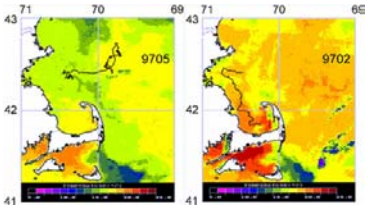
REPÚBLICA DE MOÇAMBIQUE
Ministério da Agricultura

NATIONAL CENSUS OF WILDLIFE IN MOZAMBIQUE



Final Report

December 2008

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Executive Summary

Project Objective

The general objective of this Project was to conduct a country-wide wildlife survey and census, to contribute to the preparation of a strategy for the management of wildlife at the national scale, and to the prevention or mitigation of human-wildlife conflicts.

Aerial Survey

The 2008 survey covered 56 strata that were surveyed with transects and had a combined area of 537041 km^2. Systematic, parallel transects were positioned across each stratum in flattish country, with the position of the first transect in each stratum determined randomly. Transects were orientated north-south. The spacing between adjacent transects in the same stratum was 15 km. The survey was flown during the period 24 June to 25 August 2008. The calibrated widths of the transects averaged 341 m at a flying height of 350 feet above ground level. Sampling intensity was 2.35 %. Search intensity averaged 0.89 minutes km^{-2}.

Four large mountainous strata that were going to be sampled with block counts were not surveyed for logistical reasons. The population estimates for the 56 strata were combined with the estimates from areas of Mozambique where the wildlife has been sampled from the air during the previous five years to give population estimates for Mozambique as a whole. The area surveyed during 2008 and the areas that had already been surveyed totalled approximately 80 % of Mozambique's land area. For simplicity, the estimates of the total number of each species in this area are referred to here as the national population estimates, but the estimates, at least for some species, would probably be greater if data were available for the unsurveyed 20 % of the country.

Crocodiles seen during the transect surveys were recorded, although only large ones (longer than 2 m) were likely to be seen from the air. Special surveys of hippos and large crocodiles were undertaken by flying along sections of some of Mozambique's major rivers, namely the lower Rovuma River, the Save River and the section of the Zambezi River between Tete town and Mutarara.

The following table gives the national population estimates of the large species of wildlife and domestic livestock, together with the confidence intervals for the means. No correction factors have been applied to compensate for any animals missed by the observers and so, especially for smaller or cryptic species, these figures will represent minimum estimates. Maps were prepared to show the density distribution within Mozambique of the major wildlife species, domestic cattle and goats, and various human activities (settlement, cultivation, vegetation clearance, logging, charcoal production and fishing). Owing to the special interest in elephant map distribution, the map from the aerial survey was combined with other documented presence/absence information to produce a distribution map for elephant.

Long-term trends in the distribution of wildlife in Mozambique were determined by comparing the current distributions of the wildlife with their distributions prior to the 1970s (Smithers & Lobão Tello, 1976), although the different methods by which the two sets of maps were compared do complicate the comparisons..

Population Estimates

Species	Portuguese name	Estimate	95% Limits
Baboon (groups)	Macaco-cão	2425	1820 - 3030
Buffalo	Bufalo	5717	2678 - 8756
Duiker grey	Cabrito cinzento	45246	42245 - 48246
Eland	Elande, Pacala ou Tuca	9382	5597 - 3168
Elephant	Elefant	22144	16393 -27894
Giraffe	Girafa	125	25 - 340
Hartebeest	Gondonga, Nameriga, Ecoce	5107	3742 - 6473
Hippopotamus	Hipopótamo	8388	3896 - 12879
Impala	Impala	11677	1932 - 21422
Kudu	Cudo	15764	12952 - 18575
Nyala	Inhala	3435	1923 - 4947
Ostrich	Avestruz	1566	511 - 2621
Reedbuck	Chango	12293	9923 - 14664
Rhinoceros black	Rinoceronte de lábio preênsil	1	-
Rhinoceros white	Rinoceronte de lábio direito	20	-
Roan antelope	Matagaica ou Palapala cinzenta	525	30 - 1775
Sable antelope	Palapala	32393	21799 - 42987
Warthog	Facocero	18880	15734 - 22025
Waterbuck	Piva, Inhacoso ou Namedouro	9956	4188 - 15723
Wildebeest	Cocone ou Boi-cavalo	2031	1090 - 2972
Zebra	Zebra	7480	5801 - 9159
Cattle	Gado bovino	593476	504243 - 682708
Goat	Cabrito	501762	437088 - 566436
Crocodile (large)	Crocodilo	1511	561 - 2462

Long-term Changes in Distribution

The **buffalo** was found across Mozambique pre-1970s, but now its distribution is much more limited. It has apparently disappeared from southern Mozambique, except for a reintroduced population in Limpopo NP and a few animals near the Mozambique/South Africa border. In central Mozambique, buffaloes were seen during 2008 only in the vicinity of Marromeu Reserve. In western Tete and northern Mozambique, the buffalo is not longer widespread, but appears to be largely confined to western Magoe, Niassa Reserve and the Chipanje area.

Significant numbers of large **crocodiles** were seen along the Rovuma, Zambezi and Save Rivers, but there are many lakes, dams and rivers in Mozambique where large crocodiles could live, but which were not surveyed.

Prior to the 1970s, the **eland** was found across Mozambique, but it has largely disappeared from southern Mozambique and has a much reduced distribution in central and northern Mozambique. Approximately 70 % of the estimated population is in Niassa Reserve.

Prior to the 1970s, the **giraffe** was confined to southern Mozambique, west of 34° E, but it is confined to Limpopo NP, where the species was reintroduced.

Prior to the 1970s, the **hippopotamus** was found widely distributed across Mozambique wherever there was suitable habitat. It was found across northern Mozambique, along the Zambezi Valley, in Gorongosa NP and Marromeu Reserve, along the Save and Limpopo Rivers and in southern Inhambane and Gaza provinces. During 2008, the hippopotamus was still found in Maputo Elephant Reserve, along the Save River (particularly within Zinave NP), in Gorongosa NP, along the Zambezi River and the shores of Lake Cabora Bassa, and along the Rovuma and Lugenda Rivers in the north.

Prior to the 1970s, the **impala** was found throughout Mozambique, but with few records for southern Inhambane province and Zambezia and Nampula provinces. During 2008, the distribution in southern and central Mozambique was broadly similar to that recorded earlier, but in northern Mozambique none were seen except in Niassa Reserve.

Prior to the 1970s, the **kudu** was found across Mozambique. But by 2008 the kudu was largely absent from Inhambane, Zambezia and Nampula provinces. Sightings of kudu during the 2008 survey were often close to the borders of conservation areas.

A provisional map of the distribution of **lion** in Mozambique was prepared, showing districts where lions were noted in the DNTF records as responsible for conflict, and protected areas where recent surveys recorded their presence

During 2008, the **ostrich** was confined to the Limpopo/Banhine/Zinave complex of national parks and the areas around them in southern Mozambique.

There used to be two species of **rhinoceros** in Mozambique, the white rhinoceros and the black rhinoceros. By 1970, the white rhinoceros, which was never found north of the Zambezi River, had become nationally extinct and had been reintroduced (introduced?) to Maputo Elephant Reserve and Gorongosa NP. The black rhinoceros was sparsely distributed across central and northern Mozambique and western Tete. By 2008, there were a small, reintroduced population of white rhinos in Limpopo NP; and a lone rhinoceros seen in northern Mozambique during 2008 survey can only have been a black rhinoceros.

Prior to the 1970s, the **sable antelope** was widely distributed across Mozambique, except for south-eastern Gaza and Inhambane provinces. During 2008, it was still present in central and northern Mozambique and Limpopo NP (where it was reintroduced). The 2008 survey estimated that there were 32393 (± 33 %) sable antelopes in Mozambique, with approximately 15000 animals outside the previously surveyed areas, in the coutadas of central Mozambique and in the area south of Niassa Reserve.

Prior to the 1970s, the **wildebeest** was found in northern Mozambique, in Gile Reserve and Gorongosa NP, in the Save Valley, Banhine and Zinave NPs and along the border with Kruger NP. During 2008, there were two small, discrete subpopulations, the larger one in Niassa Reserve and a small one in Limpopo NP.

Prior to the 1970s, the **zebra** was found throughout most of Mozambique, although scarce in Maputo and Inhambane provinces. During 2008, there was a northern subpopulation in and near Niassa Reserve, a small population along the border with Kruger NP and Limpopo NP, and a few in the Magoe area.

The study of the long-term trends in Mozambique's wildlife revealed that:

- most wildlife species now have a much more restricted distribution than they did 40+ years ago;
- many species occur at relatively high density in conservation areas and at low density (if at all) outside protected areas;

- a significant proportion of the national populations of many of the larger species of wildlife are in Niassa Reserve and its adjacent hunting areas; and
- the Limpopo NP is a relatively new national park, where many species of wildlife have been reintroduced and which contains almost the entire Mozambican population of some wildlife species, for example giraffe and white rhinoceros.

Elephant

The number of elephant carcasses seen during the 2008 survey was relatively low, which suggested that elephants within the survey area had not been subjected to heavy poaching recently.

The 2008 survey covered a large area of Mozambique where the wildlife had not been surveyed previously and thus the survey provided better quality data than was previously available. As a consequence, the number of elephants 'definitely' in Mozambique has increased by more than 2000 animals. The number of elephants 'definitely' or 'probably' in Mozambique has increased from 16475 during 2006 to 22144 during 2008. The improved quality of the data for estimating the number of elephants in the country may have implications for changing the CITES export quota for Mozambique: Furthermore, DNTF records reveal that 85 elephants were killed in response to human-elephant conflicts during July 2006 to September 2008. This figure is equivalent to approximately 40 elephants per year, which is similar to Mozambique's current export quota. But if some of the elephants killed on problem animal control were included in the export quota, the value of the benefits that local people received from elephants hunted in their districts could be increased.

It is proposed that there are probably six **elephant subpopulations** in Mozambique.

Maputo Elephant Reserve: where there is a long history of human-elephant conflict; and where Futi corridor will facilitate movement between Maputo Reserve and the Tembe Elephant Park in South Africa after removal of the fence that demarcates Tembe Park's northern boundary.

Southern Inhambane province: only footprints were seen here during the 2008 survey, but there have been frequent reports of human-elephant conflicts in these districts during recent years.

Limpopo/Gaza: the elephant was recently reintroduced to Limpopo NP and, with sections of the fence along parts of the Mozambique/South Africa border having been removed, the Limpopo population is contiguous to the elephant population in Kruger NP. The Kruger elephant population is contiguous to elephants in south-eastern Zimbabwe, including Gonarezhou NP. Hence, elephants entering Mozambique from Zimbabwe between the Limpopo and Save Rivers should be seen as part of Mozambique's Limpopo/Gaza subpopulation.

Zambezi Valley, Tete province and central Mozambique: elephant distribution here extends from Zumbo in the west, to the Zambezi delta in the east. However, whether this distribution is continuous is uncertain. The area includes Gorongosa NP and Marromeu Reserve. Elephants in the western Magoe region are contiguous to elephants in Zimbabwe's Zambezi Valley population. When further information is available on numbers and distribution, it is possible that, at least for management purposes, more than one subpopulation will be recognised here.

Northern Mozambique: subpopulation occupies northern Mozambique, including Niassa Reserve and adjacent hunting areas and Quirimbas NP. It overlaps the Mozambique/Tanzania border and is contiguous to elephants in southern Tanzania. This subpopulation is the largest in Mozambique (15087 elephants $\pm$ 21 %).

Gile: no elephants were seen here during the 2008 survey, but possibly some elephants live in the vicinity of Gile Reserve and, if so, this subpopulation is now geographically isolated. This small subpopulation is surrounded by human settlement and cultivation and likely

human-elephant conflict will continue around the reserve until the human and elephant populations are separated, either by the elimination of the elephants, or by the implementation of a land-use plan that might include fencing some or all of the reserve boundary.

Conservation of Large Riverine Species: Hippopotamus and Crocodile

The removal of hippos and large crocodiles from areas where they cause conflicts is often recommended. The unstated assumption that viable populations of these species exist in protected areas needs to be tested, because many protected areas on Mozambique have major rivers as one of their boundaries. Hence, hippos or crocodiles living in rivers that form the boundaries of protected areas are still likely to cause conflicts with people. It is recommended that national conservation strategies for the crocodile and hippopotamus should consider the scope for the conservation of viable populations of these species in rivers or lakes well inside protected areas, instead of only along the borders of protected areas.

