low densities (except along the Molocué river; Appendix 3); exceptions were the common duiker, the striped polecat, and to a lesser degree, the greater kudu (Appendix 3).

Table IV: Presence(x)/absence of mammal species per habitat type with distances covered per habitat in brackets (species with less than 20 observations excluded from the analysis)

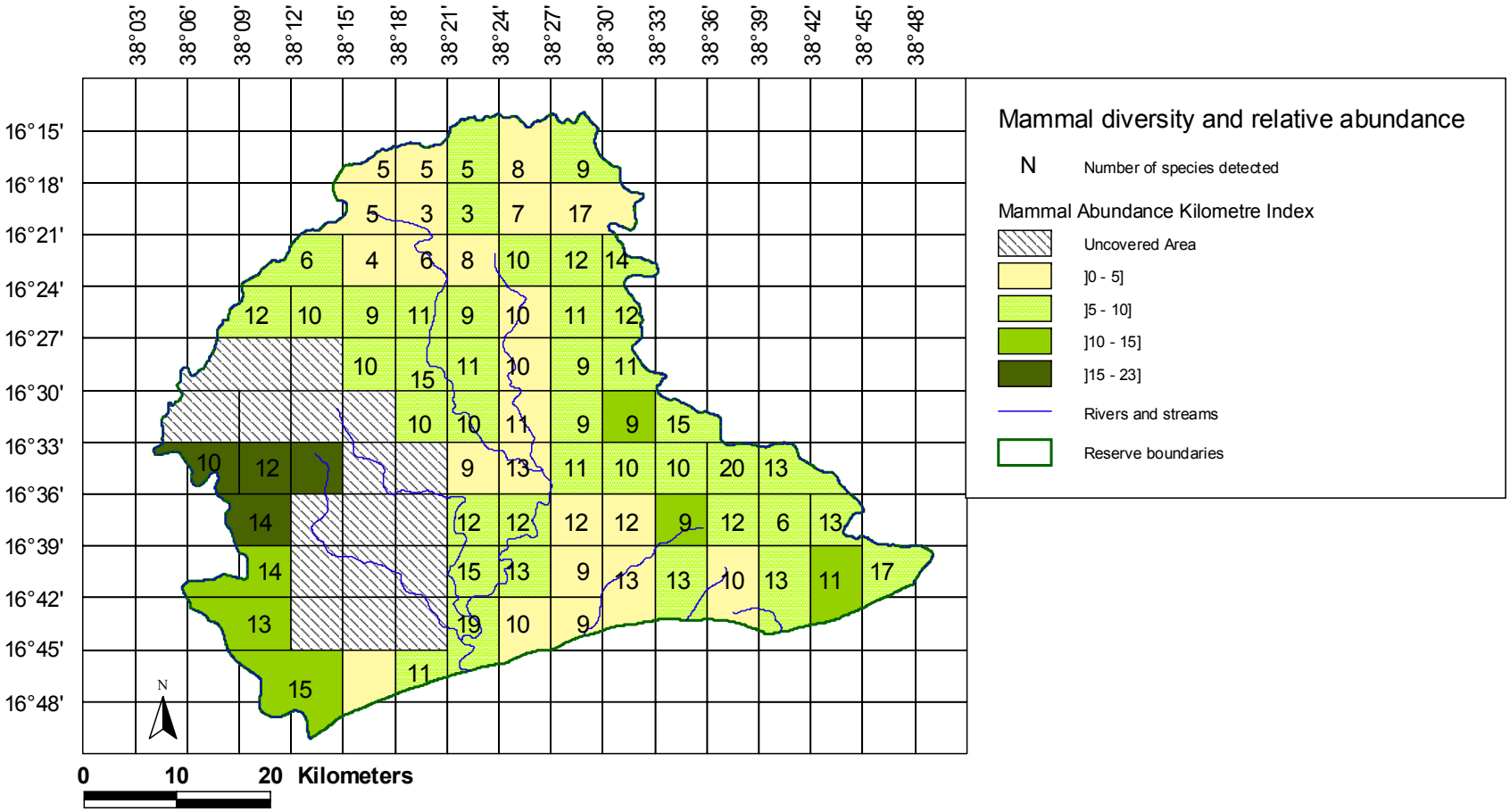
Species	Habitat type								
	Closed forest		Open forest		Woodland		Dambo		Inselberg
	Dry[1] (28)	Watered[2] (5.5)	Dry (228)	Watered (135)	Dry (89)	Watered (52)	Dry (30)	Watered (10)	(2.9)
Common duiker	x	x	x	x	x	x	x	x	
Bushbuck	x	x	x	x	x	x	x	x	x
Spiny mouse	x	x	x	x	x	x	x	x	x
Striped polecat	x	x	x	x	x	x			x
Greater kudu	x		x	x	x	x	x	x	
Waterbuck	x	x	x	x	x	x	x	x	
Southern reedbuck			x	x	x	x	x	x	
Bushpig	x	x	x	x	x	x	x	x	
Sable antelope			x	x	x	x	x	x	
Natal duiker	x	x	x	x		x			x
Yellow baboon	x		x	x	x	x	x	x	
Scrub hare			x	x	x	x			
Giant pouched rat			x	x	x	x			
Suni		x	x	x					
Wild cat			x	x	x	x			
Aardvark	x	x	x	x	x	x		x	
Elephant			x	x	x	x			

[1]: Along watercourses; [2]: Away from watercourses

Table V: Number of observations (refer to single or grouped animals) and Abundance Kilometre Index per species (for species with more than 10 observations)

Species	Direct observation	Indirect observation[1]			Total	Abundance Kilometre Index
		Day	Recent[2]	Old[3]		
Common duiker	81	2079	933	79	3172	3.729
Bushbuck	12	466	342	50	870	0.825
Spiny mouse	2	209	3		214	0.364
Striped polecat		200	82	8	290	0.345
Greater kudu	4	163	189	46	402	0.288
Waterbuck	2	157	123	16	298	0.275
Southern reedbuck	6	147	91	15	259	0.264
Bushpig	1	111	88	20	220	0.193
Sable antelope	3	81	70	23	177	0.145
Natal duiker	4	40	8		52	0.076
Yellow baboon	11	23	30	1	65	0.059
Scrub hare	10	21	9	2	42	0.054
Giant pouched rat	1	21			22	0.038
Suni	1	22	6	1	30	0.040
Cane rat		16	2		18	0.028
Wild cat		14	12	3	29	0.024
Elephant	1	12	4	3	20	0.022
Four-toed elephant shrew	11				11	0.019

[1]: Signs of presence (spoors, feces, feeding sites...) [2]: Between 1 and 2 day old [3]: 3 day old and more



Map 6: Mammal Abundance Kilometre Index (all mammal species included) per cell, with the number of species encountered per cell

Species' hotspots were mostly observed along the three main watercourses of the reserve (Mulela/Lice, Malema, and Molocué rivers). The waterbuck was relatively more abundant along these three watercourses (Appendix 3). Hotspots were located along Mulela and Malema rivers for the bushbuck and along Lice and Molocué rivers for the Natal duiker. Elephants were mostly encountered along the Mulela river, in the south-western part of the reserve (Appendix 3). Finally, the range of the suni was restricted to the edges of the Molocué river.

The southern reedbuck was relatively more abundant in an area located between the Malema and Molocué rivers in longitude and between 16°30' and 16°39' in latitude (Appendix 3). For the striped polecat and the sable antelope, the hotspots were located respectively in the western and south-eastern parts of the reserve. There were no noticeable hotspots for the common duiker, the greater kudu, the bushpig, the aardvark and the wild cat (Appendix 3).

- **By habitats**

The highest AKI_m was recorded in woodlands, with respective values of 10.4 along watercourses and 7.43 away from watercourses (Table VI). The lowest value was found in the 'watered' closed forest (2.93).

Some species were detected at the same rates across all the habitat types where they occurred (i.e. bushpig, yellow baboon, wild cat, scrub hare, giant pouched rat, spiny mouse, striped polecat and elephant). On the other hand, other species were apparently found in specifics habitats (Table VI). The common duiker had a large relative abundance in each used habitat ($2.6 < AKIe < 4.8$) but 'watered' closed forest ($AKIe = 0.18$). The southern reedbuck was the only species for which relative abundance appeared higher in dambos ($AKIe = 1.4$) than in any other used habitat ($AKIe\ max = 0.53$).

The waterbuck, the bushbuck, the Natal duiker and the suni were more frequently met on transects along watercourses. We recorded the maximal relative abundance of Natal duiker and suni in 'watered' closed forest, with respective AKIe values of 0.55 and 0.37. The second largest values, recorded in 'watered' open forest, were respectively 0.19 for the Natal duiker and 0.13 for the suni. The waterbuck and the bushbuck were mainly observed in 'watered' open forest and 'watered' woodland. In addition, the difference between relative abundance in these habitats and the others was greater for the bushbuck (Table VI).

On the other hand, the greater kudu and the sable antelope were more frequently encountered in 'dry' habitat types. The highest relative abundances of the greater kudu were recorded in 'dry' woodland ($AKIe = 0.44$) and 'dry' open forest ($AKIe = 0.38$), while the sable antelope was more frequently observed in 'dry' woodland ($AKI_e = 0.32$) and 'dry' dambo ($AKI_e = 0.34$).

2.4. Group size and composition

The ratio of solitary animals was high in all species, being below 50% only for the greater kudu, the elephant and the cane rat (Table VII). We recorded the largest groups in elephants ($n=24$), waterbucks ($n=17$), sable antelope and cane rat ($n=12$). At the opposite, species like jackal, leopard, wild cat, and aardvark were always solitary.

With a minimal estimated population of 78 individuals, and a high ratio of immatures (32%), the population of elephant appeared particularly dynamic.

Table VI: Mammal Abundance Kilometre Index (all mammal species included) per type of habitat and AKI per species and type of habitat, with distance covered in each habitat, inselberg excluded (for species with more than 20 observations)

	Along watercourse ('watered' habitat)				Away from watercourse ('dry' habitat)			
Species	**Closed Forest 5.5km**	**Open Forest 134.7km**	**Woodland 51.6 km**	**Dambo 10 km**	**Closed Forest 28.3 km**	**Open Forest 228.4 km**	**Woodland 88.6 km**	**Dambo 29.7 km**
Common duiker	0.18	2.63	4.73	3.00	3.64	3.89	4.81	3.77
Bushbuck	0.92	1.85	2.69	0.50	0.42	0.22	0.17	0.07
Spiny mouse	0.18	0.37	0.60	0.10	0.28	0.39	0.26	0.20
Striped polecat	0.18	0.31	0.47	-	0.42	0.43	0.25	-
Greater kudu	-	0.15	0.25	-	-	0.38	0.44	0.27
Waterbuck	0.18	0.55	0.47	0.20	-	0.18	0.18	0.07
Southern reedbuck	-	0.01	0.25	1.40	-	0.15	0.53	1.42
Bushpig	0.37	0.16	0.16	0.10	0.18	0.21	0.19	0.27
Sable antelope	-	0.08	0.25	0.10	-	0.09	0.32	0.34
Natal duiker	0.55	0.19	0.16	-	0.11	0.01	-	-
Yellow baboon	-	0.01	0.04	0.20	0.21	0.05	0.08	0.13
Scrub hare	-	0.01	0.12	-	0.04	0.07	0.06	-
Giant pouched rat	-	0.06	0.04	-	-	0.03	0.07	-
Suni	0.37	0.13	-	-	-	0.02	-	-
Wild cat	-	0.04	0.02	-	-	0.03	0.02	-
Elephant	-	0.04	0.08	-	-	0.02	-	-
Mammal	2.93	6.70	10.4	5.60	5.37	6.23	7.43	6.61

Table VII: Number of individuals encountered (direct and indirect records), group size and group composition per species (adult sex ratio non available when discrimination of sex was not possible from spoors); data for elephants were corrected following suppression of putative doubloons (estimation of minimal population size)

Species	**Total number**	**Median Group size**	**Group size interval**	**Ratio of solitary animals (%)**	**Adult sex ratio female per male**	**Ratio of immatures (%)**
Common duiker	3637	1	[1-2]	87	N/A	2.5
Bushbuck	1021	1	[1-3]	84	1.25	4
Greater kudu	777	2	[1-8]	49	1.45	3
Waterbuck	456	1	[1-17]	64	1.05	2
Bushpig	374	1	[1-8]	58	1.04	10
Southern reedbuck	340	1	[1-4]	74	0.97	7
Striped polecat	318	1	[1-8]	95	N/A	0
Sable antelope	218	1	[1-12]	62	1.1	3.2
Elephant $_1$	78	3	[1-24]	27	2.33	32
Cane rat	83	4	[1-12]	28	N/A	0
Natal duiker	55	1	[1-2]	94	N/A	3.6
Scrub hare	44	1	[1-2]	95	N/A	0
Suni	34	1	[1-3]	90	N/A	0
Wild cat	29	-	-	100	N/A	0
Aardvark	28	-	-	100	N/A	0
Warthog	21	1	[1-3]	82	2	5
Four-toed elephant shrew	11	-	-	100	N/A	0
Klipspringer	11	1	[1-3]	57	N/A	9
Leopard	8	-	-	100	N/A	0
Side-striped jackal	8	-	-	100	N/A	0

$_1$: data corrected N/A: Non available

3. BIRDS

Although we took advantage of any occasion to identify birds, only 34 species were recorded (Table VIII). Birds are particularly difficult to observe in wooded habitats, and most of them were identified outside field sessions, along watercourses. However, we observed seven species not recorded previously, of which the uncommon Böhm's bee eater (*Merops boehmi*).