Crocodile Conservation

One recommendation for resolving human-crocodile conflict is the removal of large crocodiles from waters in rural areas where they are causing conflict. While this is a valid means of dealing with human-crocodile conflict, it is the large crocodiles that form the breeding population. Hence, the removal of all large crocodiles would probably prevent future recruitment to that population. Thus, the consequences of removing all large crocodiles from a population would, in the long term, be similar to removing all crocodiles. It is recommended that a national conservation strategy for crocodile should consider the long term consequences, of removing large crocodiles from populations, for conservation of the species in Mozambique.

Species Diversity

There appeared to be five principal areas where the species richness of wildlife was relatively high:

- northern Mozambique (Niassa Reserve, the Chipanje area and the surrounding lands, including Quirimbas NP);
- western Tete province (north and south of Lake Cabora Bassa);
- central Mozambique (Gorongosa NP, Marromeu Reserve and coutadas 6, 7 and 9 to 15);
- the area encompassing Limpopo, Banhine and Zinave NPs and adjacent lands; and
- Maputo Elephant Reserve.

Areas Proposed for Aerial Survey during 2009

It is proposed that two high-diversity areas – northern Mozambique excluding Niassa Reserve and the Chipanje area; and western Tete province – are surveyed during 2009, in order both to fill the gaps in the existing survey coverage and to provide additional information, gathered with more intensive surveys, on the species and densities of wildlife in these two areas

DNTF Records of Conflicts

The DNTF keeps records of human-wildlife conflict and these records were used by this Project to provide a description of human-wildlife conflict in Mozambique. During the 27 months from July 2006 to September 2008 inclusive, 265 people were reported killed and 82 injured during conflicts with wildlife. Crocodiles, lions, elephants and hippos were responsible

for most deaths, but crocodiles killed 66 % of the people for whom the responsible species was reported.

Crocodile, elephant and hippopotamus were the species most frequently shot in response to conflicts. Elephant and hippopotamus were shot more often in relation to the number of their human victims than the other species, presumably reflecting that elephant and hippopotamus were shot not only in response to attacks on people, but also in response to crop-raiding. One leopard was recorded killed, although the records did not include any incidences of leopards killing or injuring people, or killing domestic livestock.

Structured Interviews with Local People

Project staff visited 32 selected districts throughout Mozambique and conducted approximately 60 structured interviews with local people and officials. The districts were selected because the DNTF records showed that human-wildlife conflicts were commonly reported in them.

The interviews sought to determine which wildlife species occurred in the district, whether these were resident there and their movements, the conflicts that they caused and the temporal trends in their numbers and conflicts. Interviewees were asked to rank the major wildlife species according to their belief of the number and intensity of the conflicts that each species caused. The interviews were intended to determine the local people's perceptions of human-wildlife conflicts. Interviewees were asked to list the measures that they took to prevent or mitigate human-wildlife conflicts, and to suggest appropriate responses to conflicts.

Conflicts caused by elephants or crocodiles were usually considered by local people to be the most serious of the human-wildlife conflicts that they encountered. In districts where both crocodile and hippopotamus were ranked as problem species, most interviews noted that crocodiles caused more serious conflicts than hippos. In just a few districts were lions perceived to cause the most serious problems. Conflicts caused by buffalo and leopard were relatively unimportant compared with the conflicts caused by other species

The interviewees reported that elephant and hippopotamus were often responsible for serious crop damage and were difficult to deal with. Both species sometimes killed or injured people, and elephant occasionally damaged houses. Crocodile and lion sometimes killed or injured people and domestic livestock. Crop-guarding was often mentioned as the activity at the time when some people were killed by elephants or lions.

Interviewees often believed that the elephants causing conflicts in their district came from nearby National Parks or Game Reserves, While some of their beliefs were probably correct, some were not so: for example, recent surveys have revealed that there are no elephants resident in Banhine NP. Interviewees in Cabo Delgado believed (probably correctly) that the elephants in their district were resident there. Conflicts caused by elephant, hippopotamus and crocodile were perceived as having increased in frequency during the last five years by all interviewees.

For all human-wildlife conflict, the commonest response of the local people was to inform the government authorities. Some people attempted to reduce crop-raiding by elephant and hippopotamus by block farming, using rope barriers to deter crop-raiders, guarding fields, or using noise and fire to drive off crop-raiders. In some districts, attempts were made to trap lions. The interviewees never mentioned the killing of problem animals as a current measure to mitigate human-wildlife conflicts, possibly because they themselves did not attempt to kill large animals in response to conflicts.

Killing – either of problem individuals, or in the form of culling to reduce the number of that species in the district – was the most popular suggestion for the most appropriate way of responding to human-wildlife conflicts, regardless of which species caused the conflicts. A few people suggested relocating elephants or lions to national parks or game reserves. Fencing was often suggested as a response to human-hippopotamus conflict, or at least the

crop raiding dimension of it. The installation of water pumps was sometimes suggested as a response to human-crocodile conflicts, to enable people to obtain water without having to collect it directly from rivers or lakes inhabited by crocodiles.

Nearly all interviewees believed that they received little benefit from wildlife, except occasionally in the form of bush meat (in those districts where interviewees admitted that hunting of small animals occurred), or meat from animals killed in response to human-wildlife conflicts.

Human-Crocodile Conflict

- Crocodiles killed more people each year in Mozambique than did all the other species of wildlife combined;
- attacks on people by crocodiles occurred in more districts of Mozambique (46 districts) than did attacks by any other wildlife species; and
- the number of people killed annually by crocodiles has increased during the past decade.

Human-Elephant Conflict

- Elephants killed or injured fewer people each year in Mozambique than did crocodiles, with elephants being responsible for 15 % of human deaths and 7 % of injuries caused by wildlife;
- attacks on people by elephants were concentrated largely in parts of northern Mozambique;
- crop-raiding by elephants was more widespread (reported in 46 districts) than were elephant attacks on people (22 districts);
- elephants raided crops more frequently during March-October than during other months of the year;
- elephants were killed in response to conflicts more frequently during March-October (the period when crops ripen and are harvested) than during other months of the year;
- the number of elephants killed in response to conflicts was greater than for any other species of wildlife, with elephants forming 31 % of problem animals killed; and
- the number of elephants killed annually in response to conflicts increased during the last decade.

A long term response to human-elephant conflict is the development of land use plans, to consider the possibility of creating areas where elephants can be sustainably managed to provide benefits for the local communities without competing with people for the same resources.

Human-Lion Conflict

- Lions attacked people in relatively few districts of Mozambique (6 districts);
- lions killed or injured fewer people each year in Mozambique than did crocodiles, with lions being responsible for 12 % of human deaths and 24 % of injuries caused by wildlife;
- although, in terms of their attacks on people, lions were less of a problem than crocodiles, this was true only at the national level;
- in the districts where lion attacks on people were recorded, there were an average of 7.3 attacks per district over 27 months, which was twice the number of attacks by crocodiles (average of 3.7 attacks on people per district);
- lions attacked people more frequently during March-August than during other months of the year;
- the number of people killed by lions apparently increased during the last decade;

- lions were the major predator of domestic livestock, being responsible for killing 81 % of the cattle and 62 % of the goats recorded killed, as well as killing some sheep, chickens and domestic dogs; and
- the killing of domestic animals by lions was a more widespread conflict (reported in 12 districts) than lion attacks on people.

Human-Hippopotamus Conflict

- Hippos attacked people in relatively few districts of Mozambique (8 districts);
- hippos were responsible for 6 % of human deaths and 12 % of injuries caused by wildlife;
- crop-raiding by hippos was a more widespread conflict (reported in 28 districts) than hippo attacks on people;
- crop-raiding by hippos occurred throughout the year;
- people living in the vicinity of large rivers or lakes regarded human-crocodile conflicts as a more serious problem than human-hippo conflicts; and
- the number of hippos killed annually in response to conflicts increased three-fold during the last decade.

Land use planning is required to determine where hippos could be conserved outside conservation areas and where hippos were incompatible with the needs of people and therefore should be removed. Strong low barriers will exclude hippos from crops.

Human-Buffalo Conflict

- Reported human-buffalo conflicts were concentrated in districts that included Limpopo NP, or were adjacent to Limpopo NP or South Africa's Kruger NP; and
- at the national level, the buffalo appeared to be a minor conflict species, being responsible for the death of one person (0.5 % of people killed by wildlife) and injuries to seven people (9 % of recorded injuries). Eleven buffaloes were killed (4 % of large animals killed in response to conflicts), with three of them apparently killed in response to crop damage.

Although the DNTF records suggested that the buffalo was a minor conflict species, it has the potential to cause conflicts that would not be noted in the DNTF records. This is because buffalo and domestic cattle often share diseases, for example, foot and mouth disease, corridor disease, brucellosis and bovine tuberculosis.

Human-Hyaena Conflict

- Reported human-hyaena conflicts were in districts adjacent to Zimbabwe's Gonarezhou NP, or South Africa's Kruger NP; and
- at the national level, the spotted hyaena was a minor conflict species, with no reports of people killed or injured by hyaenas during the 27 months of records, and hyaenas being responsible for killing two cattle (1 % of cattle reported killed by wild animals) and 12 goats (9 % of goats reported killed). No hyaenas were reported killed in response to conflicts.

Human-Leopard Conflict

- The leopard was a minor conflict species, with no reports of people or domestic livestock being killed or injured by leopards during the 27 months of DNTF records. But one leopard was killed in response to a conflict.

Human-Wildlife Conflict generally

- Conflicts are common in the districts that border South Africa's Kruger NP and Zimbabwe's Gonarezhou NP;
- local people throughout Mozambique believed that they received no benefits from the wildlife in their district, except occasionally when they received meat from animals shot in response to human-wildlife conflicts, or when they obtained small species in the form of bush meat;
- not surprisingly, local people believed that the elimination of problem species, or at least a reduction in their numbers, was the most appropriate way of dealing with human-wildlife conflicts;
- local people believed that human-wildlife conflicts were becoming more frequent;
- the available data also suggested that conflicts generally have increased during the past decade (although the completeness of the dataset is uncertain);
- it is possible even now that many conflicts are not reported to DNTF; and
- more information is needed about the circumstances in which conflicts occur.

If large animals in Mozambique are to survive outside conservation areas, then probably the benefits to the local people of living with wildlife must exceed the costs of living with wildlife *and* the benefits of living without wildlife.

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1 Introduction

The general objective of this Project was to conduct a country-wide wildlife survey and census. The results of this work would contribute to the preparation of a strategy for the management of wildlife at the national scale, and to the prevention or mitigation of human-wildlife conflicts.

The specific objectives of this Project were:

1. to determine the distribution and the density of wildlife populations and of human settlements in Mozambique;
2. to understand the spatial and temporal dynamics of the wildlife;
3. to describe human-wildlife conflicts in Mozambique; and
4. to supply the National Directorate of Land and Forests (DNTF) with a geodatabase on wildlife in Mozambique within the larger information system of the Forest Inventory project.

It was intended that there would be four main sources of data available for analysis, to permit these objectives to be met:

1. the results of an extensive, low-intensity aerial survey of wildlife conducted by this Project in Mozambique during the dry season of 2008;
2. the DNTF records of human-wildlife conflicts;
3. completed and returned questionnaires compiled especially for this Project and sent to the provincial offices of the Ministry of Agriculture, soliciting information about the presence of seven wildlife species likely to cause or already causing conflicts, their population trend and movements, and trends in conflicts within the districts of each province; and
4. reports of interviews conducted for this Project with individuals and groups of people in districts selected because the DNTF records indicated that there was a high incidence of human-wildlife conflict within these districts.

At the request of the Ministry of Agriculture, this final Project report is being submitted two months earlier than originally planned.

2 Aerial Survey of Wildlife in Mozambique

2.1 Introduction

The objective of the aerial survey was to provide estimates of the numbers of the major wildlife species in Mozambique and describe, with maps, the spatial distribution of these species, and the distribution of human settlements.

The major advantage of sample aerial surveys of wildlife – especially in areas where the terrain permits the use of systematically-arranged transects – is that they can cover very large areas within a relatively short time. A sample aerial survey was the only feasible method for censusing wildlife at a national scale within Mozambique during just a single dry season. The sampling intensity (in other words, the sample percentage) during the 2008 survey was determined by the number of flying hours available for the survey and was 2.35 %, which is relatively low. Generally speaking, the less the sampling intensity, the lower the precision of population estimates derived from a survey.

When population estimates from several subdivisions (called strata) within a larger survey area are combined, the population estimate for the entire survey area will generally be more precise than the estimates for the individual strata. Put simply, this is because the population estimates for the individual strata will overestimate or underestimate the true population numbers by a significant degree, but when the strata estimates are combined (summed) to produce the estimate for the entire study area, the over- and under-estimates will – to some extent but by no means all – tend to cancel out each other.

Fifty-six strata were sampled at low intensity during the 2008 Mozambique survey and the population estimates for all these strata have been combined with the estimates from areas of Mozambique where the wildlife has been sampled from the air during the previous five years, to give population estimates for Mozambique as a whole. It should be noted that this survey was designed to be a national survey. Thus, while it is possible to use the data collected to derive population estimates for smaller regions within Mozambique, the precision of any such estimates would generally be so high as to give very little value to any such estimates.

An aerial survey reveals the spatial distribution of animals only during the period when the survey is conducted. Aerial surveys are usually conducted during the dry season, when trees and bushes are leafless, or nearly so, and thus such surveys reveal nothing about the spatial distribution of wildlife during the rainy season.

2.2 Methods

2.2.1 Survey design

The procedures used during the survey followed those well established for aerial surveys of African large herbivores (Norton-Griffiths, 1978). Prior to the survey, the entire land surface of Mozambique was stratified, differentiating between: areas where the land surface was sufficiently flat to permit survey aircraft to fly safely at low level (total area 547724 km^2); areas that were mountainous and thus where block counts were the only safe way of surveying wildlife (nine areas totalling 151600 km^2); large urban areas where there was a very low probability of wildlife occurring (three areas totalling 1534 km^2); and conservation areas and other areas where the wildlife had been surveyed from the air within the previous five years (nine areas totalling 75186 km^2, plus some waterways – Table 1). Lake Cabora Bassa (area 2729 km^2) was also excluded from the 2008 survey (Map 1).

2.2.2 Transect surveys

Systematic, parallel transects were positioned across each stratum in flattish country, with the position of the first transect in each stratum determined randomly. Transects were arranged north-south, in order to facilitate the mapping of spatial distributions and often also to cause the transects to cut across the principal environmental feature (usually rivers) within strata. Overall sampling intensity was planned to be 2.7 % with a transect width (i.e. combined width of the two search strips) of 400 m. Thus, the spacing between adjacent transects in the same stratum was 15 km.

The survey was designed using custom computer software from the WorldWide Fund for Nature – Southern Africa Regional Programme Office (WWF-SARPO). When given a stratum boundary in the form of an ATLAS GIS bna format file, and the transect orientation (0°, = north) and spacing (15 km), this software generated flight lines (the transects), with the first flight line offset from the end of the stratum by an entered random number. The start and end points for each transect were transferred as waypoints to a Global Positioning System (GPS) receiver in the plane prior to flying each stratum.

Two aircraft were used for the transect surveys, a Cessna 180 and a Cessna 182. Each was fitted with a radar altimeter and a GPS receiver. During surveys, the aircraft were flown at approximately 200 km per hour at approximately 350 feet above ground level. Waypoints denoting the start and end points of transects were used to construct routes and navigation along the transects was undertaken by the pilot, with reference to the GPS receiver and its course deviation indicator.

Each aircraft had a crew of four people, including a pilot, a recorder who sat next to the pilot, and two observers who sat behind the pilot and recorder. All four crew members were able to talk to one another through an intercom system. All animals seen by the observers within the search strips were called to the recorder, who used a personal digital assistant (PDA) with custom software (SurveyCapture) to record the species, the number of individuals of the group that were within the search strip, and the GPS location and time. The recorder recorded the time at the start and end of each transect. The actual height of the plane above ground level (agl) was recorded (in feet) from the radar altimeter at frequent intervals of time while flying along the transects. After the flight, the mean height above ground level for each transect was calculated. From this and the calibrated strip width (see below), the actual width of each transect were determined, thereby correcting transect width for any variations in flying height during the survey.

Two rods were attached with custom brackets to each wing strut of the aircraft, so that the rods pointed backwards and parallel to the ground during level flight. The distance between the rods on each strut was arranged so that, when the aircraft was flying at 350 feet agl, this distance represented a strip approximately 200 m wide on the ground. Each outer rod was marked with a small piece of tape to provide the observers with a “decision point” (it is at this point that the observer decided whether an animal was inside his/her search strip). When deciding whether animals were inside or outside the strip, the observer moved his/her eye so as to align the tape on the outer rod with a small piece of tape on the window, thereby ensuring that all decisions were made at the same viewing angle.

Prior to the survey and prior to any changes in the observers, the strip widths were calibrated by flying the aircraft at right angles across a single line of markers arranged at 20-meter intervals. Each observer noted the number of markers within his/her search strip and the recorder noted the aircraft’s height above ground level (agl), as recorded by the radar altimeter. For each flight passing over the calibration numbers, the combined strip width was adjusted to 350 feet agl. The combined strip widths, after adjustment to 350 feet agl, were then averaged to give the calibrated combined strip width at 350 feet agl.

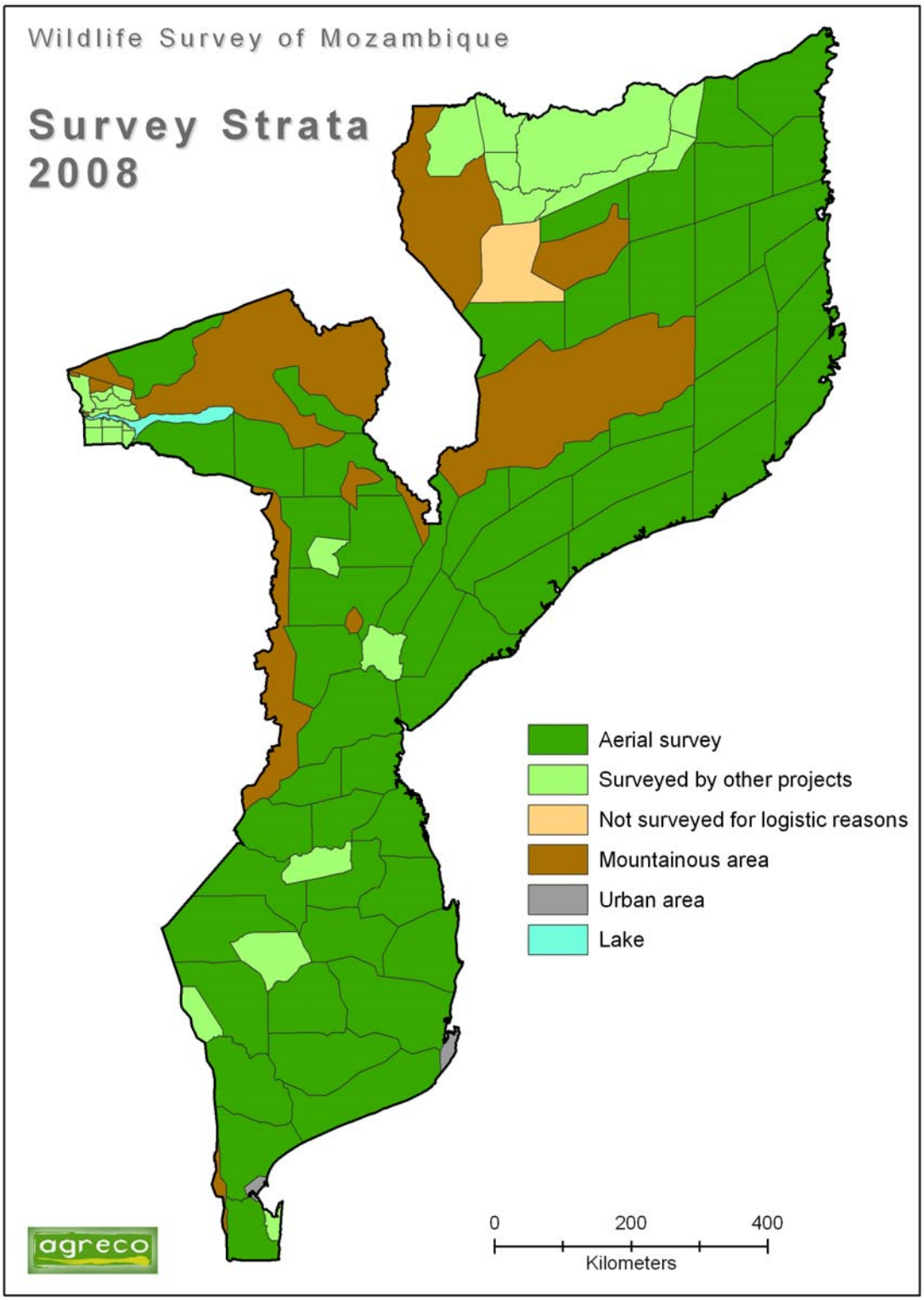
The survey was flown during the period 24 June to 25 August 2008. Six differing combinations of observers were used in the two aircraft and the calibrated strip widths (for left and right search strips combined) averaged 341 m (range 294.3-359.2 m) at a flying

height of 350 feet agl. The total area of all transects was 2.35 % of the total area surveyed. Search intensity averaged 0.89 minutes km^{-2}.

Table 1. Summary of areas where the wildlife had been surveyed from the air during the five years preceding the 2008 national survey of wildlife.

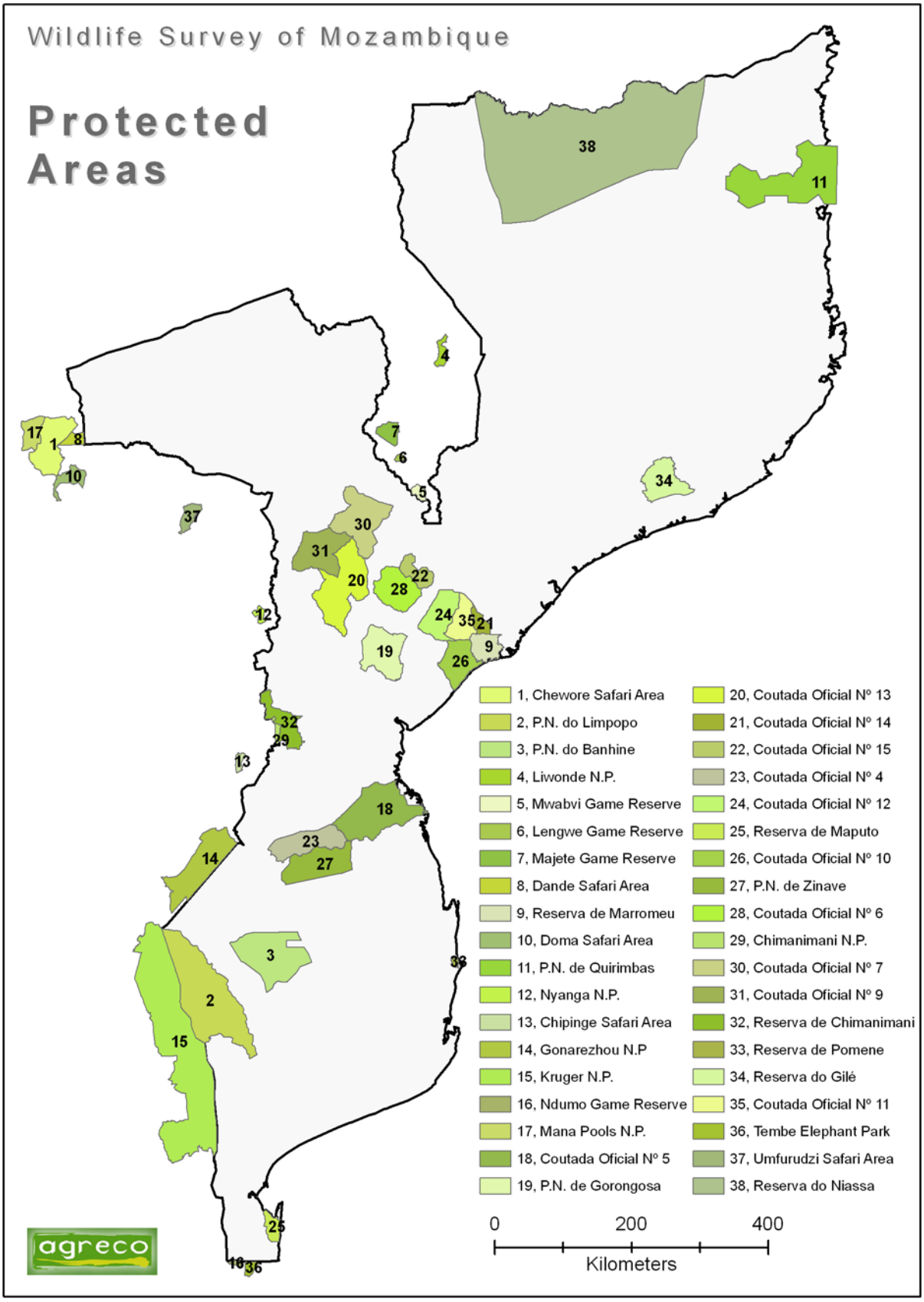
The locations of these areas are shown on Map 2.