Table VIII: Checklist of identified birds (**new records***)

Latin Name	Common Name	Latin Name	Common Name
Phalacrocorax africanus	Reed cormorant	*Tauraco porphyreolophus*	Purplecrested lourie
Scopus Umbretta	Hamerkop	*Caprimulgus fossii*	Mozambique nightjar
Bostrychia hagedash	Hadeba ibis	*Ceryle rudis*	Pied kingfisher
Plegadis falcinellus*	**Glossy ibis**	***Merops boehmi****	**Böhm's bee-eater**
Nycticorax nycticorax	Blackcrowned night heron	*Coracias caudata*	Lilacbreasted roller
Milvus migrans	Black kite	*Upupa epops*	Hoopoe
Tyto alba	Barn owl	*Bucorvus cafer*	Southern ground hornbill
Pandion haliaetus	Osprey	*Bycanistes bucinator*	Trumpeter hornbill
Francolinus afer	Red-necked francolin	*Tockus alboterminatus*	Crowned hornbill
Francolinus sephaena	Crested Francolin	***Tockus nasutus****	**Grey hornbill**
Numida meleagris	Helmeted guineafowl	*Hirundo abyssinica*	Lesser Striped swallow
Guttera pucherani	Crested guineafowl	*Hirundo smithii*	Wiretailed swallow
Eupodotis melanogaster	Black-bellied bustard	*Corvus albus*	Pied crow
Rhinoptilus chalcopterus*	**Bronzewinged courser**	***Cisticola chiniana****	**Rattling cisticola**
Burhinus vermiculatus	Water dikkop	*Spermestes bicolor*	Redbacked mannikin
Vanellus lugubris*	**Lesser blackwinged plover**	***Ploceus xanthopterus****	**Brownthroated weaver**
Streptopelia capicola	Ring-necked dove	*Euplectes hordeaceus*	Firecrowned bishop

4. REPTILES

Only few reptiles were identified, as illustrated by Table IX.

Table IX: Checklist of identified reptiles

Latin Name	**Common Name**
Dendroaspis polylepis	Black mamba
Dendroaspis angusticeps	Green mamba
Naja annulifera	Snouted cobra
Dispholidus typus	Boomslang
Varanus niloticus	Nile monitor
Gerrhosauros validus	Plated lezard
Kinixys belliana	Bell's hinged tortoise
Crocodylus niloticus	Nile crocodile
Hemidactylus sp.	Tropical house geckoes

5. HUMAN ACTIVITIES

5.1. Poaching

Field observations suggested that poaching activity within the RNG was intensive and diversified. 289 poachers were detected along the transects from direct sightings and spoors. The average poacher team was made of two persons; nevertheless, large teams with more than ten hunters were occasionally met.

• Distribution and relative abundance

We recorded evidences of poacher occurrence in 90% of the surveyed cells evenly distributed within the RNG (Map 7). A total of 328 observations were made: 14 direct sightings, 62 signs of presence of the day, 61 recent signs of presence and 191 old signs of presence. The resulting AKI_e was 0.13 contacts/km. We did not find significant relationship between cell's poacher AKI_e and cell's AKI_m. There was no clear distribution pattern regarding the relative abundance of poaching signs at the scale of cells. It appeared however that the largest AKI_e values were mostly recorded in the outskirt cells (Map 7).

• Hunting techniques

Various types of poaching signs were recorded (Map 8; Appendix 4), showing a large diversity in natural resource utilizations. The poachers' signs of presence were represented by trails (33%), spoors (25%), traps (15%), camps (12%), excavation of burrowed animals (mainly spiny mouse and giant pouched rat) (6%), damage on vegetation (4%) and fish traps (4%).

During the field survey, four main types of hunting techniques were noticed for mammals: trapping, netting, hunting with dogs and excavation. The use of firearms appeared quite uncommon (cartridges found on two occasions), while ongoing bush fires were observed only three times.

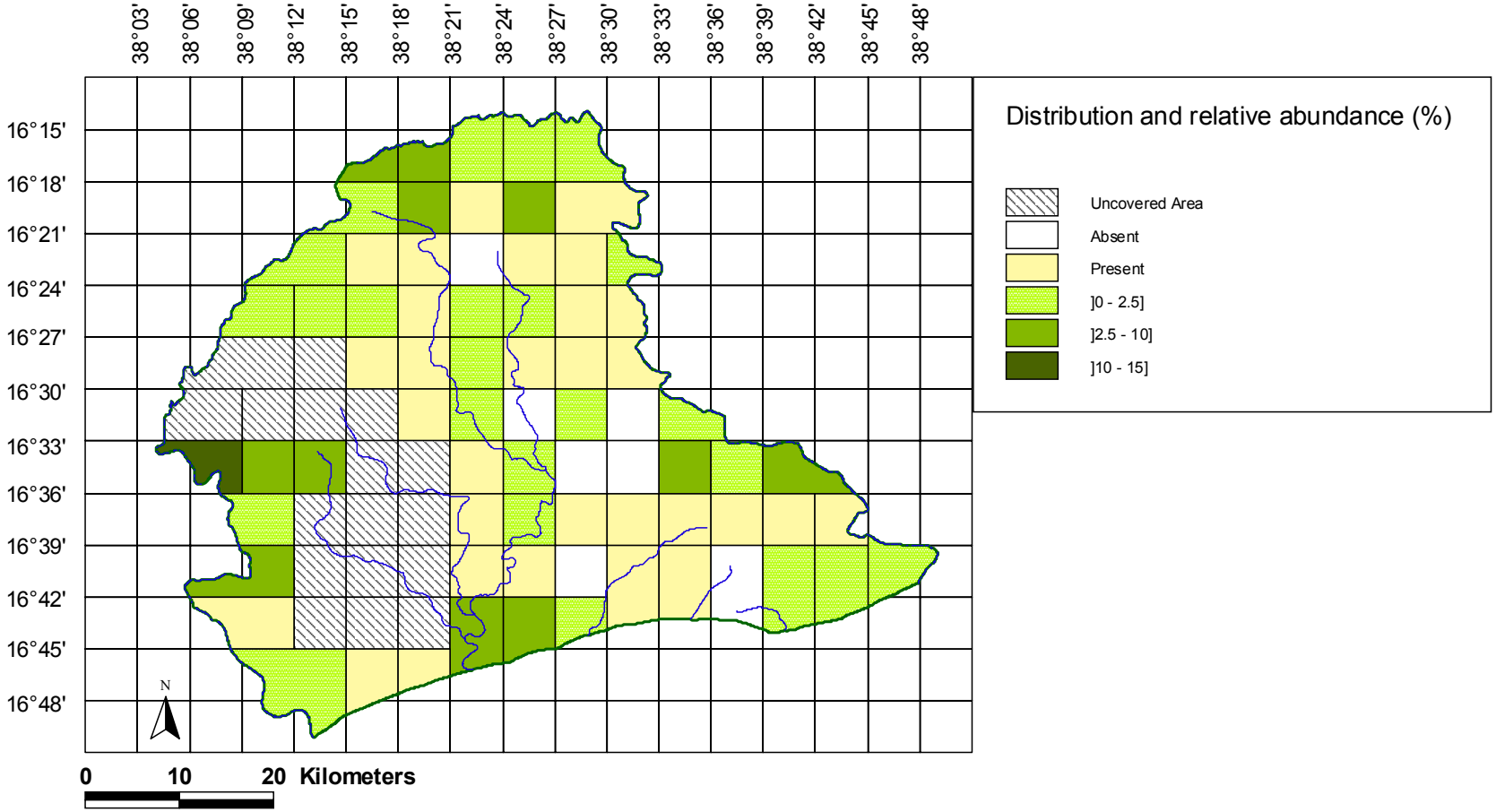
On nine occasions, we observed from direct sightings or spoors, that poachers hunted with dogs (Appendix 4 - Plate 4), a technique apparently commonly used once vegetation has grown after the first rains.

Poachers use three different kinds of traps (neck trap, leg trap and fall trap) that are all unselective.

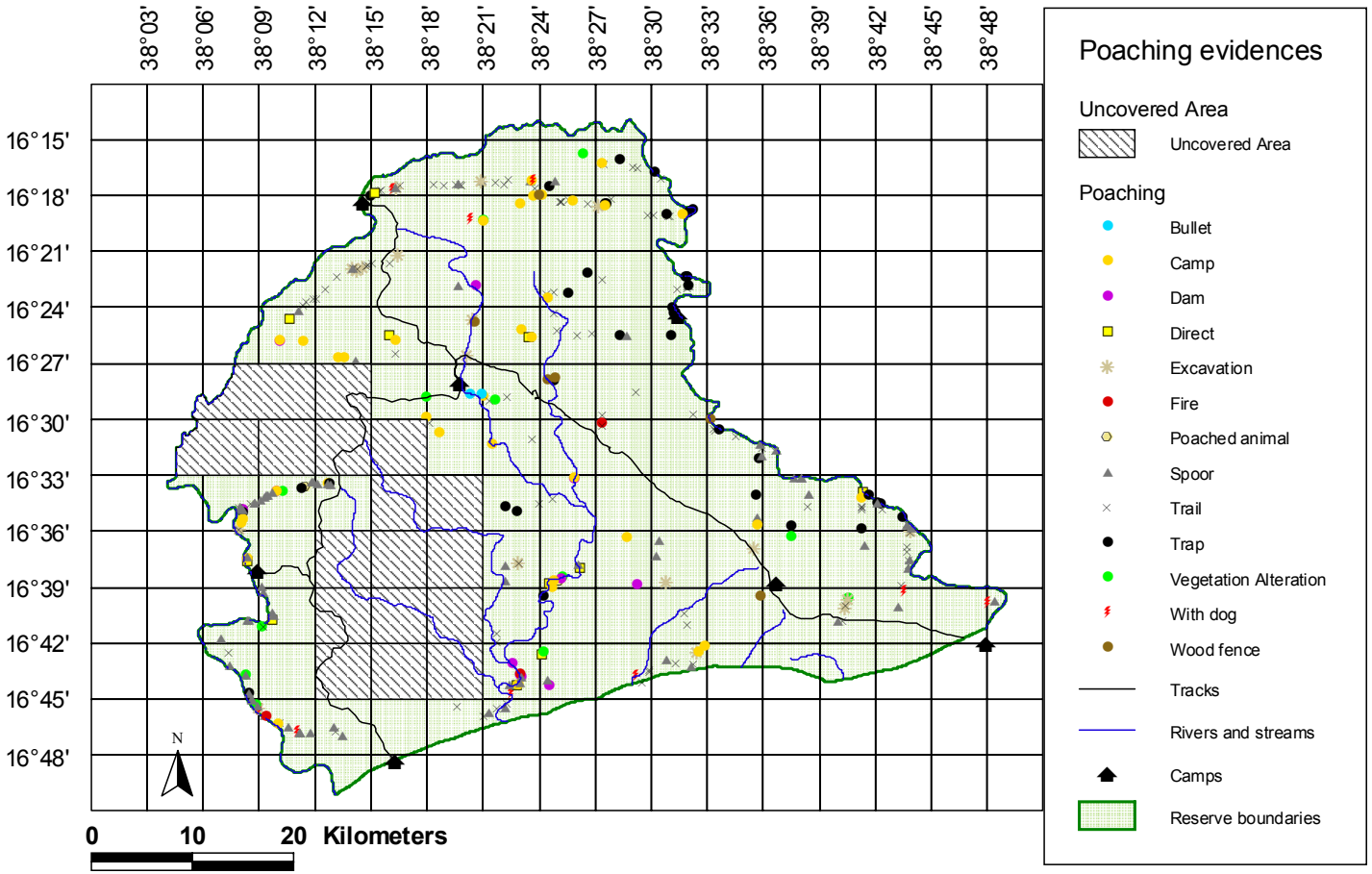
In the neck traps, a circular wire is placed between two wood-sticks in vertical position so that the animal's neck enters and activates the release the mechanism.

There are three different kinds of leg traps. The first is similar to the neck trap, but the wire is placed on the ground with the release mechanism armed in a small hole in the middle of the ring; it is released by the animal leg pressure. Both the neck trap and this leg trap are used to catch small antelopes, hares and other small to medium size mammals.

In the second type of leg trap, a trunk is hung on a wire above the opening of an artificial barrier made with branches (Appendix 4 - Plate 1). The release mechanism, armed on the ground, is activated when the animal passes through the opening, letting the trunk fall on the quarry. Such traps are intended to catch small to medium size mammals, but also large birds.