Area	Year of Survey	Survey Technique	Reference
Banhine NP	2007	Total counts within subjectively chosen blocks. Density in blocks extrapolated to entire park, but not possible to calculate variance for estimates	Stalmans (2007a)
Chipanje	2006	Sample survey using systematically-arranged transects	Craig (2006)
Coutada 9	2005	Sample survey using systematically-arranged transects	Conybeare (2005)
Gorongosa NP	2004	Sample survey using stratification and systematically-arranged transects	Dunham (2004a)
Limpopo	2006	Total area count of south-western section of Limpopo NP	Whyte & Swanepoel (2006)
Magoe	2003	Sample survey using stratification and systematically-arranged transects	Dunham (2004b)
Maputo Elephant Reserve	2006	Total area count of entire reserve	Matthews & Nemane (2006)
Niassa Reserve	2006	Sample survey using stratification and systematically-arranged transects	Craig (2006)
Zinave NP	2007	Total counts within subjectively chosen blocks. Density in blocks extrapolated to entire park, but not possible to calculate variance for estimates	Stalmans (2007b)
Cabora Bassa shore; Zambezi River, Pungwe, Revue and Buzi Rivers	2007	Total counts of large crocodiles along shorelines and rivers	Fergusson & Pentolfe (2007)



Map 1. Design of the wildlife survey of Mozambique

Prior to the survey, Mozambique was divided into three major regions: (1) areas already surveyed during other projects; (2) mountainous areas to be sampled with block counts; and (3) areas that would be surveyed with transects during 2008 (dark green). Urban areas and Lake Cabora Bassa were also excluded from the survey. The black lines indicate the strata boundaries.



Map 2. Protected areas of Mozambique

Protected Areas in South Africa, Zimbabwe and Malawi that are close to Mozambique's international borders are also shown.

2.2.3 Observations

The observers counted, within their search strips, all wild large herbivores and domestic livestock (cattle and goats/sheep). Sheep and goats are not readily distinguished during aerial surveys, but because goats are much commoner than sheep in Mozambique, all small domestic livestock seen during the survey were recorded as goats. If any animal group was too large for all the individuals within it to be counted, group size was estimated by the observer. Human settlement and cultivation were also recorded. Sometimes human settlements and/or cultivated areas were too abundant for the observers and recorder to count and record accurately. In these circumstances, the locations along the transects where areas of settlement or cultivation started or ended were recorded instead. Other human activates that were recorded included clearings (which were areas where woody vegetation had been removed for some purpose other than the creation of a field that was in current use – fields in current use were recorded as cultivation), logging (the felling of trees other than when all the woody vegetation in a area is cleared), charcoal (signs that a location was used for the production of charcoal, indicated for example by the presence of a kiln), fishing (any sign of fishing activity, including people with rods, or nets in the water, in rivers or pans) and hunting activity (including poachers' brushwood fences).

The observers counted any elephant carcasses seen and allocated each carcass to an age category (category 1 indicating an elephant that died within the few months preceding the survey; and category 3 indicating an elephant that probably died several years before the survey, as indicated by scattered and bleached bones). Elephant tracks and trees obviously broken by elephants were also observed and recorded during the survey. Elephant tracks made in very clayey soils during the rainy season are often visible from an aircraft during the following dry season. Thus, records of elephant tracks provide additional information about elephant distribution, indicating areas where elephants have been during the previous wet season, even if they were not seen there during the aerial survey.

Observations of interesting or rare species outside the search strips, or observations made while travelling to or from strata, or between transects, were recorded. While such additional observations cannot be used to calculate population estimates, they can provide additional information on spatial distribution.

2.2.4 Data analysis

Population estimates and 95 % confidence limits for these estimates were calculated for each stratum using Jolly's (1969) method 2 for unequal-sized sample units. Population estimates for the entire survey area were calculated as the sum of the estimates for the individual strata. The upper and lower 95 % confidence limits for each of these population estimates were calculated from the population estimate and the square root of the sum of the variances for the individual strata.

The greater the time spent searching each square kilometre of a transect, the greater the probability that the observer saw all the animals that were there. Search effort (in minutes per square kilometre) for a stratum was defined as the total time spent flying all transects within that stratum, divided by the total area of those same transects. Even the largest herbivores are not easily seen from the air and the numbers of all species were probably underestimated, with the degree of underestimation greater for small or cryptic species than for large species. No corrections have been applied to any of the estimates to compensate for any undercounting or missed animals.

Baboons are seldom included in aerial surveys of wildlife, because of the difficulty of counting them from the air. Hence, this survey reports simply the density of baboon groups, not the density of individual baboons. Observations of elephant carcasses were used to calculate the carcass ratio (Douglas-Hamilton & Burrill, 1991). This ratio provides a useful index of elephant mortality and thus the recent trend in elephant numbers.

2.2.5 Hippopotamus and crocodile counts

Hippos and crocodiles seen during the transect surveys were recorded along with other wildlife, although only large crocodiles (that is those >2 m in length) were likely to be seen from the air. Both hippos and crocodiles are confined to the vicinity of large bodies of water during the dry season and crocodiles basking on sandbanks during the heat of the day can be counted. However, those in the water are easily missed and so aerial surveys of crocodiles usually provide a minimum estimate of the numbers of large crocodiles.

Special surveys of hippos and large crocodiles were undertaken by flying along sections of some of Mozambique's major rivers. During these counts, an attempt was made to count all hippos and large crocodiles. Special counts were conducted along the lower Rovuma River (that is, between the eastern boundary of Niassa Reserve and the sea), along the Save River (along its entire length in Mozambique, from the Mozambique/Zimbabwe border to the sea), and along the section of the Zambezi River between Tete town and Mutarara.

2.2.6 Distribution mapping

Density distribution maps were produced for the major wildlife species in Mozambique by integrating the results of the 2008 aerial survey with the results from recent aerial surveys of wildlife in other areas, which were mainly conservation areas. Density is displayed in 30 x 30 km grid squares (15 x 15 km squares for cattle and goats, which were commonly seen). For the area surveyed during 2008, the density in a grid square is the observed density within the search strip in that square. For the areas surveyed during previous years, the density is the mean density for the survey area. For areas that include both survey types, the density is the weighted mean.

The distribution map for baboon shows simply the presence of baboons, as indicated by the sightings of one or more baboons in each grid square during the survey.

2.3 Results

2.3.1 Survey area

The 2008 survey covered 56 strata that were surveyed with transects and that had a combined area of 537041 km^2. One additional transect stratum (of 10683 km^2, in western Niassa Province) was not surveyed for logistical reasons, being situated distant from the available fuel. Although it was intended that four of the larger, mountainous strata would be sampled with block counts during 2008, in practice none of them were sampled, for logistical reasons including the availability of flying hours, aircraft suitability and security reasons.

The area surveyed during 2008 and the areas that have already been surveyed during recent years totalled approximately 80 % of Mozambique's land area (Map 1). For simplicity, the estimates of the total number of each species in this area – 80 % of the country – will be referred to in this report as the national population estimates (although it is acknowledged that the estimates, at least for some species, would be greater if data were available for the unsurveyed 20 % of the country).

2.3.2 Population estimates for wildlife and domestic livestock

For those species of wildlife and domestic livestock whose numbers could be estimated by aerial survey, the national population estimates are summarised in Table 2. The columns in this table give:

the **estimate** of the number of animals of that species in the survey area;

the number of individuals of that species seen during the surveys (**number seen** - for sample surveys, this is the number inside the search strips);

the **variance** of the estimated number of animals;

the 95 % confidence interval of the population estimate for that species, as a percentage of the population estimate (**% CI**);

the lower 95 % confidence limit of the population estimate (**lower CL**); and

the upper 95 % confidence limit of the population estimate (**upper CL**).

For practical purposes, it can be assumed that the number of a given species within the survey area lies between the lower and upper confidence limits, with the 'estimate' providing the best estimate of the number there. For example, from Table 2 one can say that there were between 16393 and 27894 elephants in the surveyed area of Mozambique, with 22144 being the best estimate of the number of elephants in the area. Alternatively, one could say that there were 22144 elephants (± 26 %) in the area. For practical purposes, one might say that there were between 16000 and 28000 elephants in Mozambique, with 22000 being the best estimate of the number of elephants there.

For each species, there are three estimates:

1. the estimate of the number in the area surveyed during 2008;
2. the estimate of the total number in all the areas of Mozambique where aerial surveys have been conducted during the past five years; and
3. the estimate of the total number of animals of that species in all these areas combined, in other words in the 80 % of Mozambique that has been surveyed – this is the national population estimate.

There may appear to be small arithmetic errors in Table 2, but these are simply rounding errors: all numbers in the table were calculated to at least three decimal places before they were rounded to the required number of decimal places.

Table 2. Estimates of the numbers of larger wild animals (and baboon groups) in Mozambique, as estimated by aerial survey.
The variance and 95 % confidence interval of each estimate, and its upper and lower 95 % confidence limits, are also given. Estimates are given for the 2008 survey area, for all the previously surveyed areas combined, and for all areas combined (thus these last estimates are the national estimates).

Species	Portuguese name	Survey area	Estimate	Number seen	Variance	% CI	Lower CL	Upper CL
Baboon (groups)	Macaco-cão	2008 survey area	1461	33	92377	41	856	2066
		Previous survey areas	964	102	0	-	-	-
		Totals	**2425**	135	92377	25	1820	3030
Buffalo	Bufalo	2008 survey area	1659	38	1118288	138	38	3944
		Previous survey areas	4058	706	1166202	53	1905	6211
		Totals	**5717**	744	2284490	53	2678	8756
Duiker grey	Cabrito cinzento	2008 survey area	11634	265	1122981	18	9526	13743
		Previous survey areas	33611	2516	1191628	6	31450	35773
		Totals	**45246**	2781	2314610	7	42245	48246
Eland	Elande, Pacala ou Tuca	2008 survey area	2403	52	1568499	120	52	5291
		Previous survey areas	6980	675	1933809	40	4221	9738
		Totals	**9382**	727	3502308	40	5597	13168
Elephant	Elefant	2008 survey area	7187	187	6486304	73	1918	12455
		Previous survey areas	14957	2462	1537334	16	12509	17406
		Totals	**22144**	2649	8023638	26	16393	27894
Giraffe	Girafa	2008 survey area	102	2	9862	210	2	317
		Previous survey areas	23	23				
		Totals	**125**	25	9862	172	25	340

Species	Portuguese name	Survey area	Estimate	Number seen	Variance	% CI	Lower CL	Upper CL
Hartebeest	Gondonga Nameriga Ecoce	2008 survey area	395	9	103809	178	9	1097
		Previous survey areas	4712	460	371648	26	3507	5918
		Totals	**5107**	469	475457	27	3742	6473
Hippopotamus	Hipopótamo	2008 survey area	6087	142	4314156	73	1632	10542
		Previous survey areas	2301	572	174618	36	1465	3137
		Totals	**8388**	714	4488774	54	3896	12879
Impala	Impala	2008 survey area	7075	163	18323453	140	163	16946
		Previous survey areas	4602	918	234030	21	3644	5559
		Totals	**11677**	1081	18557482	83	1932	21422
Kudu	Cudo	2008 survey area	6274	140	1729092	42	3636	8911
		Previous survey areas	9490	965	257219	11	8491	10489
		Totals	**15764**	1105	1986312	18	12952	18575
Nyala	Inhala	2008 survey area	2083	46	530051	72	583	3582
		Previous survey areas	1352	341	8778	14	1160	1544
		Totals	**3435**	387	538829	44	1923	4947
Ostrich	Avestruz	2008 survey area	843	17	255742	125	17	1898
		Previous survey areas	723	36				
		Totals	**1566**	53	255742	67	511	2621
Reedbuck	Chango	2008 survey area	1664	38	389201	78	366	2961
		Previous survey areas	10630	1748	1032455	19	8601	12659
		Totals	**12293**	1786	1421656	19	9923	14664
Rhinoceros black	Rinoceronte de lábio preênsil	2008 survey area	1	1				
		Previous survey areas	0	0				
		Totals	**1**	1				

Species	Portuguese name	Survey area	Estimate	Number seen	Variance	% CI	Lower CL	Upper CL
Rhinoceros white	Rinoceronte de lábio direito	2008 survey area	4	2				
		Previous survey areas	16	16				
		Totals	**20**	18				
Roan antelope	Matagaica ou Palapala cinzenta	2008 survey area	463	15	235263	269	15	1710
		Previous survey areas	63	15	893	97	15	123
		Totals	**525**	30	236156	238	30	1775
Sable antelope	Palapala	2008 survey area	14969	343	23696302	69	4650	25288
		Previous survey areas	17424	1740	2097393	16	14571	20277
		Totals	**32393**	2083	25793695	33	21799	42987
Warthog	Facocero	2008 survey area	5967	143	1916987	47	3150	8784
		Previous survey areas	12913	1362	542203	11	11459	14367
		Totals	**18880**	1505	2459190	17	15734	22025
Waterbuck	Piva, Inhacoso ou Namedouro	2008 survey area	3026	69	4786638	159	69	7841
		Previous survey areas	6930	781	3056534	52	3343	10517
		Totals	**9956**	850	7843172	58	4188	15723
Wildebeest	Cocone ou Boi-cavalo	2008 survey area	130	3	11922	185	3	370
		Previous survey areas	1901	502	211382	48	984	2818
		Totals	**2031**	505	223304	46	1090	2972
Zebra	Zebra	2008 survey area	544	15	102466	126	15	1230
		Previous survey areas	6936	944	612482	22	5379	8494
		Totals	**7480**	959	714948	22	5801	9159
Cattle	Gado bovino	2008 survey area	588992	14006	2027525343	15	499766	678218
		Previous survey areas	4484	3339	299554	30	3339	5823
		Totals	**593476**	17345	2027824897	15	504243	682708

Species	Portuguese name	Survey area	Estimate	Number seen	Variance	% CI	Lower CL	Upper CL
Goat	Cabrito	2008 survey area	490986	11333	1064441058	13	426458	555514
		Previous survey areas	10776	1420	4959084	46	5814	15738
		Totals	**501762**	12753	1069400142	13	437088	566436
Crocodile (large *)	Crocodilo	2008 survey area	1220	28	190660	76	289	2151
		Previous survey areas	291	140	12299	78	140	519
		Totals	**1511**	168	202959	63	561	2462

* large crocodiles are those approximately 2 m or more in length

2.3.3 Distribution maps for wildlife

Maps showing the distribution in Mozambique of the major wildlife species (baboon, buffalo, grey duiker, eland, elephant, giraffe, hartebeest, impala, kudu, nyala, ostrich, reedbuck, rhino, roan, sable, warthog, waterbuck, wildebeest and zebra) accompany this report (Maps 3 to 23 inclusive).

2.3.4 Hippopotamus

When the number of hippos was estimated using the results of sample surveys for areas for which total count data were not available, there were estimated to be 8388 (± 54 %) hippos in Mozambique (Table 2), with more than 50 % of these animals along the southern shore of Lake Cabora Bassa. The national estimate includes 47 hippos seen during special hippopotamus and crocodile counts during 2008 along the lower Rovuma River (that is, downstream of the Niassa Reserve), and 40 hippos seen along the Save River between the Mozambique/Zimbabwe international border and the sea (Map 24).

Sample surveys designed to estimate the numbers of large terrestrial animals (for example, elephants) are not ideal for estimating the number of hippopotamus, a species that – during the day - is largely confined to permanent rivers and large water bodies. This is illustrated for the Tete Southeast and Tete strata, where sightings of hippos in the Zambezi River and within the search strips provided an estimate of 1748 (± 165 %) hippos in these two strata. But a total count of hippos in the section of the Zambezi River flowing through these strata during 2008 provided a figure of just 199 hippos.

The 2008 survey suggests that – if this Project is extended into 2009 – then the shores of Lake Cabora Bassa should be a priority area for dedicated hippopotamus counts during 2009.

2.3.5 Crocodile

During aerial surveys, the only crocodiles likely to be seen by the observers are large crocodiles, namely those more than approximately 2 m in length. The total number of crocodiles in an area will be greater than the number of large crocodiles in that same area. Determining the ratio of large crocodiles to all crocodiles in an area requires nocturnal boat surveys with spotlights, which was not possible during 2008.

In the area surveyed by transects during 2008, there were estimated to be 1220 (± 76 %) large crocodiles. Most of the large crocodiles on which this estimate was based were seen along the Zambezi River or the Rovuma River. When this estimate is supplemented with available data for areas not surveyed during 2008, the national estimate is 1511 (± 63 %) large crocodiles. This approach probably gives a conservative estimation of the total number of large crocodiles.

During total counts of large crocodiles along rivers during 2008, 42 large crocodiles were counted along the lower Rovuma River (that is, downstream of the Niassa Reserve), 64 were counted along the Save River (between the Mozambique/Zimbabwe international border and the sea), and 195 were counted along the Zambezi River between Tete town and Mutarara (Map 25).

2.3.6 Distribution maps for domestic livestock

Maps showing the distribution in Mozambique of domestic cattle and goats (Maps 26 and 27) accompany this report.

2.3.7 Spatial distribution of human activities

During the 2008 aerial survey, the following human activities were recorded and are mapped to illustrate their relative distribution in Mozambique: human settlement, cultivation, vegetation clearance (often indicative of abandoned fields, or new ones about to be established); logging (for timber production); charcoal production; and fishing (Maps 28 to 33).

2.3.8 Long-term trends in wildlife in Mozambique

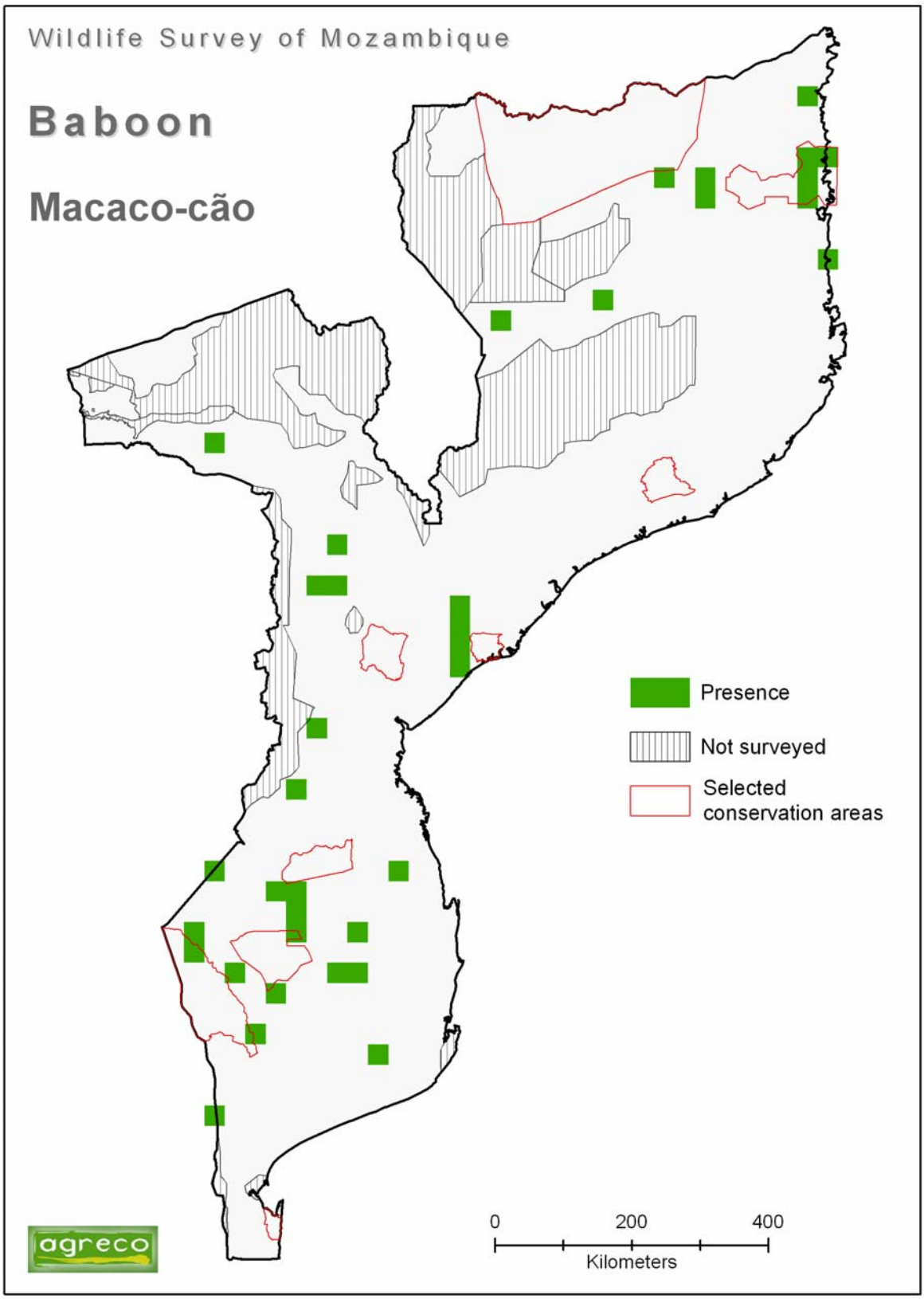
Long-term trends in the distribution of wildlife in Mozambique were determined by converting the density distribution maps produced during this Project into presence/absence maps for comparison with the maps produced by Smithers & Lobão Tello (1976), who plotted the distribution of mammals in Mozambique prior to the 1970s. When making these comparisons, it is important to remember that different methods were used to prepare the pre-1970s map and the 2008 map. While the 2008 maps were based on a single survey conducted during the dry season, the pre-1970s maps were based on evidence of the presence of the given species collected during all seasons over many years.

Maps showing the changes in distribution in Mozambique for buffalo, eland, elephant, giraffe, hippopotamus, impala, kudu, nyala, roan, sable and waterbuck (Maps 46 to 56) accompany this report.