Map 7: Distribution and relative abundance of poaching evidences.
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded



Map 8: Locations of poaching activities within the RNG

The third type of leg trap used in the target area, is a gin trap (iron-made trap: 'ratoeira') with a jaw-edge (Appendix 4 - Plate 2). These traps are commonly used and, depending on their size, are able to catch medium to large mammals.

Fall traps (Appendix 4 - Plate 3) are not commonly used in the study area. This kind of trap is simply a large hole in the ground with several iron-tip spears to the bottom. The hole is covered and hidden with branches and leaves. Fall traps allow local hunters to catch medium and large animals.

5.2. Other activities

Damages on vegetation were carried out for various purposes: honey or caterpillar collection, bark removal to extract poison (used for fishing) or to build basic canoes (Appendix 4 - Plate 6). We even observed that poachers had cut down a tree to close the main RNG track (between Mulela and Namurrua camps). In addition, we crossed three wooded areas that had been cleaned to grow manioc in the northern part of the RNG (cells A01 and B01).

IV. DISCUSSION AND PERSPECTIVES

1. SCALE OF THE SURVEY

Information about mammal diversity and abundance in the RNG were scarce, and derived from three main surveys (Dutton *et al.*, 1973; Chande *et al.*, 1997; Carpaneto, 2001; Appendix 2). Even though the information on the survey effort (Table X) provided by these authors is only partial, we assume that a wildlife survey to such a scale had never been carried out in the RNG: 600 km have been covered by foot, in 240 hours.

Table X: Available information about survey effort of previous studies in RNG

Kind of survey	**Study**		
	Dutton *et al.*, 1973*	**Chande *et al.*, 1997***	**Carpaneto, 2001****
Aerial survey	~20 hours	8h30min	2h
Survey by car	N/A	No	?
Survey on foot	N/A	No	
Ethnozoological enquiry	N/A	N/A	N/A

* Aerial survey by helicopter

** Aerial survey by plane

2. METHODOLOGY

• Transect on foot

The National Reserve of Gilé covers 2 100 km² and has a limited network of tracks (i.e. 170 km). Since our objective was to carry out a wildlife survey throughout the whole RNG, only a survey on foot or an aerial survey were conceivable. However, aerial surveys had already been performed in the RNG, with poor results (e.g. five species observed in Chande *et al.*, 1997; no observations in Carpaneto, 2001); in addition, aerial surveys only permit direct observation of the largest species in open areas. We therefore carried out a survey on foot.

Watercourses were followed at a distance varying from ten to hundred meters. As a consequence, species like otters were less likely to be observed and the probability of detecting rare species using riverbeds to move around, like lion and leopard, was reduced. Animals were rarely observed directly (i.e. 165 records; 2.5% of total observations). This could partially be due to the fact that our goal was not to spot animals, and that our main transect direction was consequently selected independently from wind orientation. Furthermore, sometimes the team could number up to 11 persons because poachers met were arrested, and thus 'joined' the wildlife survey team.

• Abundance kilometre index

To calculate AKI, only direct observations and indirect observations dated the day of observation were considered as contacts. Most of the indirect observations were represented by spoors (i.e. more than 90%). The probability of spoors' detection was heterogeneous, both spatially and/or temporally, according to several parameters: 1) soil structure; 2) dead leaves cover; 3) occurrence of fire and its age; 4) rain occurrence; 5) vegetation re-growth following the first rains (from mid-November).

This variability introduced bias in relative abundance estimation that could not be assessed. Rains erase signs like spoors and feeding sites. As a result, fewer spoors were observed following rainfalls; this is particularly true for the oldest spoors (Table XI). Thus, considering only direct observations and signs dated of the day for AKI calculations, allowed to reduce bias linked to rain occurrence. Additively, rain induced grass re-growth, meaning that spoors' visibility also decreased with time between mid-October and mid-December.

The probability of spoors' detection varies also according to some features of the habitat like soil structure (e.g. the soil was particularly hard and dry in dambos before the occurrence of first rains) or dead leaves cover (e.g. the dead leave cover was denser in closed forest compared to other habitats). The results of the analysis of relative abundance variations according to habitat type should therefore be considered as indicative, and conclusions could only be drawn cautiously.

Table XI: Effects of rain occurrence on number of contacts of mammals per km (direct observations and spoors)

Last Rain	Distance (km)	Number of contacts per km			
		Direct observation	Spoors of the day	Spoors of the day before	Spoors of 2 days and more
Older than 2 days	252.2	0.28	7.2	5.5	0.76
2 days ago	59.6	0.29	6.0	2.7	0.18
Day before	220.6	0.28	4.7	1.4	0.21
Day	47.8	0.36	3.7	1.7	0.21

3. MAMMAL DIVERSITY AND RELATIVE ABUNDANCE

Following the surveys carried out by Dutton *et al.* (1973), Chande *et al.* (1997) and Carpaneto (2001), Gallego-Lizon (2002) considered that 69 species of mammals had been identified in the RNG. However, only 59 species were reported as occurring in the management plan of the RNG (Fusari & Cumbane, 2002).

Among the 69 species, the quotation of the black-backed jackal (*Canis mesomelas*) identified from its spoors (Dutton *et al.,* 1973), might be a misleading deduction. The study area actually falls in the geographic range of the side-striped jackal while the black-backed occurs south of the Zambezi River and usually in arid environments (Smithers & Tello, 1976). Identically, the aardwolf (*Proteles cristata*) included in the checklist from the report of a ranger (Dutton *et al.,* 1973), is also questionable since no evidence of its occurrence has ever been recorded in the region.

In the same way, Chande *et al.* (1997) mistakenly reported the cheetah (*Acinonyx jubatus*) and the oribi (*Ourebia ourebi*) from ethnozoological enquiries. The oribi was probably mistaken for the suni (*Neotragus moschatus*) which was not mentioned in the report while the cheetah was probably mistaken for the African civet (*Civettictis civetta*), whose vernacular Lomué name is "xita" (pronounced chita). In addition, Fusari & Cumbane (2002) considered as questionable the presence of caracal (*Felis caracal*), roan antelope (*Hippotragus equinus*) and impala (*Aepyceros melampus*) in the RNG mammal checklist because evidence of their occurrence has never been recorded in the region. Finally, the black rhinoceros (*Diceros bicornis*) and the blue wildebeest (*Connochaetes taurinus*) still present in the early 1970s (Dutton *et al.*, 1973), were considered as surely extinct in 2002 (Fusari & Cumbane, 2002).

All these nine species were therefore removed from the 2002 mammal checklist as well as the white-tailed mongoose (*Ichneumia albicauda*) quoted by Dutton *et al.* (1973) (Fusari & Cumbane, 2002).

We therefore considered that the mammal checklist of the RNG totalized 60 species before the present survey. During our survey, we observed two species not recorded previously (the dwarf mongoose [*Helogale parvula*], and a rodent still to be identified). The updated checklist of mammal species of the RNG thus includes 62 species. Several species will be surely added to the present checklist in the future.

40 out of the 62 mammal species of the checklist were detected during the survey. Among the large mammals of particular interest for wildlife viewing or hunting tourism, the most abundant species are the bushbuck, the kudu, the waterbuck, the bushpig and the sable antelope. A population of elephants (minimal population number estimated at 78 individuals) also ranges in the reserve. This population which appears particularly dynamic (immature ratio: 32%), seems to have increased since the last survey conducted in the reserve which estimated the population to ca. 25 individuals (Martins & Ntumi, 2002). We only recorded a single sign of presence for the African buffalo and the Livingstone's eland. Their occurrence in the reserve is thus confirmed, but they seem to survive in such a very low number that they will certainly disappear in a near future without specific actions aiming at reinforcing their population. Among carnivores, we confirmed that the reserve hosts populations of leopard, serval and side-striped jackal; however, their abundance could not be assessed without implementing specific surveys.

Several large mammal species mentioned in the checklist have not been observed during the survey. Nevertheless, it does not mean that they have disappeared from the RNG since they could occur in the uncovered cells (17 out of 90, *i.e.* 19%). We therefore interviewed the RNG's guards and rangers (8 persons) to clarify the status of species that were not recorded

during the survey. As a result of these interviews, it appeared that: (i) the Burchell's zebra has not been seen since 2002, when two local informants observed two individuals along Malema watercourse (Fusari & Cumbane, 2002); (ii) the Lichtenstein's hartebeest might possibly survive in very low numbers (last observation from a reliable informant: two individuals in September 2005); (iii) according to local informants, the spotted hyena might survive in very low number; an individual had been observed in March 2006 in the south-eastern part of the reserve and a footprint was observed by Fusari & Chardonnet in May 2007; (iv) although the wild dog population is considered as decreasing in the last decade, local informants observed in 2007, around Musseia camp, once a loner individual and once a pack of 16 individuals.

Finally, even though we have not recorded the presence of lions, a population is undoubtedly ranging within the reserve; lions were heard roaring by Lice camp guards during the survey (December 2007) and a footprint was observed by Fusari & Chardonnet in May 2007.

4. PERSPECTIVES AND RECOMMENDATIONS

• Further ecological monitoring

By applying a systematic sampling, the first quantitative data about mammal distribution and relative abundance have been provided for the RNG. The selected survey method (census of direct sightings and signs along transects) has the advantage of being readily repeatable, efficient, reasonably accurate and cost-effective. **We therefore recommend repeating consistently the same survey in the forthcoming years in order to assess the trends of mammals' populations and so assess the effects of future management decisions.**

However, the survey has been disturbed by rain occurrence. This could have been avoided by starting the survey by early September rather than mid-October. In addition, the smallest and the less common mammal species are difficult to observe along transect on foot. Hiding out in attractive areas (e.g. nearby water-pool) could probably increase significantly the probability of detection for these species. **Transect survey should therefore be completed by hiding out survey.**

Few contacts with carnivores were recorded. This is not surprising since the systematic sampling along transect is not known as the most appropriate method to assess carnivores' abundance in forested areas (Gittleman *et al.*, 2001). Large carnivores using preferentially the tracks to move around, a better and cost-effective way to assess their relative abundance would be to look for spoors on the track network of the reserve using bicycles (170 km; around 3 days per repetition). Should more time be available to monitor carnivores, methods like calling stations (suitable for social species: lion, hyena, wild dog; e.g. Ogutu & Dublin, 1998), or individual markings (capture - mark - recapture method; e.g. Castley *et al.*, 2002) might also be implemented. **Carrying out alternative surveys with the specific aim of carnivore census is consequently suggested.**

A thorough inventory of smaller mammal species (e.g. rodents) and invertebrates requires individual captures and skilled specialists. In addition, the bird and reptile checklists are still very much preliminary. **The possibility to carry out a mega-inventory of the RNG, engaging specialists of each zoological taxon, is to be considered in order to produce a thorough checklist of the RNG fauna communities.**

Finally, the habitat types crossed along transects did not always matched the vegetation map of the RNG currently available (Fusari & Cumbane, 2002). **A specific survey to update this vegetation map is also recommended.**

• Surveillance

The main threat to the ecological integrity of the reserve is the unsustainable poaching using devastating and unselective hunting techniques (Fusari & Cumbane, 2002, Fusari & Carpaneto, 2006). **The focus of forthcoming management decision should therefore be based on hunting and fire control.**

The current team of the RNG numbers only seven rangers; a few equipped with rifles. The efficiency of anti-poaching patrols could be substantially improved by **increasing the number of rangers (10-15), training them and providing each of them with proper rifles and ammunitions. In the same way, the patrols should be given means of communication allowing them to interact efficiently.**

The mammal community appeared particularly depleted in the northern part of the reserve (except along the Molocué river; Appendix 3). **This area should receive specific attention.**

The number of direct sightings (i.e. 2.5% of observations) was very low. It seems that the pressure of subsistence hunting caused not only a degradation of game species' populations but also an increased wariness of the animals towards humans. Nevertheless, abundant tracks and signs of ungulates (common duiker, southern reedbuck, bushbuck, waterbuck, sable antelope and bushpig) were observed. We suggest that such a scarcity of direct observations might be a response to hunting pressure. **An effective control of hunting activities over years is a prerequisite for an easier observation of many species** once they had recovered a higher density and a confidential behaviour towards people (i.e. a lower fleeing distance).

• Wildlife management

Some species of large mammals seem particularly threatened with extinction in the short term and should consequently receive increased attention (African buffalo, Livingstone's eland, Lichtenstein's hartebeest, lion, spotted hyena and African wild dog). Depending on the thorough specific studies that have to be carried out urgently, **the restocking of the populations of these species should be considered**. **Reintroduction is the only management option available for species already extinct within the RNG, like the wildebeest.**

Special efforts need to be placed on the protection of elephants and African wild dogs since both species represent taxa of conservation concern and could be flag species for the RNG. The population of elephant seems concentrated in the south-western part of the reserve, where intensification of anti-poaching patrols appeared particularly needed. Since the wild dog is neither eaten nor hunted by native people who have a traditional respect for it, the RNG could be a particularly optimal site for restocking this endangered species.

V. CONCLUSIONS

The National Reserve of Gilé has a considerable ecological potential due to the following reasons: (i) there are no human settlements and no human encroachments within the reserve, except a few manioc fields at the northern boundary; (ii) the human population density is low around the reserve, especially along the western boundary; (iii) the area is not very appropriate for both agriculture (low soil fertility) and livestock husbandry (occurrence of bovine trypanosomiasis); (iv) the deciduous woodland of the reserve is very interesting from a scientific point of view because it represents a relict remain left over after human alteration of the Zambézian landscape; (v) the biological communities seem rich and diverse, reflecting a well structured trophic web (Carpaneto, 2001); (vi) the reserve hosts a population of elephant and probably African wild dog and should be considered as a conservation priority to this respect.

The main threat to the ecological integrity of the reserve is the heavy poaching pressure using devastating and unselective hunting techniques. The recovery of the mammal community should be possible after 5 to 10 years of good management. Restocking populations of key mammal species, probably close to extinction in the reserve, like the African buffalo, the Livingstone's eland, the Lichtenstein's hartebeest, and the African wild dog, appears to be a relevant option when poaching will be under control. The effects of future management decisions on dynamic processes of mammal species would be possibly monitored should the survey hereby applied be repeated in the forthcoming years.

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APPENDICES

Appendix 1: Timetable of field sessions, with survey effort and distance covered

Appendix 2: Checklist of mammals

Appendix 3: Species distribution and relative abundance maps of remarkable species

- Common Duiker
- Bushbuck
- Greater Kudu
- Southern Reedbuck
- Bushpig
- Waterbuck
- Sable Antelope
- Natal Duiker
- Suni
- Elephant
- Aardvark
- Striped Polecat
- Wild Cat

Appendix 4: Poaching sign plates

- **Plate 1:** Leg traps
- **Plate 2:** Gin trap (‘ratoeira’)
- **Plate 3:** Fall trap
- **Plate 4:** Hunting with hound
- **Plate 5:** Fish trap
- **Plate 6:** Damage on vegetation; bark removal
- **Plate 7:** Poacher camp
- **Plate 8:** Meat drying facility

Appendix 1: Timetable of field sessions, with survey effort and distance covered

Session	Cell Code	Track Code	Date	Distance (km)	Survey Effort (hour:min)
1	B05	B05	19-oct	11.2	6:40
	B04	B04	19-oct and 20-oct	6.1	3:04
	A04	A04	20-oct and 21-oct	9.5	4:08
	A05	A05	21-oct	8.3	3:22
	total			35.1	17:14
2	D08	D08-1	23-oct	1.3	1:20
	C07	C07	23-oct	8.7	4:24
	C06	C06	23-oct and 24-oct	6	3:16
	C05	C05	24-oct	8.6	5:26
	D06	D06	24-oct	7	2:56
	D07	D07	24-oct and 25-oct	5.9	2:33
	D08	D08-2	25-oct	4.5	1:25
	total			42	21:20
3	I11	I11-1	27-oct	3.7	1:37
	H11	H11	27-oct	6.4	2:17
	G12	G12	27-oct and 28-oct	11.6	4:38
	H12	H12	28-oct	6.6	2:43
	I12	I12	28-oct	6.9	2:57
	total			35.2	14:12
3'	I13	I13	17-nov	8.9	3:23
4	G03	G03	29-oct	2.9	1:53
	G02	G02	29-oct	6.6	3:44
	G01	G01	29-oct and 30-oct	5	3:03
	H01	H01	30-oct	7.8	4:26
	I01	I01	30-oct and 31-oct	11.6	7:14
	J01	J01	31-oct	6.9	3:14
	K01	K01	31-oct and 1-nov	15.2	7:48
	K02	K02-1	01-nov	1.2	0:31
	K02	K02-Road	01-nov	2.6	0:50
	total			59.8	32:43
5	I10	I10-1	04-nov	3.1	1:39
	H10	H10	04-nov and 05-nov	6.5	2:47
	G11	G11	05-nov	12.4	5:43
	G10	G10	05-nov and 06-nov	5.6	2:10
	H09	H09	06-nov	6	2:25
	I09	I09	06-nov	5.9	2:21
	I10	I10-2	06-nov	6.3	1:52
	I11	I11-2	06-nov	2.6	0:59
	total			48.4	19:56
6	K03	K03	09-nov	7	2:34
	J05	J05	09-nov and 10-nov	12.4	5:22
	I05	I05	10-nov	7.8	3:09
	H05	H05	10-nov	6.1	2:17
	H06	H06	10-nov and 11-nov	9.9	4:23
	I06	I06	11-nov	9.7	4:20
	J06	J06	11-nov	7.4	2:07
	total			60.3	24:12
7	F09	F09	13-nov	5.9	2:21
	F10	F10	13-nov and 14-nov	20.3	8:27
	E08	E08	14-nov	7.3	2:42
	E07	E07	14-nov	7.6	2:50
	F08	F08	14-nov and 15-nov	7.4	3:01
	total			48.5	19:21

Appendix 1: Timetable of field sessions, with survey effort and distance covered (continued)

Session	Cell Code	Track Code	Date	Distance (km)	Survey Effort (hour:min)
8	G09	G09-1	18-nov	4.3	1:48
	H08	H08	18-nov	6.6	2:36
	I08	I08	18-nov and 19-nov	15.4	5:24
	J07	J07	19-nov	7	2:28
	I07	I07	19-nov	7	2:28
	H07	H07	20-nov	7.2	3:04
	G08	G08	20-nov	7.9	3:06
	G09	G09-2	20-nov	0.6	0:23
	total			56	21:17
9	E04	E04-1	28-nov	4.4	2:00
	E05	E05-1	28-nov	6.6	2:40
	E06	E06	28-nov and 29-nov	7.9	3:09
	D05	D05	29-nov	7	2:27
	C04	C04	29-nov	7.6	2:37
	C03	C03	29-nov and 30-nov	7.7	2:25
	D04	D04	30-nov	6.4	2:10
	E04	E04-2	30-nov	2.4	0:42
	total			50	18:10
10	E04	E04-3	01-déc	3.4	1:06
	E05	E05-2	01-déc	1.7	0:32
	F06	F06	01-déc	7.5	2:23
	F07	F07	01-déc	8.1	2:51
	G07	G07	01-déc and 2-déc	12.2	4:54
	G06	G06	02-déc	8.6	2:44
	F05	F05	02-déc and 03-déc	8	2:39
	E03	E03-1	03-déc	3.2	1:05
	E03	E03-Road	03-déc	1.1	0:22
	total			53.8	18:36
11	C02	C02	12-déc	5.7	2:02
	C01	C01	12-déc	9.3	3:13
	D01	D01	12-déc	9.2	3:47
	D02	D02	12-déc and 13-déc	6.3	2:11
	D03	D03	13-déc	9.8	3:31
	total			40.3	14:44
12	B01	B01-1	14-déc	1.2	0:26
	A01	A01	14-déc and 15-déc	6.1	1:59
	A02	A02	15-déc	5.8	1:50
	A03	A03	15-déc	7.6	3:32
	B03	B03	15-déc	7	2:24
	B02	B02	15-déc and 16-déc	6.6	2:04
	B01	B01-2	16-déc	7.5	2:08
	total			41.8	14:23
total				**580.1**	**239:31**

Appendix 2: Checklist of mammals

Order	Family	Subfamily	Species	Common Name	Dutton *et al.*, 1973	Chande *et al.*, 1997	Carpaneto, 2001	Dobremez & Chardonnet, 2005	Fusari & Chardonnet, April 2007	Boulet & Lamarque, July 2007	Present Survey
Carnivora	*Protelidae*		*Proteles cristata*	Aardwolf	guard report						
	Hyaenidae		*Crocuta crocuta*	Spotted hyena	spoors		X	spoors	spoors		
	Felidae		*Panthera leo*	Lion	spoors	spoors (rare)	10		spoors	spoors	
			Panthera pardus	Leopard	spoors & skins		20-30	spoors		spoors	spoors
			Felis serval	Serval	skins		X				spoors + seen
			Felis sylvestris libyca	Wild cat	guard report		X				spoors
	Canidae		*Lycaon pictus*	Wild dog	guard report	guard report (rare)	14				
			Canis adustus	Side-striped jackal			X			seen	spoors
	Mustelidae	*Lutrinae*	*Lutra maculicollis*	Spotted-necked otter			X	spoors + seen?		feces	
			Aonyx capensis	Cape clawless otter	skins		X				
		Mellivorinae	*Mellivora capensis*	Ratel	spoors		X				spoors
		Mustelinae	*Ictonyx striatus*	Striped polecat	skins		X			den	feeding site + spoors
	Viverridae	*Viverrinae*	*Civecttictis civetta*	Civet	spoors	feces (common)	X	spoors			spoors
			Genetta tigrina	Blotched genet	skins		X				
			Genetta angolensis	Miombo genet			X				seen
		Herpestinae	*Herpetes ichneumon*	Ichneumon mongoose			X				
			Atilax paludinosus	Marsh mongoose	guard report		X				seen
			Ichneumia albicauda	White-tailed mongoose	seen						
			Helogale parvula	Dwarf mongoose*							seen
			Mungos mungo	Banded mongoose	seen		X			seen	spoors + seen
Tubulidentata	*Orycteropodidae*		*Orycteropus afer*	Aardvark	guard report		X				spoors
Pholidota	*Manidae*		*Smutsia temminckii*	Ground pangolin	guard report		X				feeding site
Proboscidea	*Elephantidae*		*Loxodonta africana*	Elephant	39	30	20-30	spoors		spoors + feces	spoors + seen
Hyracoidea	*Procaviidae*		*Heterohyrax brucei*	Bush hyrax			X			seen	seen
			Procavia capensis	Rock hyrax	seen		X				
Perissodactyla	*Rhinocerotidae*		*Diceros bicornis*	Black rhinoceros	guard report						
	Equidae		*Equus burchelli*	Zebra	seen	guard report (occasional)	> 2				

*new record

Appendix 2: Checklist of mammals (continued)

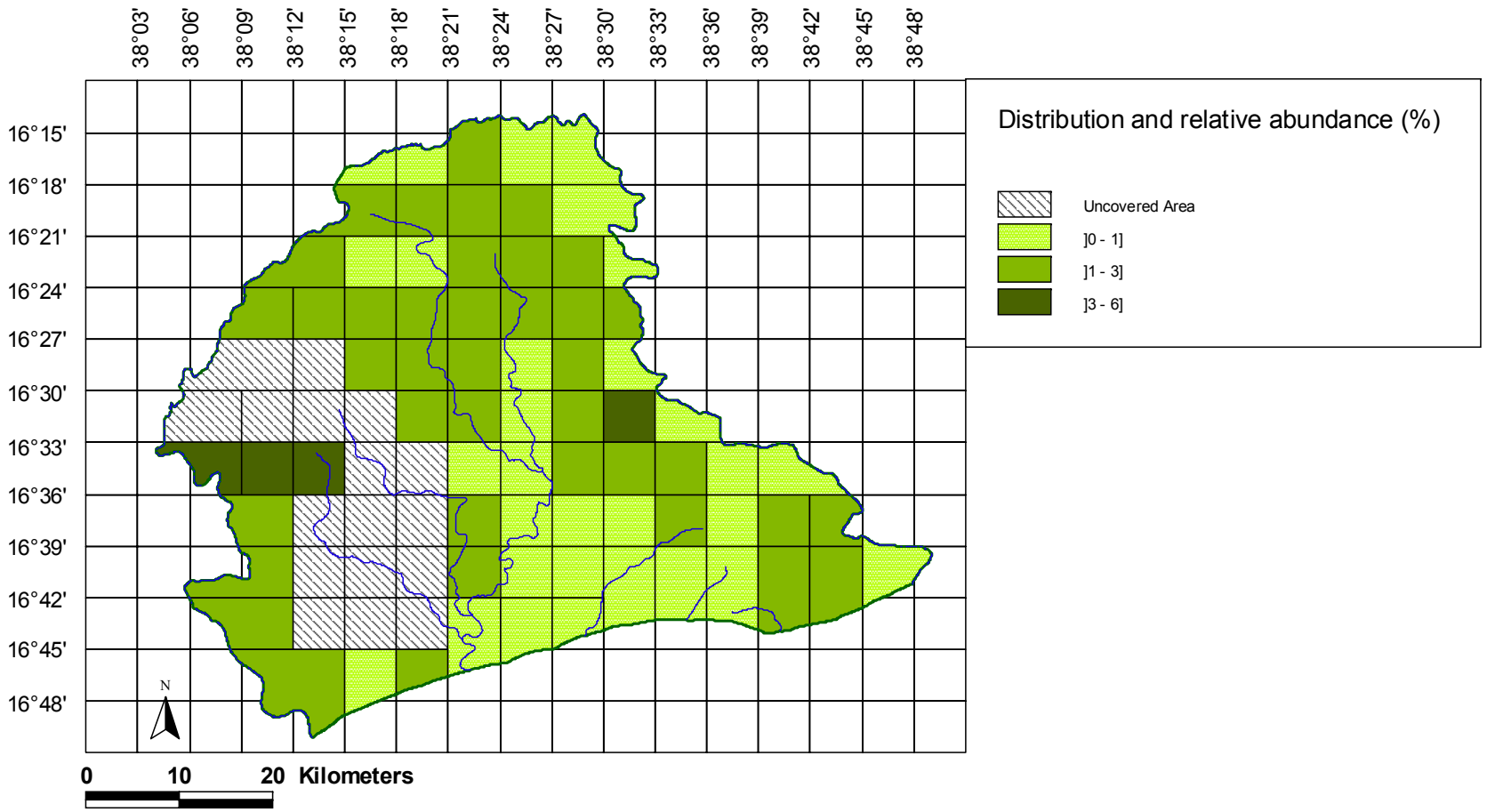
Order	Family	Subfamily	Species	Common Name	Dutton *et al.* , 1973	Chande *et al.* , 1997	Carpaneto, 2001	Dobremez & Chardonnet, 2005	Fusari & Chardonnet, April 2007	Boulet & Lamarque, July 2007	Present Survey
Artiodactyla	*Suidae*		*Phacochoerus africanus*	Warthog	seen	13	X	spoors	spoors	spoors	spoors
			Potamochoerus larvatus	Bushpig	seen	spoors (common)	X			spoors + feces	spoors + seen
	Hippopotamidae		*Hippopotamus amphibius*	Hippopotamus	guard report		> 2				
	Bovidae	*Alcelaphinae*	*Connochaetes taurinus*	Wildebeest	141	guard report (occasional)					
			Alcelaphus lichtensteinii	Lichtenstein hartebeest	423	guard report (rare)	X				
		Cephalophinae	*Sylvicapra grimmia*	Common duiker	seen	462	X	seen	seen	seen	spoors + seen
			Cephalophus natalensis	Natal duiker	skins		X		seen		spoors + seen
		Neotraginae	*Oreotragus oreotragus*	Klipspringer	seen	rare	X			feces	spoors
			Neotragus moschatus	Suni			X			spoors + feces	spoors + seen
		Hippotraginae	*Hippotragus niger*	Sable antelope	69	guard report (rare)	X	spoors		spoors + feces	spoors + seen
		Bovinae	*Syncerus caffer*	African buffalo	600		X				feces
		Tragelaphinae	*Tragelaphus scriptus*	Bushbuck	seen	105	X	seen			spoors + seen
			Tragelaphus strepsiceros	Greater kudu	12	communities report (common)	X	seen		spoors + feces	spoors + seen
			Taurotragus oryx	Common eland	720	15 (guard)	X				spoors
		Reduncinae	*Redunca arundinum*	Southern reedbuck	seen	guard report (common)	X			spoors	spoors + seen
			Kobus ellipsiprymnus	Waterbuck	43	6 (spoors)	X		spoors	spoors + feces	spoors + seen