2.3.8.1 Elephant mortality rate

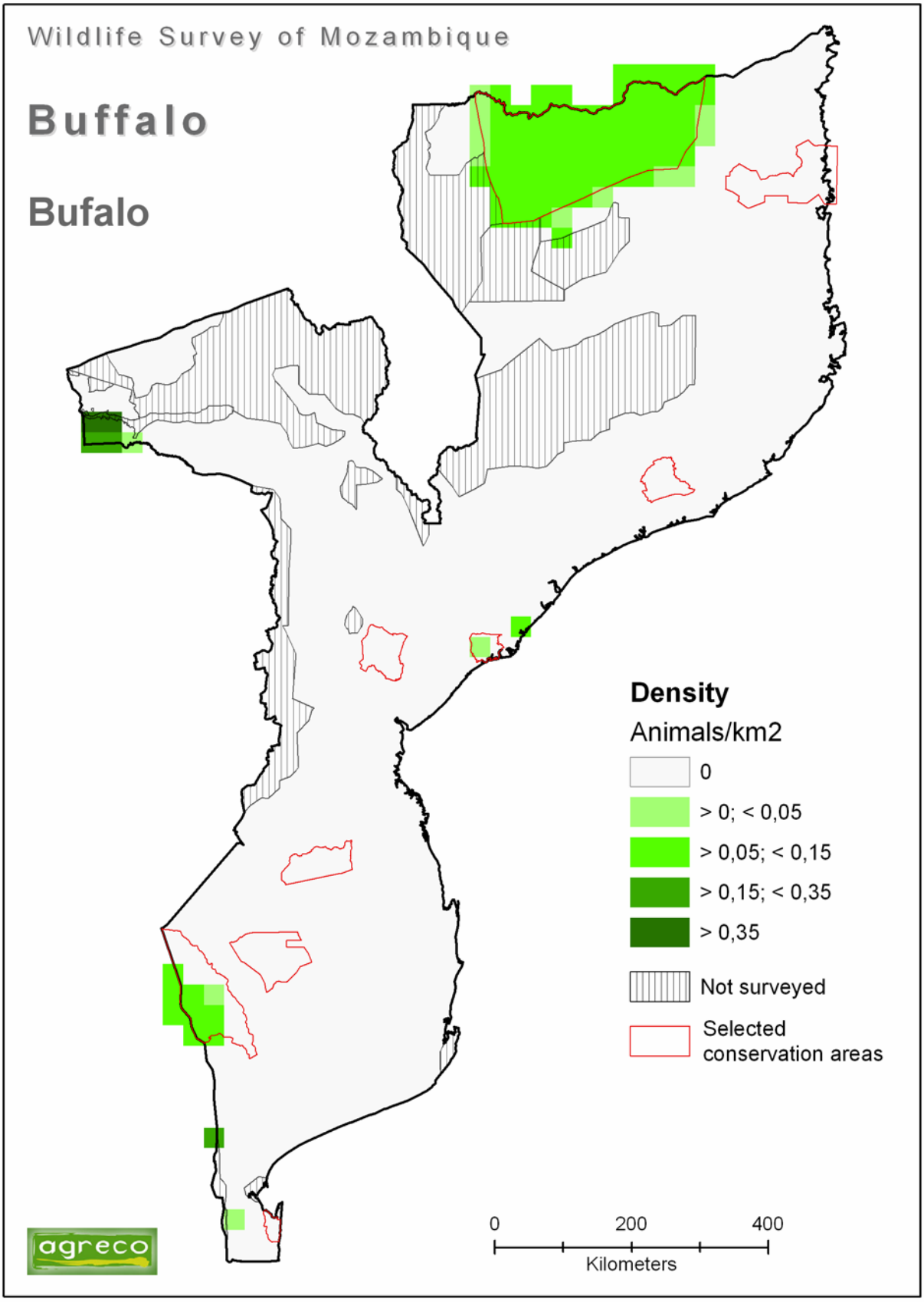
For very large animals like the elephant, it is possible to determine the recent trend in population number from the ratio of elephant carcasses. During the 2008 survey, just two recent carcasses (category I carcasses, of elephants judged to have died during 2008) and five old carcasses (category III carcasses, of elephants judged to have died any time during the several years prior to the 2008 survey) were seen. No category II carcasses were recorded. From these observations, it is estimated that there were 67 (± 257 %) recent carcasses and 266 (± 93 %) old carcasses in the 2008 survey area. In the same area, there were estimated to be 7187 (± 73 %) live elephants.

Thus, the 1+2 carcass ratio (an index of elephant mortality during the year preceding the survey) is calculated as: (67+0)x100 / (67+0+7187) = 0.9 %. And the all-carcass ratio (an index of elephant mortality in the several years preceding the survey) is calculated to be: (67+0+266)x100 / (67+0+266+7187) = 4.4 %.



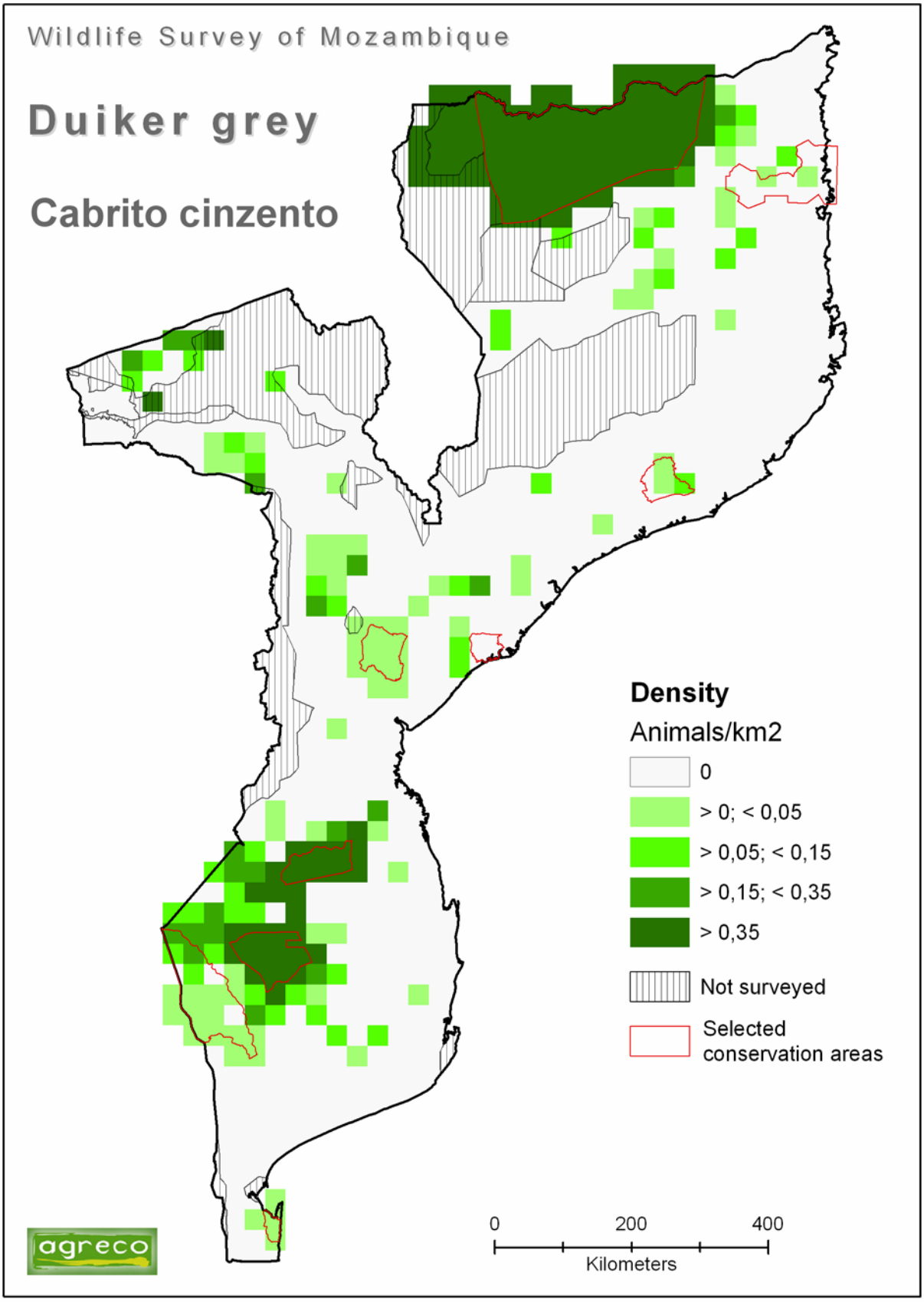
Map 3. Distribution of baboon in Mozambique

There are two species of baboon in Mozambique, Yellow Baboon in the north and Chacma Baboon in southern and central Mozambique and the Zambezi Valley. No attempt was made to determine species during the 2008 survey. Baboons are often not recorded during aerial surveys, because of the difficulty of counting them. Hence, this map notes the presence of baboons, not their density. Also, previous surveys did not always record baboons, hence their apparent absence from some previously surveyed areas. Baboons are present in Limpopo, Banhine and Zinave NPs and Niassa Reserve.



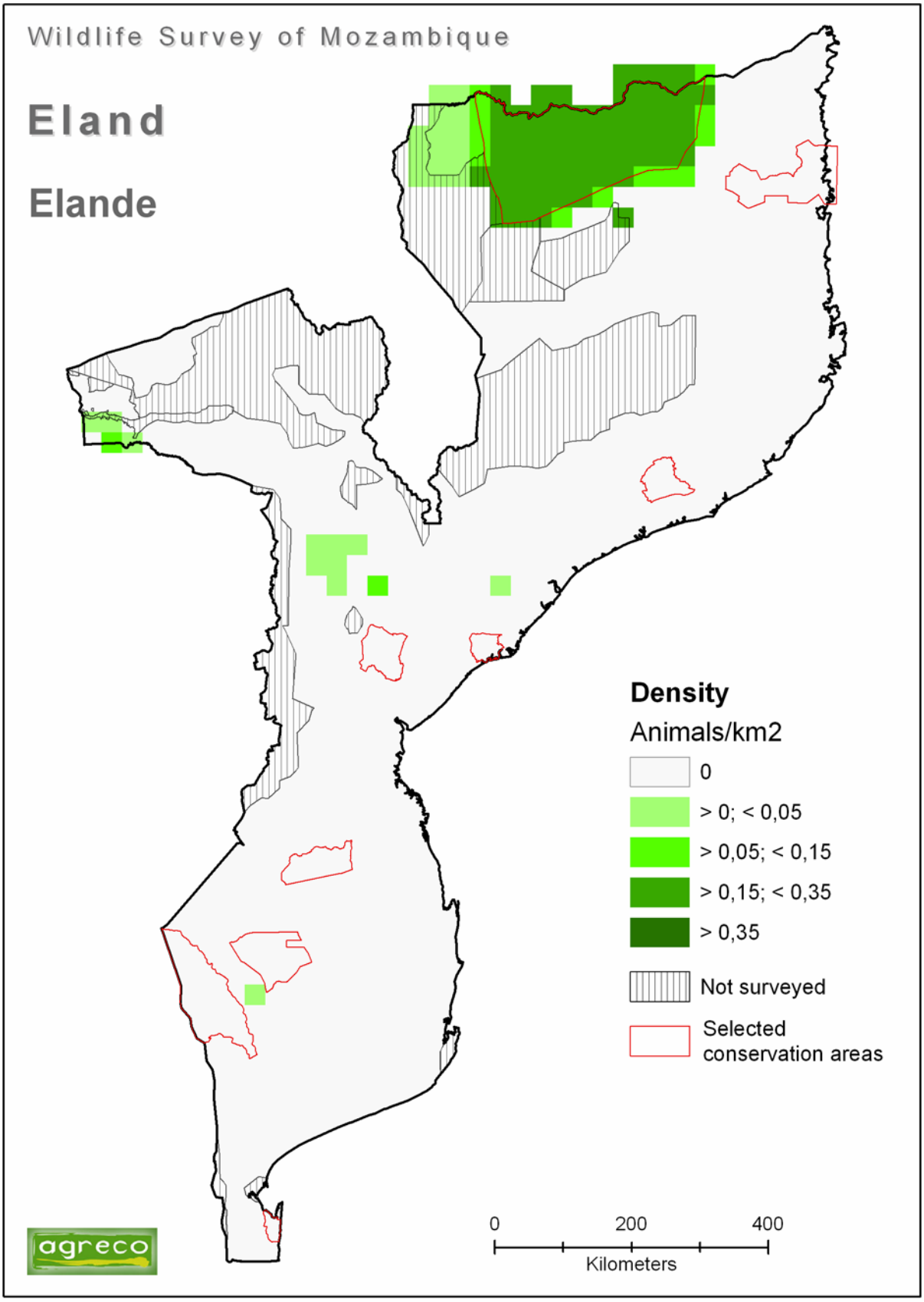
Map 4. Density distribution of buffalo in Mozambique

There were estimated to be 5717 (± 53 %) buffaloes in Mozambique, with the larger populations in Niassa Reserve, in and around Marromeu Reserve, and the Magoe communal area in western Tete Province. The conservation areas shown on this map are (from north to south) Niassa Reserve and the adjacent hunting areas, Quirimbas NP, Gile Reserve, Gorongosa NP, Marromeu Reserve, Zinave NP, Banhine NP, Limpopo NP and Maputo Elephant Reserve.