Appendix 2: Checklist of mammals (continued)

Order	Family	Subfamily	Species	Common Name	Dutton *et al.*, 1973	Chande *et al.*, 1997	Carpaneto, 2001	Dobremez & Chardonnet, 2005	Fusari & Chardonnet, April 2007	Boulet & Lamarque, July 2007	Present Survey
Primate	*Cercopithecidae*	*Papiinae*	*Papio cynocephalus*	Yellow baboon	seen	13	X	seen		seen	spoors + seen
		Cercopithecinae	*Chlorocebus pygerythrus*	Vervet monkey	seen		X				spoors + seen
			Cercopithecus albogularis	Samango monkey	seen		X				
	Galagonidae		*Otolemur crassicaudatus*	Greater galago	seen		X				
			Galago moholi	South African galago			X				
Macroscelidea	*Macroscelididae*	*Macroscelidinae*	*Petrodromus tetradactylus*	Four-toed elephant shrew			X				seen
			Rhynchocyon cirnei	Chequered elephant shrew	seen		X				seen
Lagomorpha	*Leporidae*		*Lepus saxatilis*	Scrub hare	seen		X			seen	spoors + seen
			Pronolagus crassicaudatus	Natal red rock hare	seen		X				seen
Rodentia	*Sciuridae*	*Myosciurinae*	*Paraxerus cepapi*	Smith's bush squirrel	seen		X				seen
			Paraxerus flavovittis	Striped bush squirrel			X				
		Protoxerinae	*Heliosciurus mutabilis*	Mutable sun squirrel			X				
	Anomaluridae		*Anomalurus derbianus*	Lord Derby's anomalure	skins		X				
	Gliridae		*Graphiurus murinus*	African dormouse			X				
	Bathyergidae		*heliophobius argentocinereus*	Silky blesmol			X				
	Hystryicidae		*Hystrix africaeaustralis*	South African porcupine	spoors + spine		X	spines			feces + spine
	Thryonomyidae		*Thryonomys swinderianus*	Cane-rat	feces		X			feces	spoors + seen
	Muroidea	*Gerbillinae*	*Tatera* sp.	Tatera gerbil			X				
	Muridae	*Cricetomyinae*	*Cricetomys gambianus*	Giant pouched rat	guard report		X				Hole + seen
			Acomys spinosissimus	Spiny mouse			X				spoors + seen
			Lemniscomys griselda	Zebra mouse			X				
	?	*?*	?	Rodent to identify*							seen

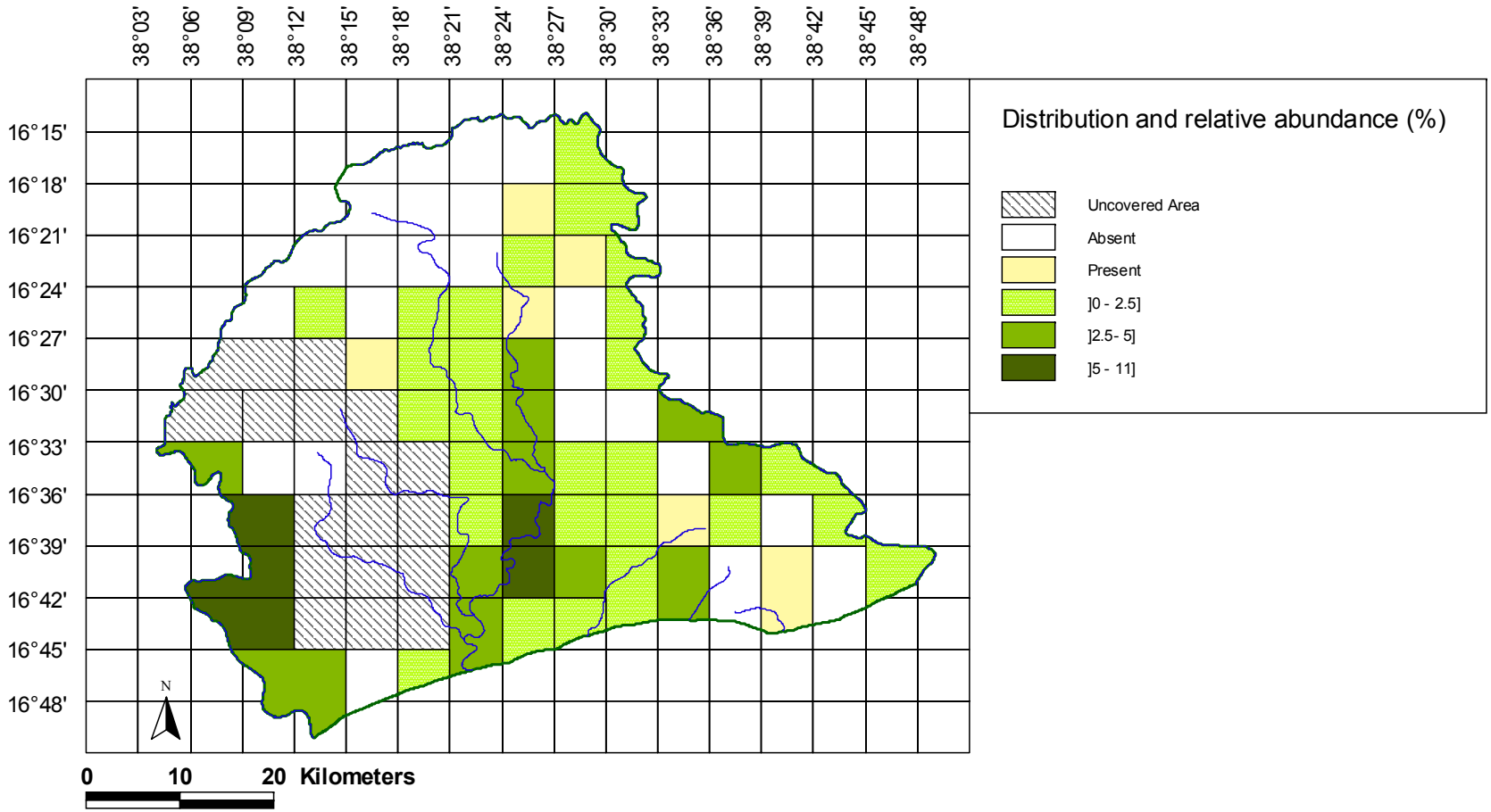
*new record

Appendix 3: Distribution and relative abundance maps of remarkable species: **Common Duiker**



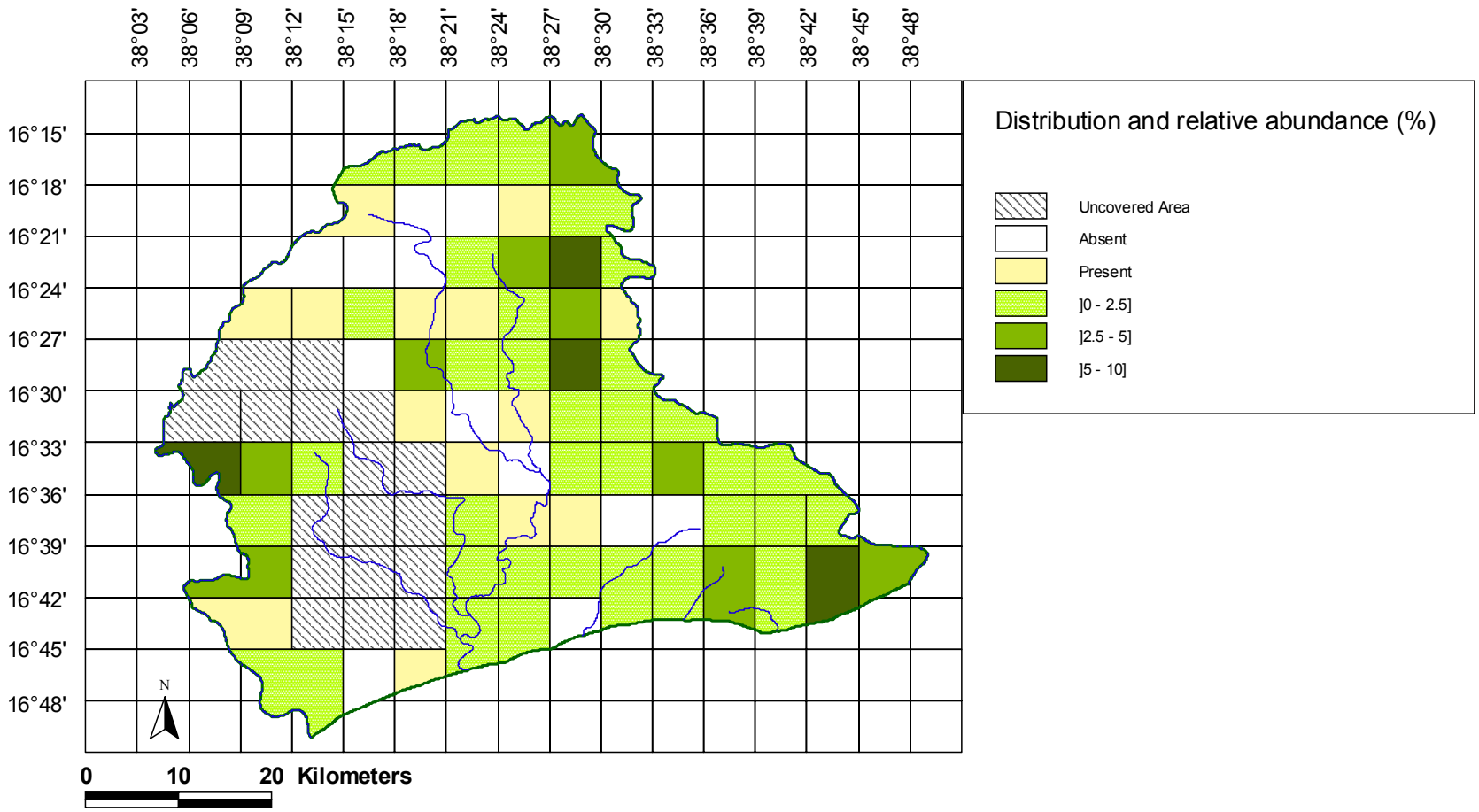
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area

Appendix 3: Distribution and relative abundance maps of remarkable species: **Bushbuck**



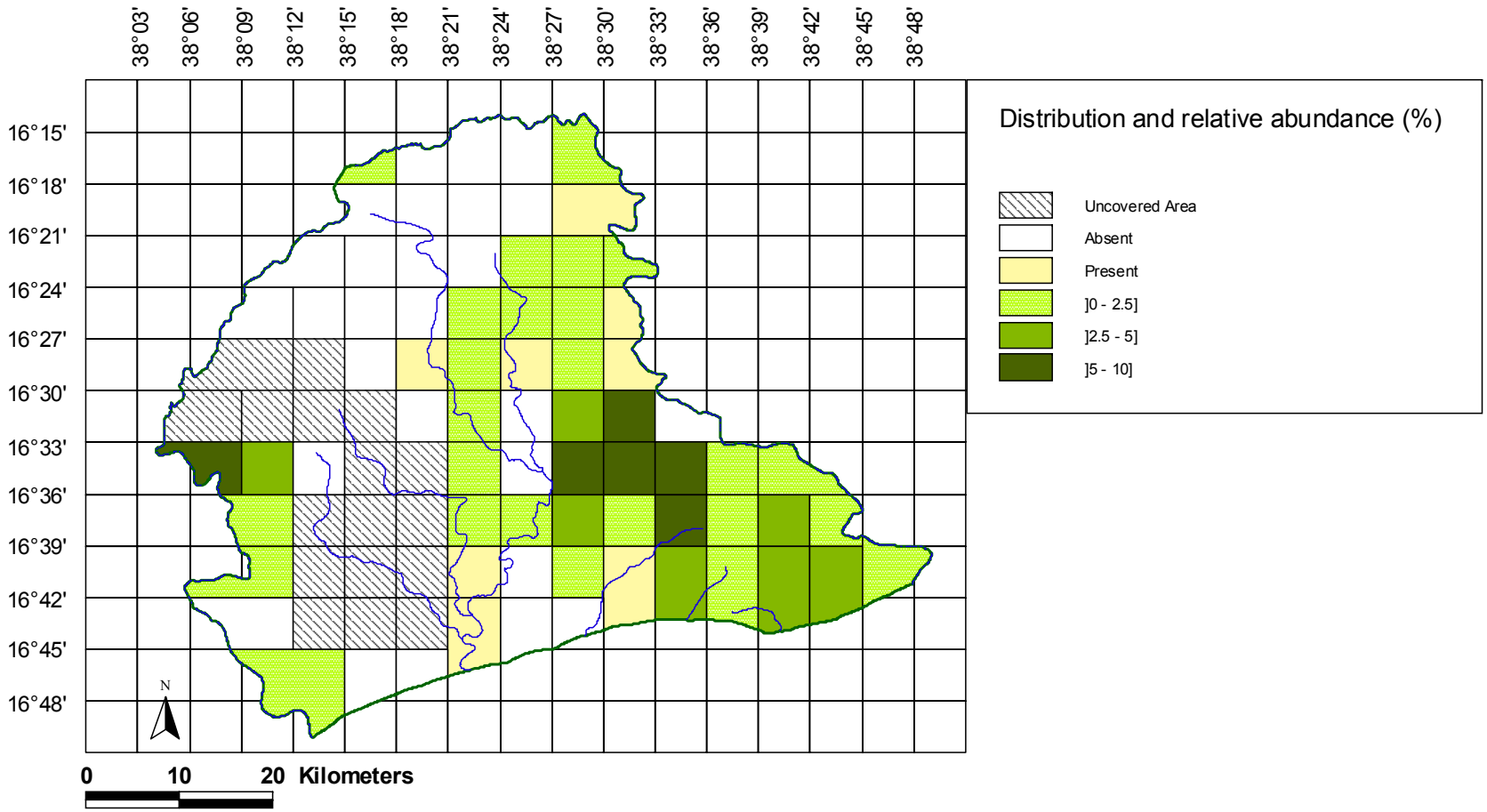
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Greater Kudu**



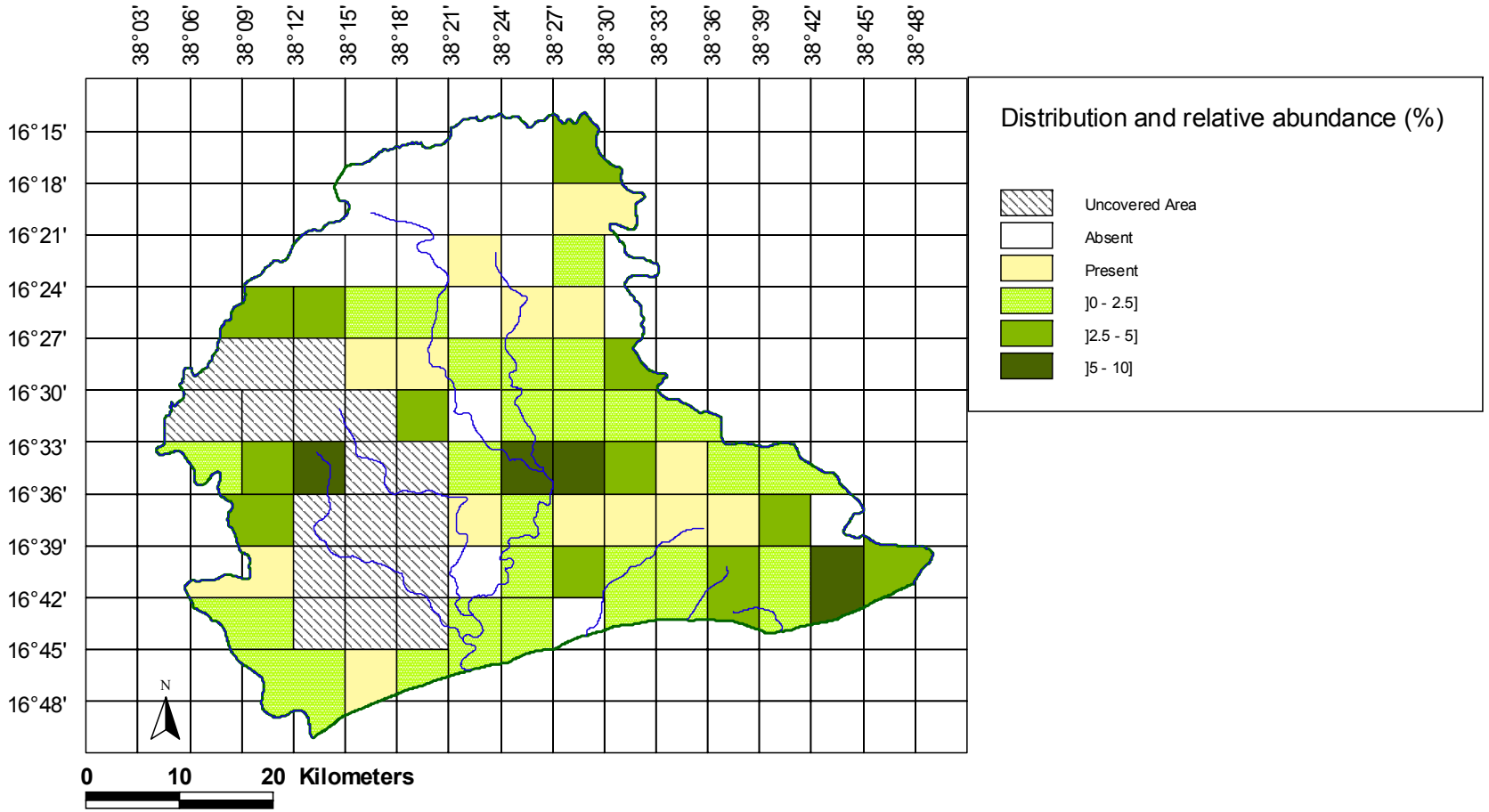
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Southern Reedbuck**



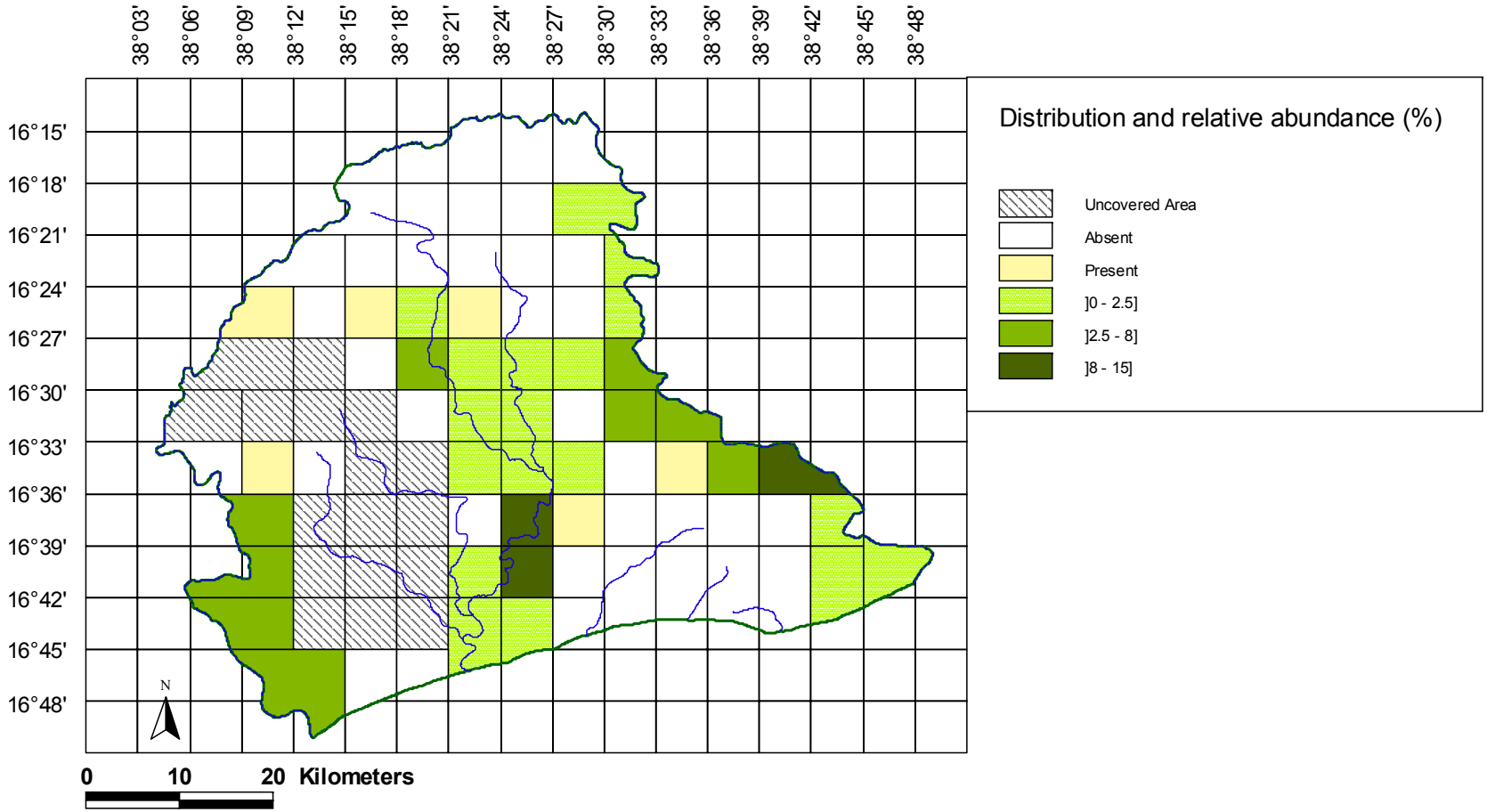
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Bushpig**