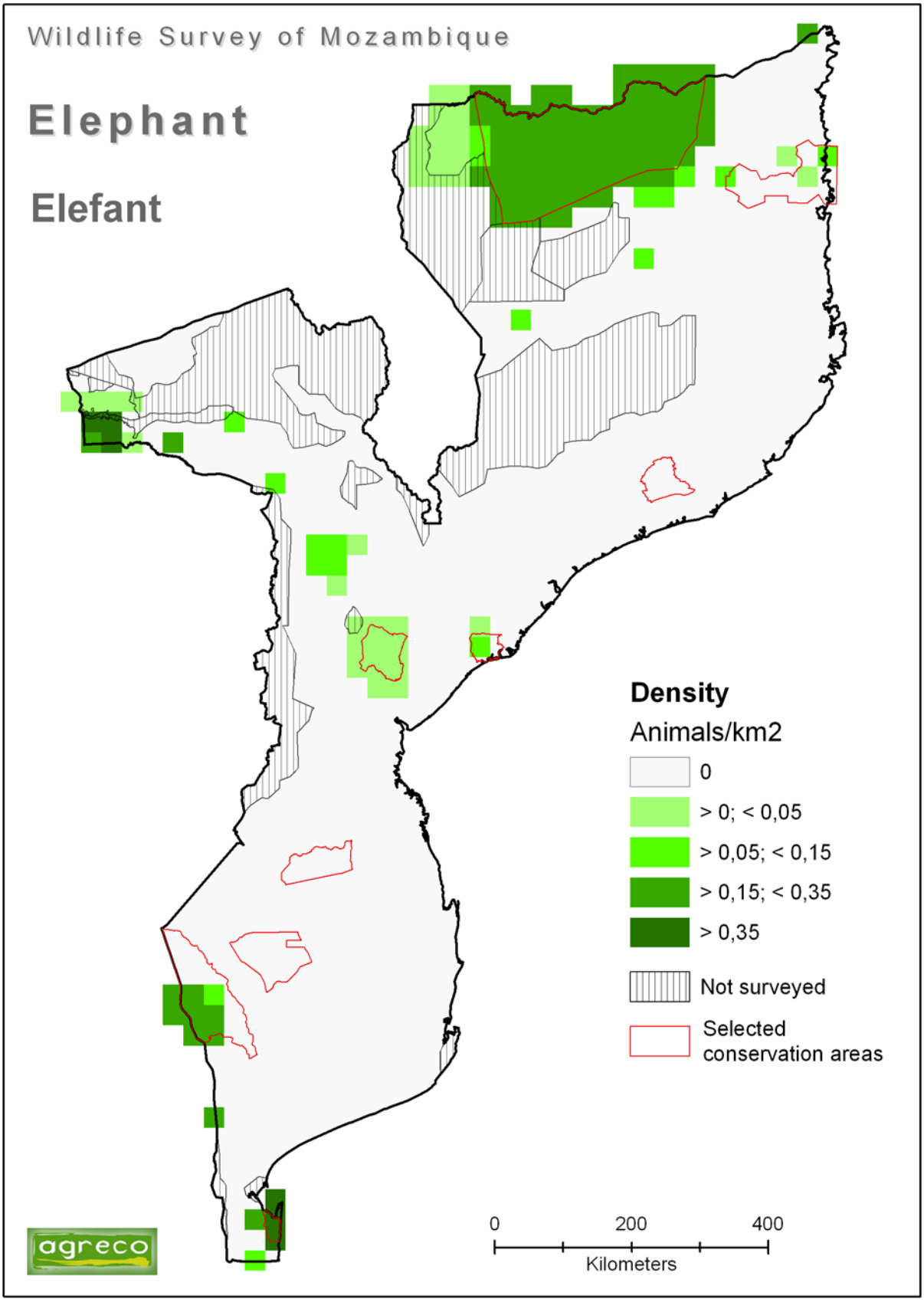
Map 5. Density distribution of grey duiker in Mozambique

There were estimated to be 45246 (± 7 %) grey duikers in Mozambique, with the species occurring throughout the country. The largest population of this small antelope is in Niassa Reserve and there are high densities in Zinave NP and Banhine NP.



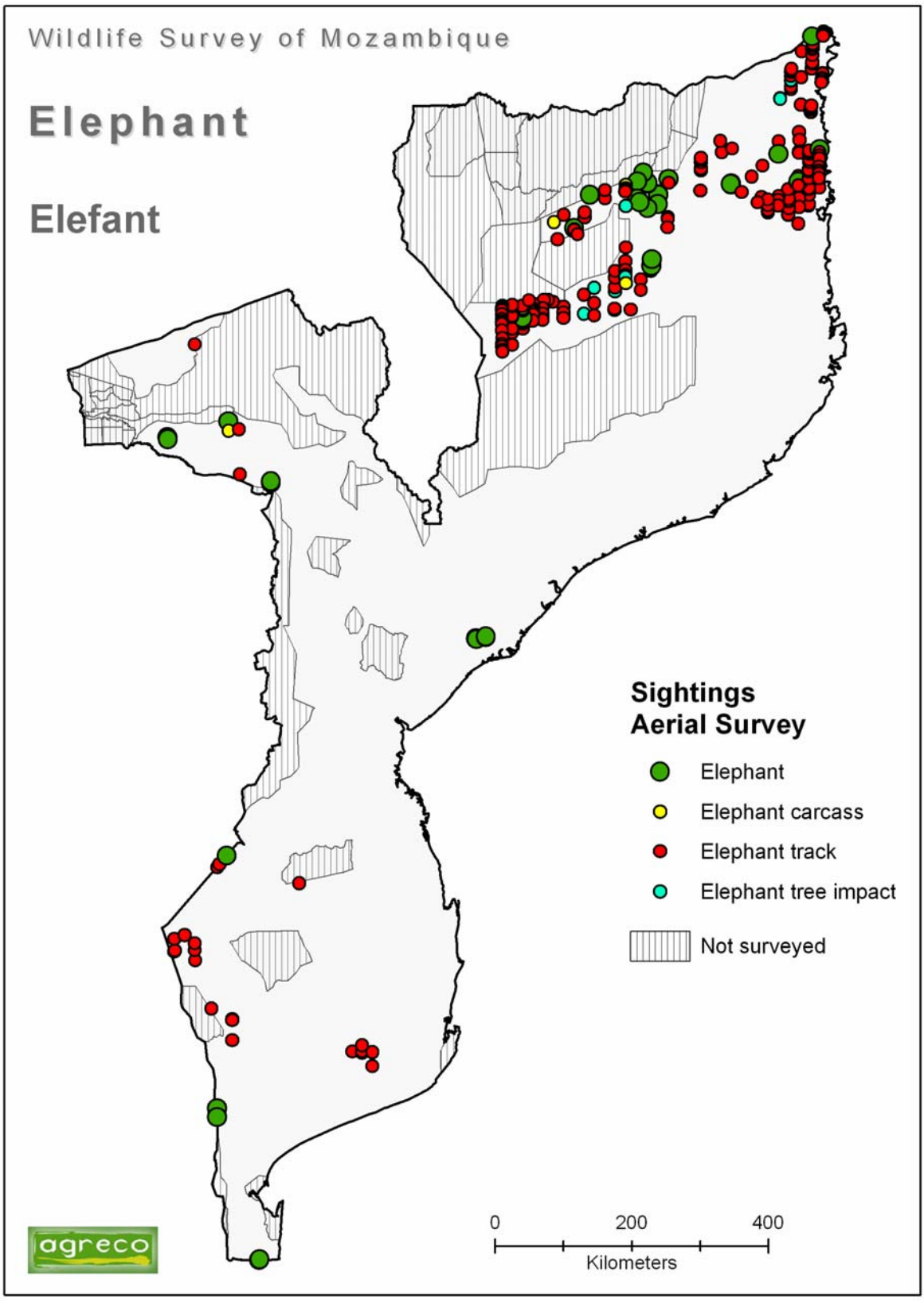
Map 6. Density distribution of eland in Mozambique

There were estimated to be 9382 (± 40 %) elands in Mozambique, with most of them in the Niassa Reserve.



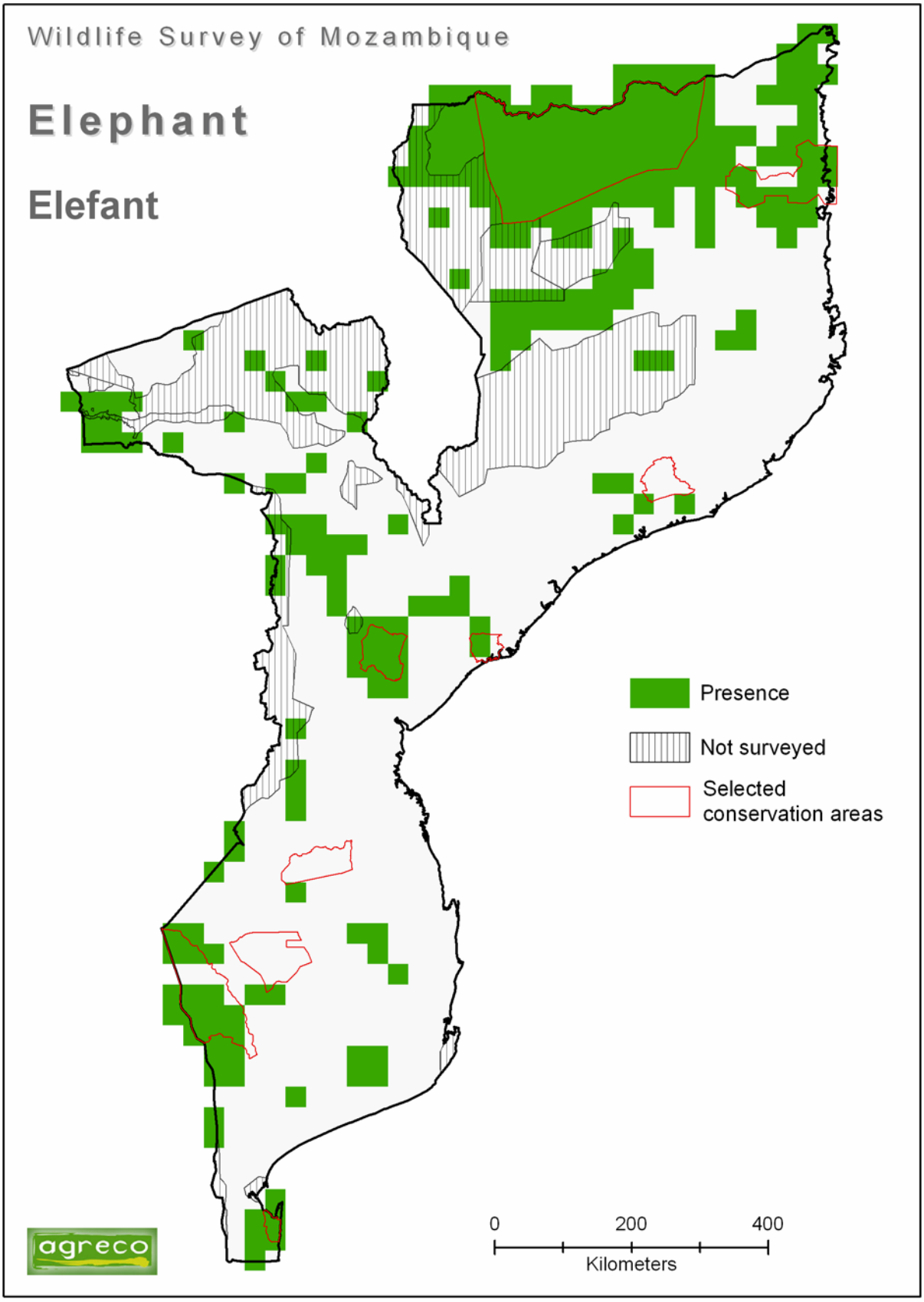
Map 7. Density distribution of elephant in Mozambique

There were estimated to be 22144 (± 26 %) elephants in Mozambique, with approximately 50 % of them in Niassa Reserve. Additional animals occur in the areas around the Niassa Reserve, including the Quirimbas NP. This density distribution map for elephant is based strictly on the sightings of elephants in the search areas during formal surveys.