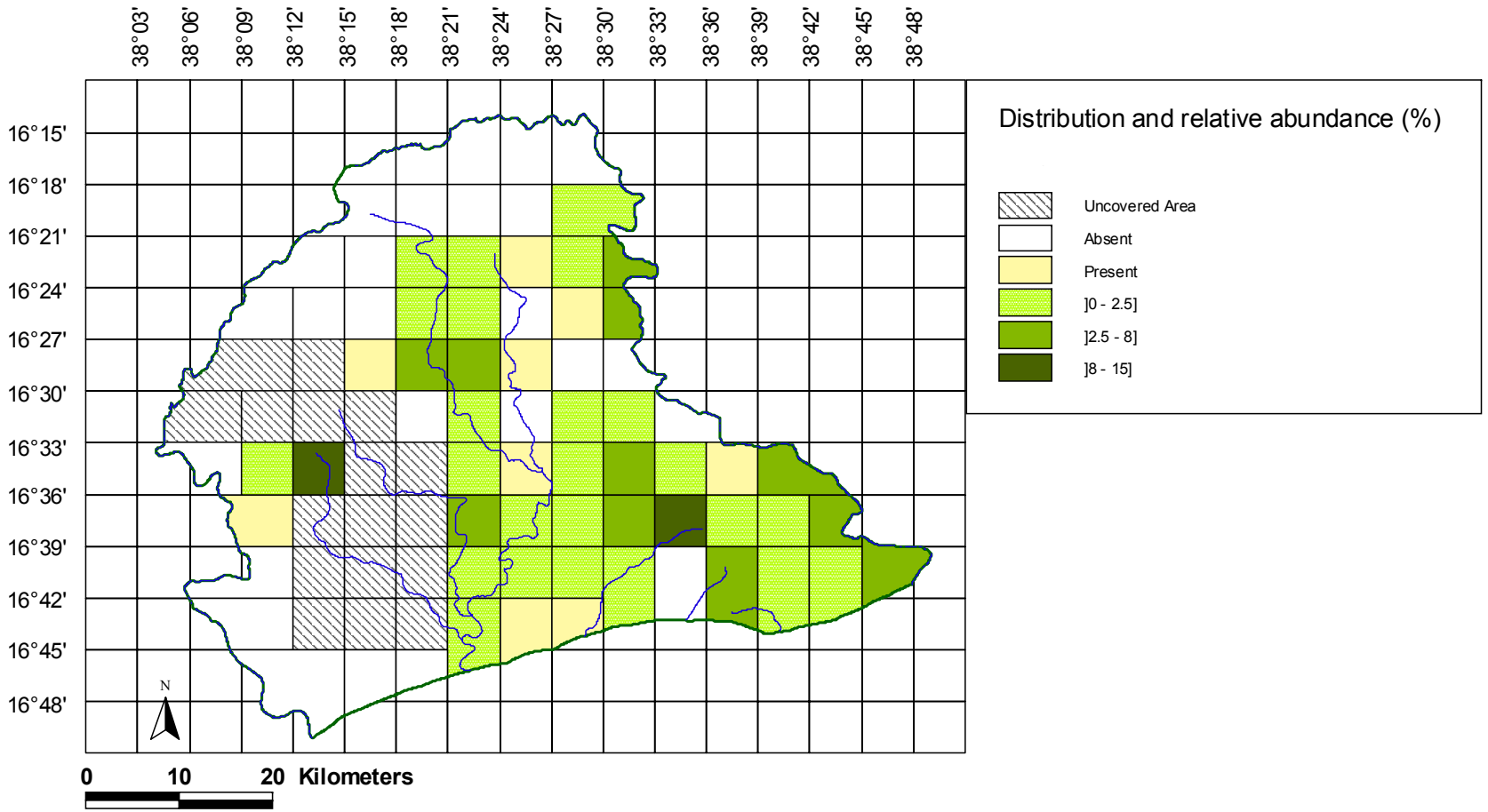
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Waterbuck**



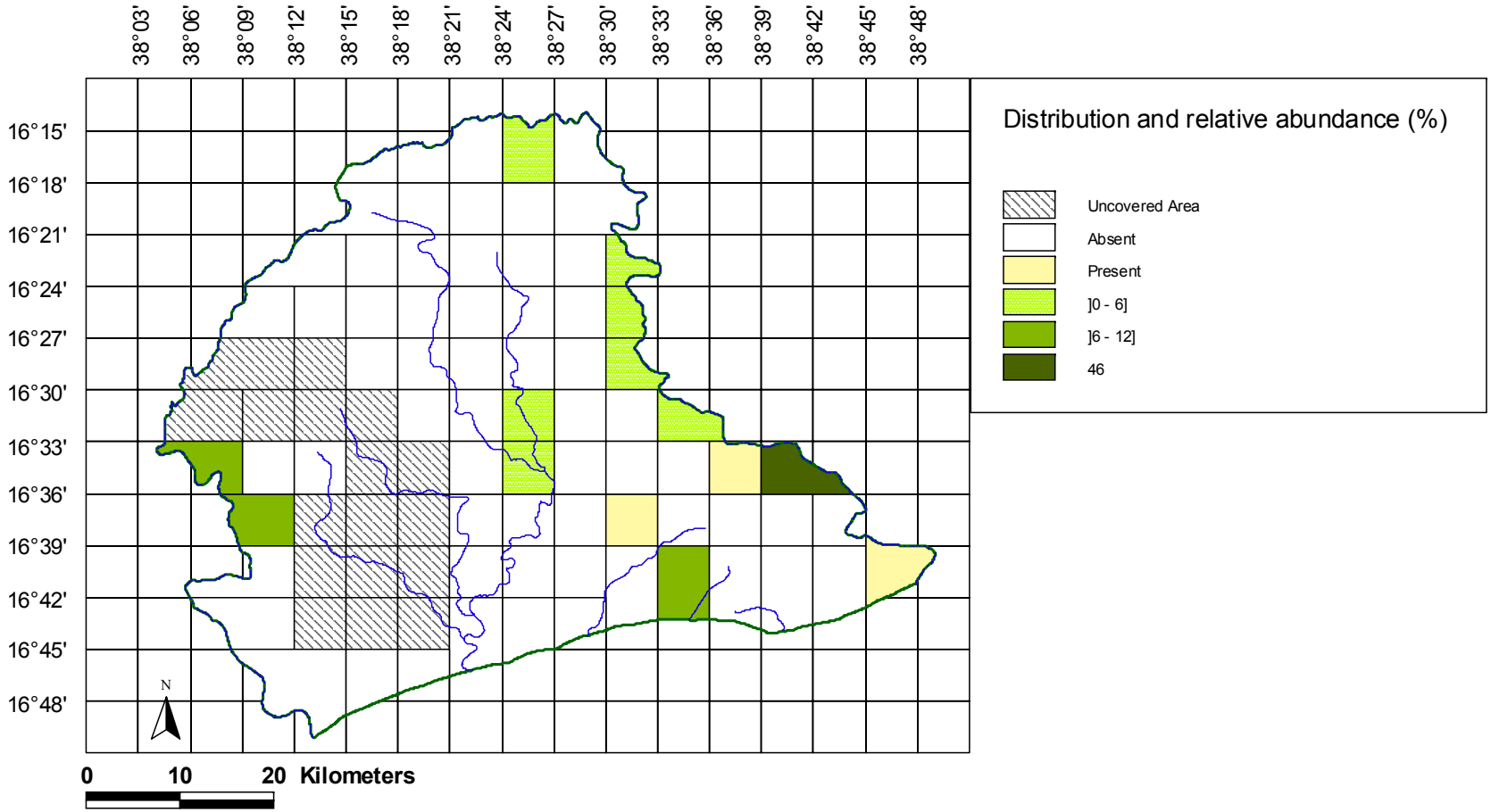
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Sable antelope**



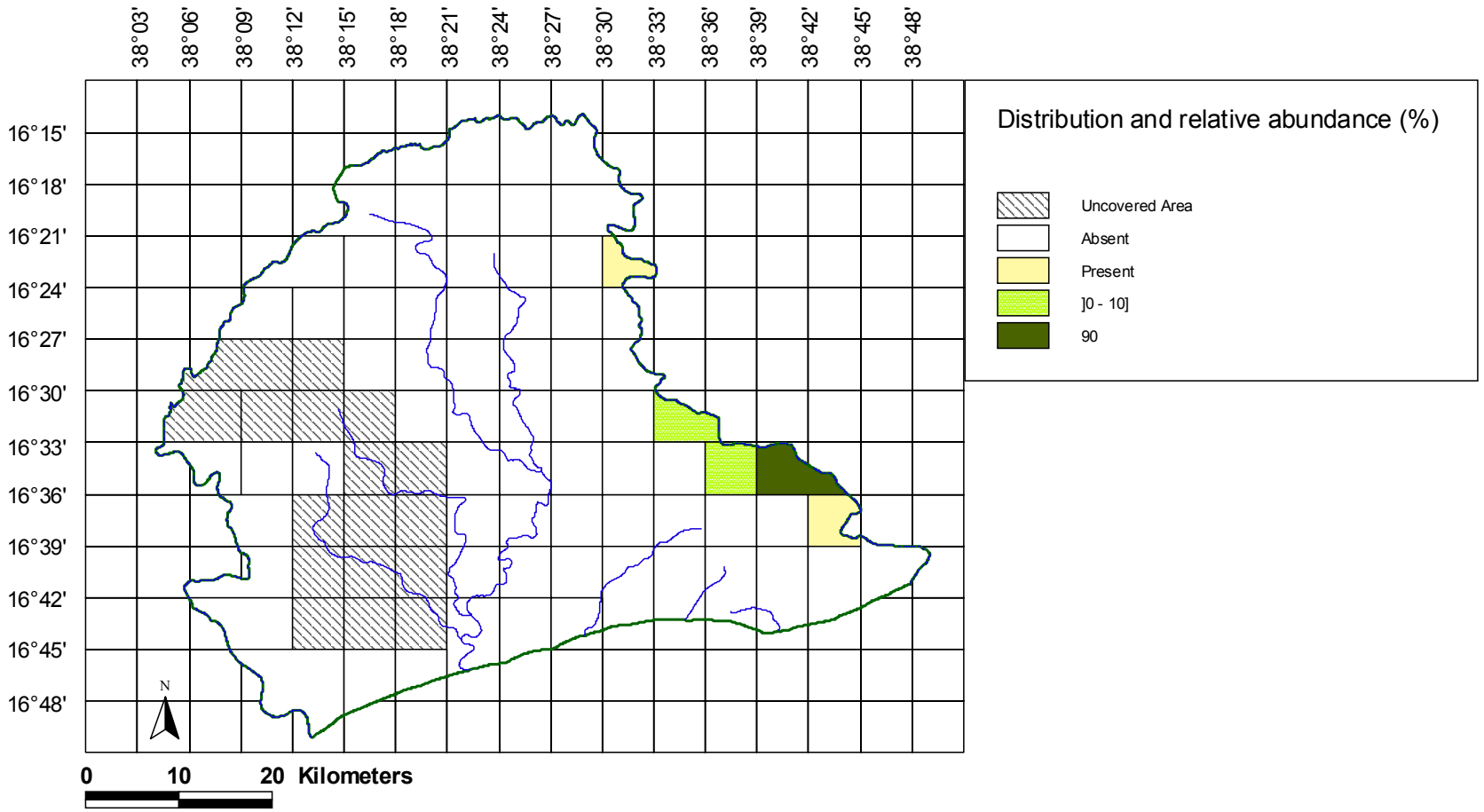
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Natal Duiker**



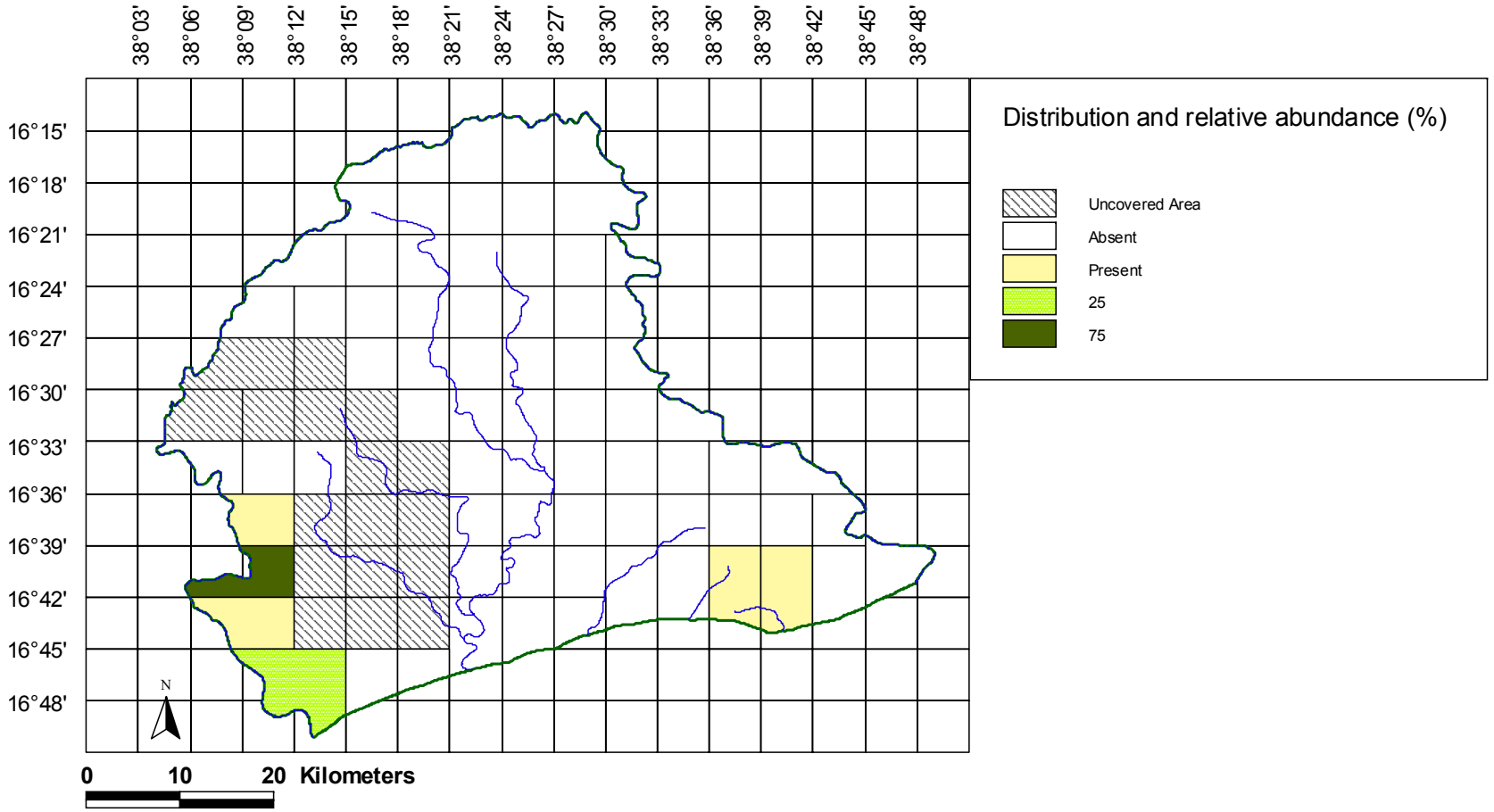
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Suni**



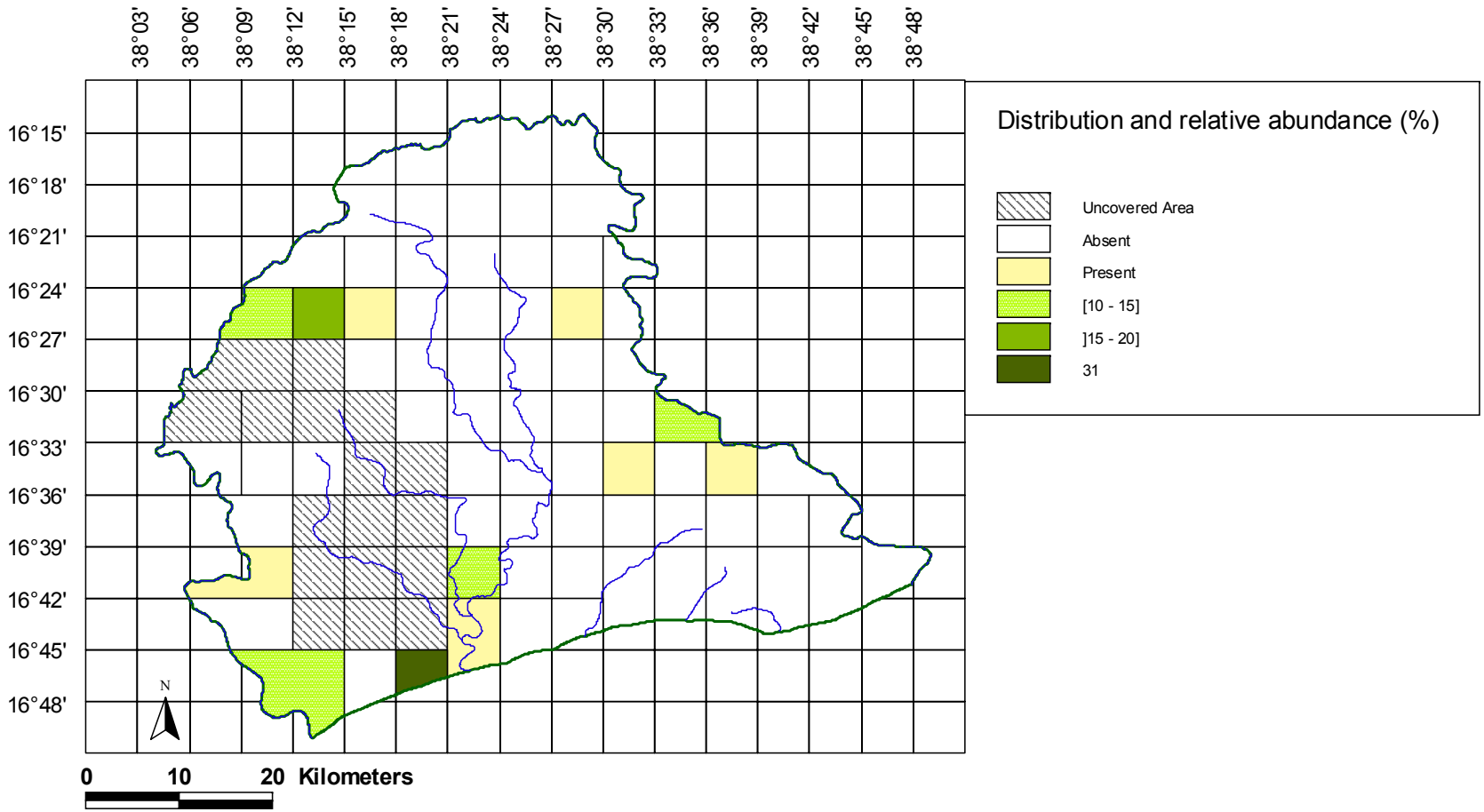
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Elephant**



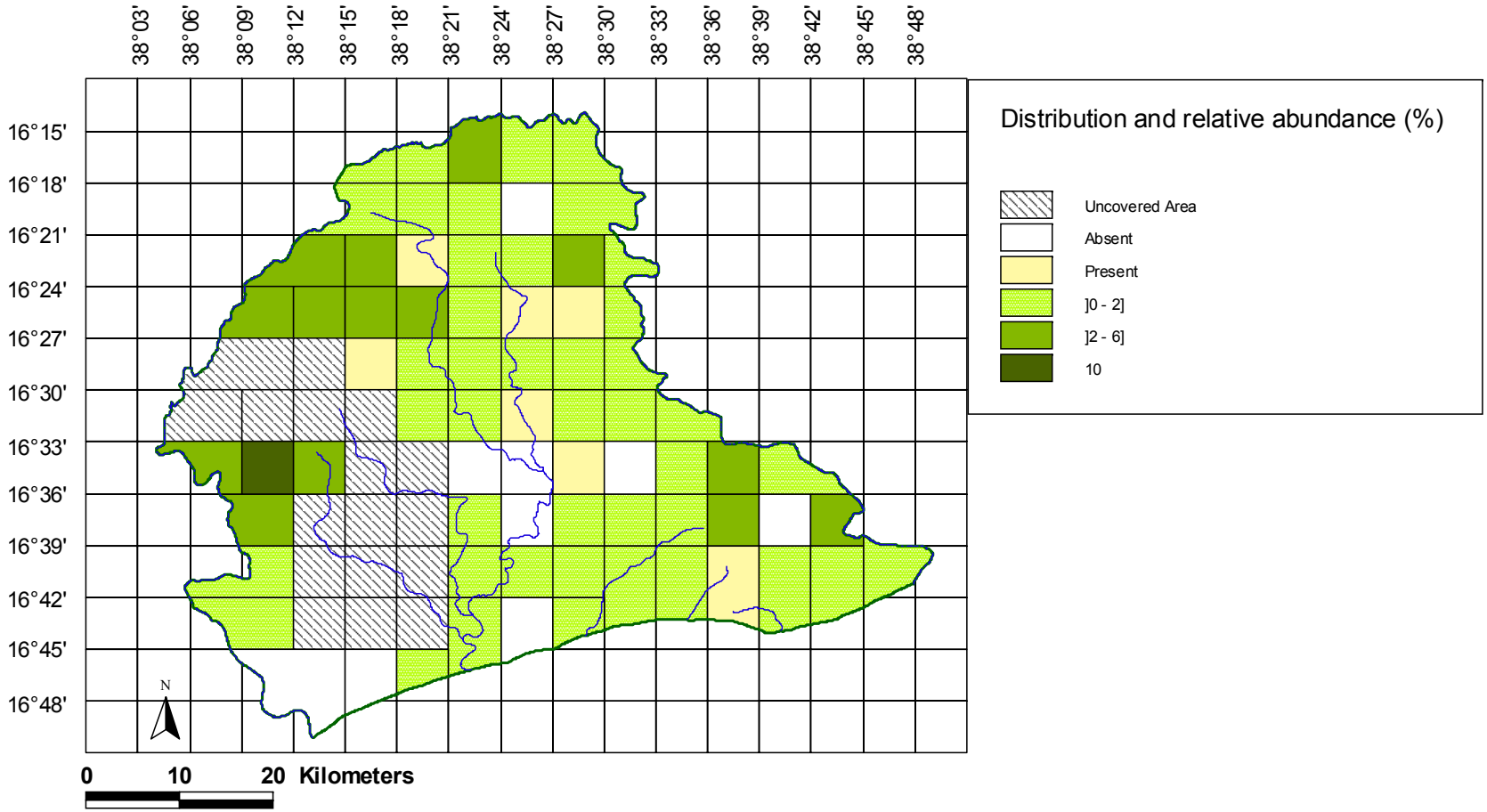
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Aardvark**



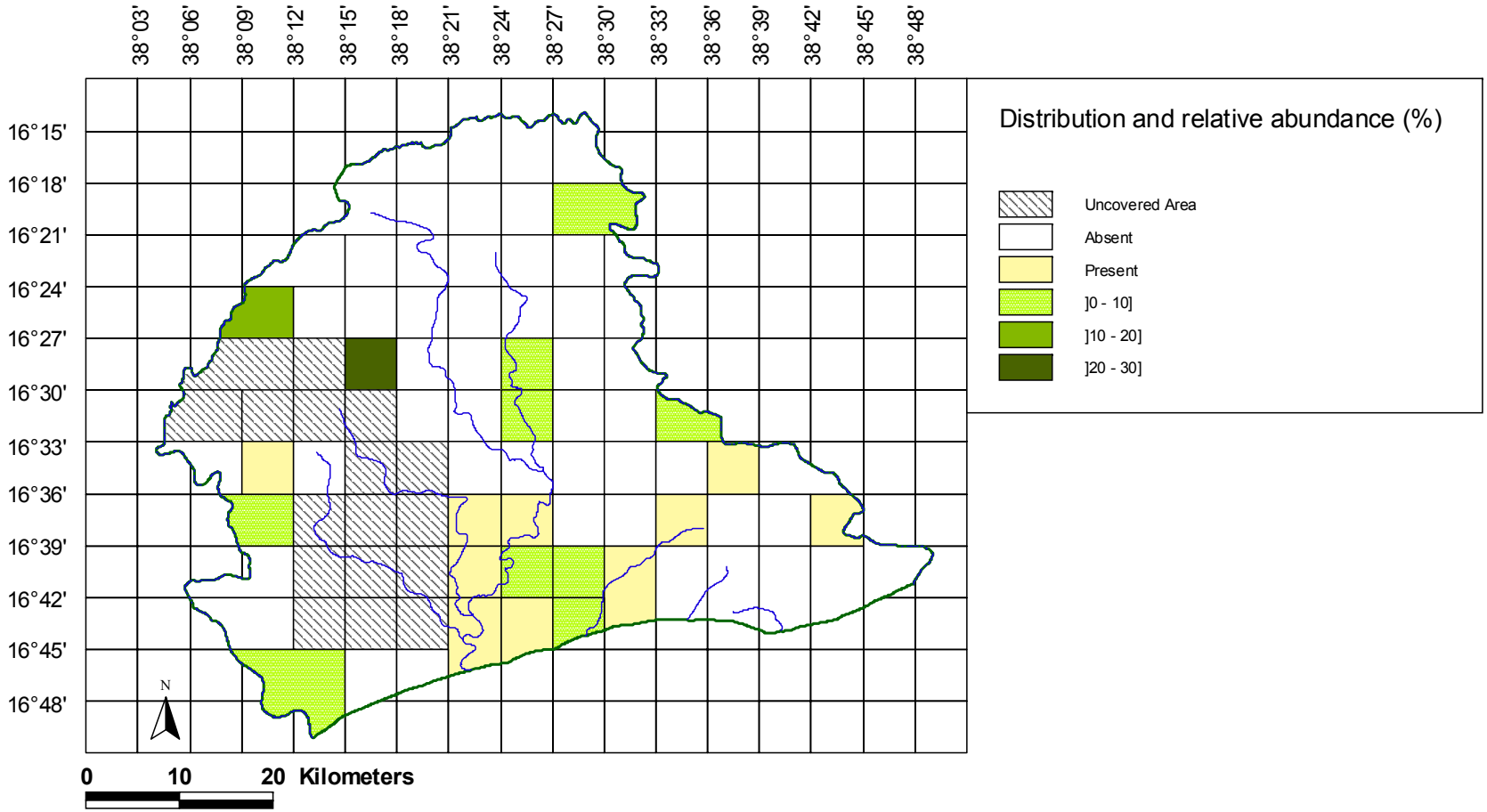
Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Striped Polecat**



Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 3: Distribution and relative abundance maps of remarkable species: **Wild Cat**



Relative abundance (%) = AKI_e of $cell_i$ × 100 / cumulative AKI_e over the whole area;
Present: AKI_e could not be calculated in cells where only old signs were recorded

Appendix 4: Poaching sign plates

Plate 1: Leg traps (©*IGF Foundation*)

Plate 2: Gin trap - 'ratoeira' (©*IGF Foundation*)

Appendix 4: Poaching sign plates

Plate 3: Fall trap (©*IGF Foundation*)

Plate 4: Hunting with hound (©*IGF Foundation*)

Appendix 4: Poaching sign plates

Plate 5: Fish trap (©*IGF Foundation*)

Plate 6: Damage on vegetation; bark removal (©*IGF Foundation*)

Appendix 4: Poaching sign plates

Plate 7: Poacher camp (©*IGF Foundation*)

Plate 8: Meat drying facility (©*IGF Foundation*)