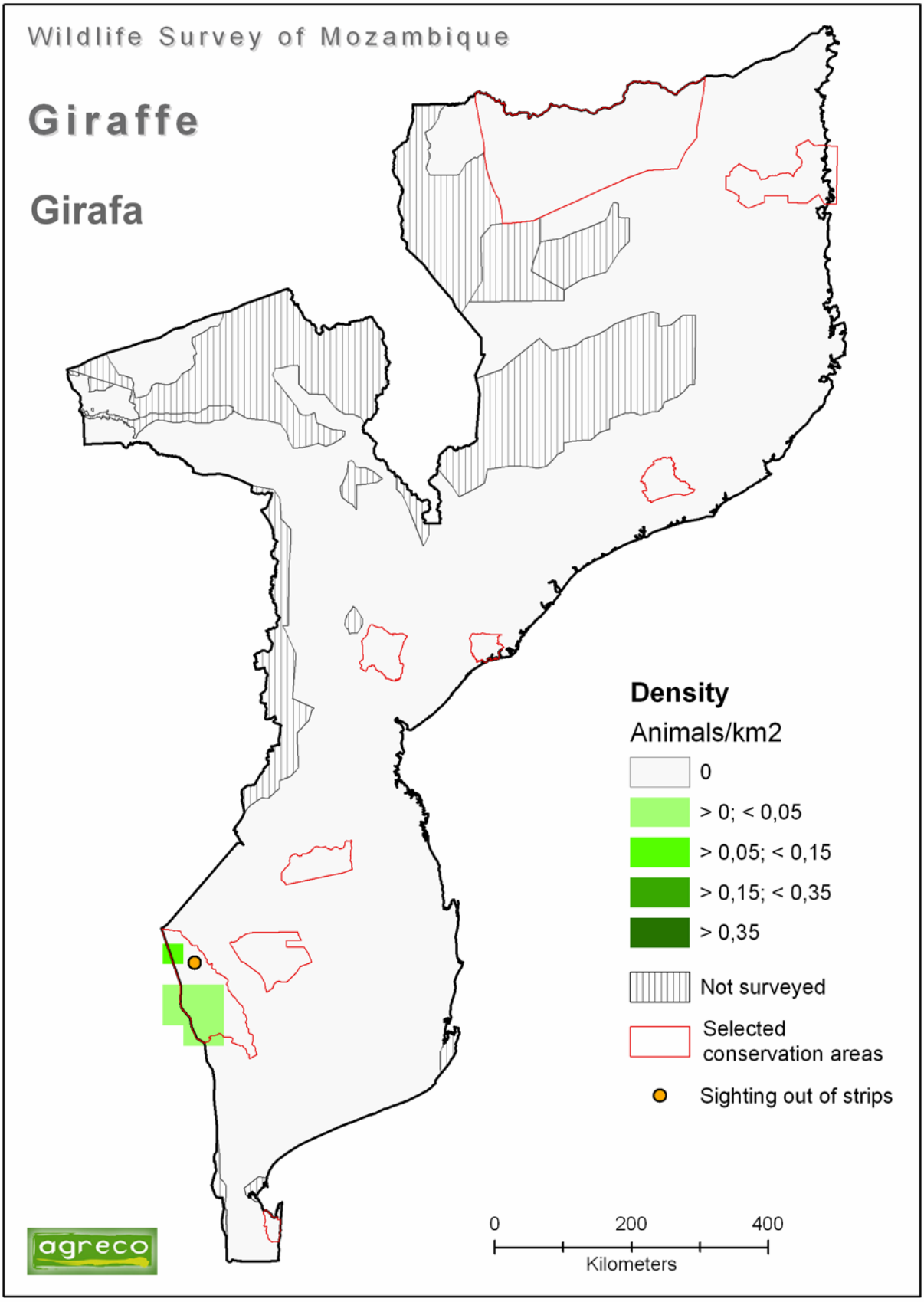


Map 8. Sightings of elephants and their signs in Mozambique during survey

The locations of sightings of elephants, elephant carcasses, elephant tracks (footprints) and trees broken by elephants during the 2008 survey all indicate regions of Mozambique that are within the elephant distributional range on a year-round basis (in contrast to observations of live elephants during the survey that can indicate just their dry-season range). Evidence of the presence of elephants was concentrated around Niassa Reserve, in the Magoe region south of Cabora Bassa, in Marromeu Reserve, and in border regions such as adjacent to Gonarezhou NP in Zimbabwe, Kruger NP in South Africa, and Limpopo NP. There is also an isolated presence of elephants to the west of Inhambane.

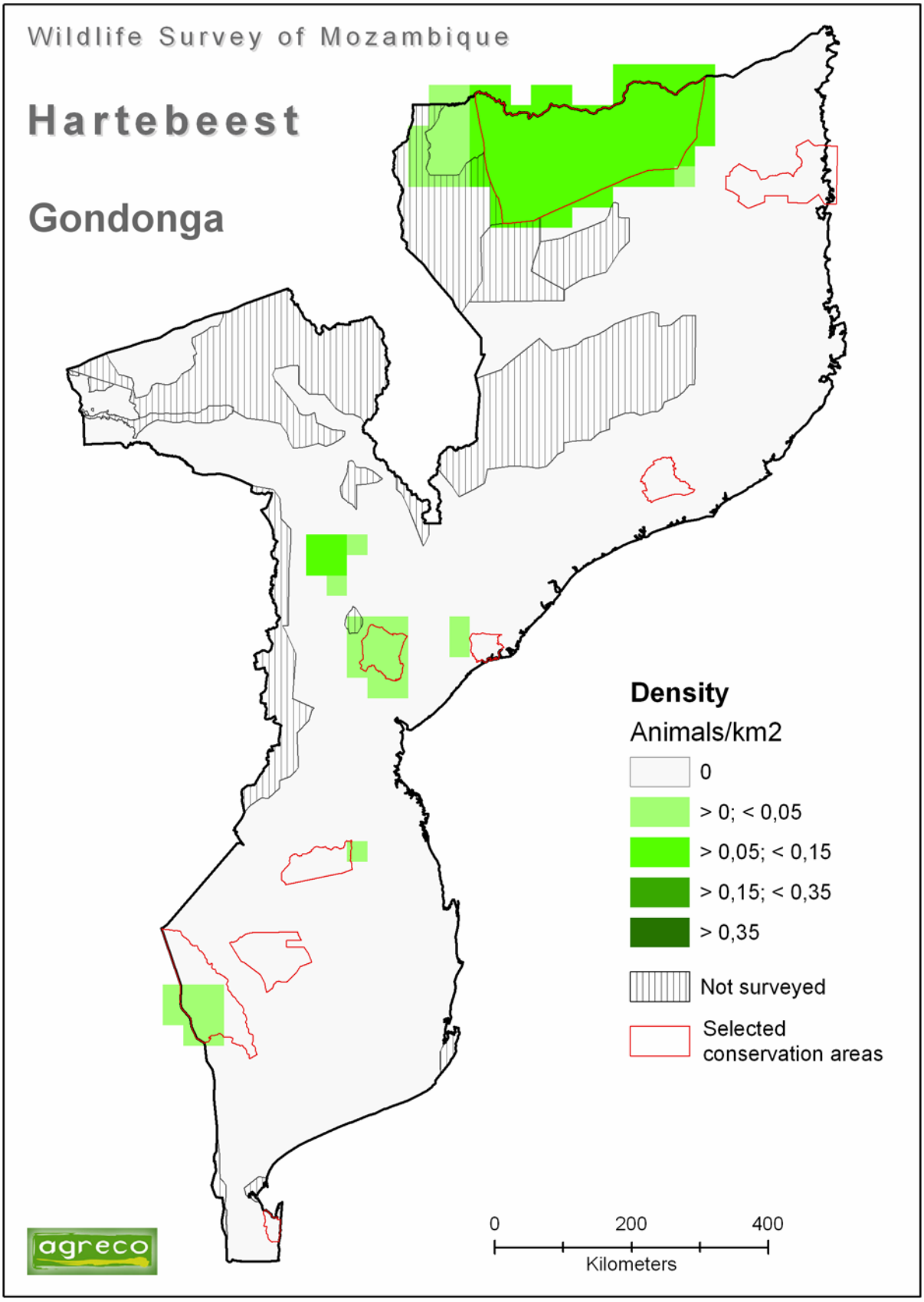


Map 9. Distribution of elephant in Mozambique: survey data and other information
This map showing the presence of elephant across Mozambique, based on information from the 2008 survey and other recent sources. The areas not surveyed during the 2008 survey are also indicated.



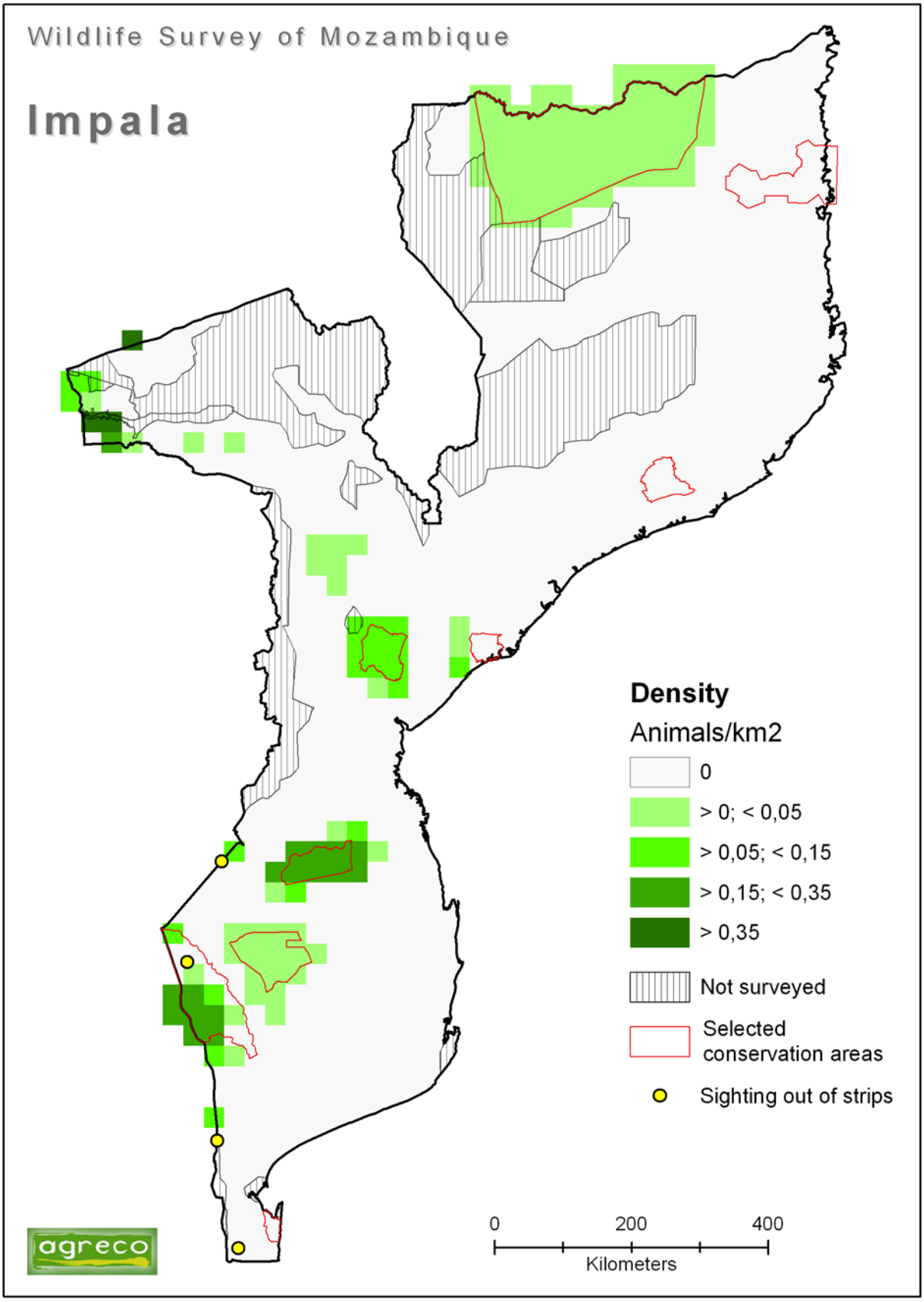
Map 10. Density distribution of giraffe in Mozambique

During the 2008 survey, there were only four sightings of giraffe (just one sighting inside the search strips), all in the northern section of Limpopo NP. Formally, there were estimated to be 125 (± 172 %) giraffes in Mozambique (all in Limpopo NP). But with such a large confidence interval, any population estimate must be treated with considerable caution.



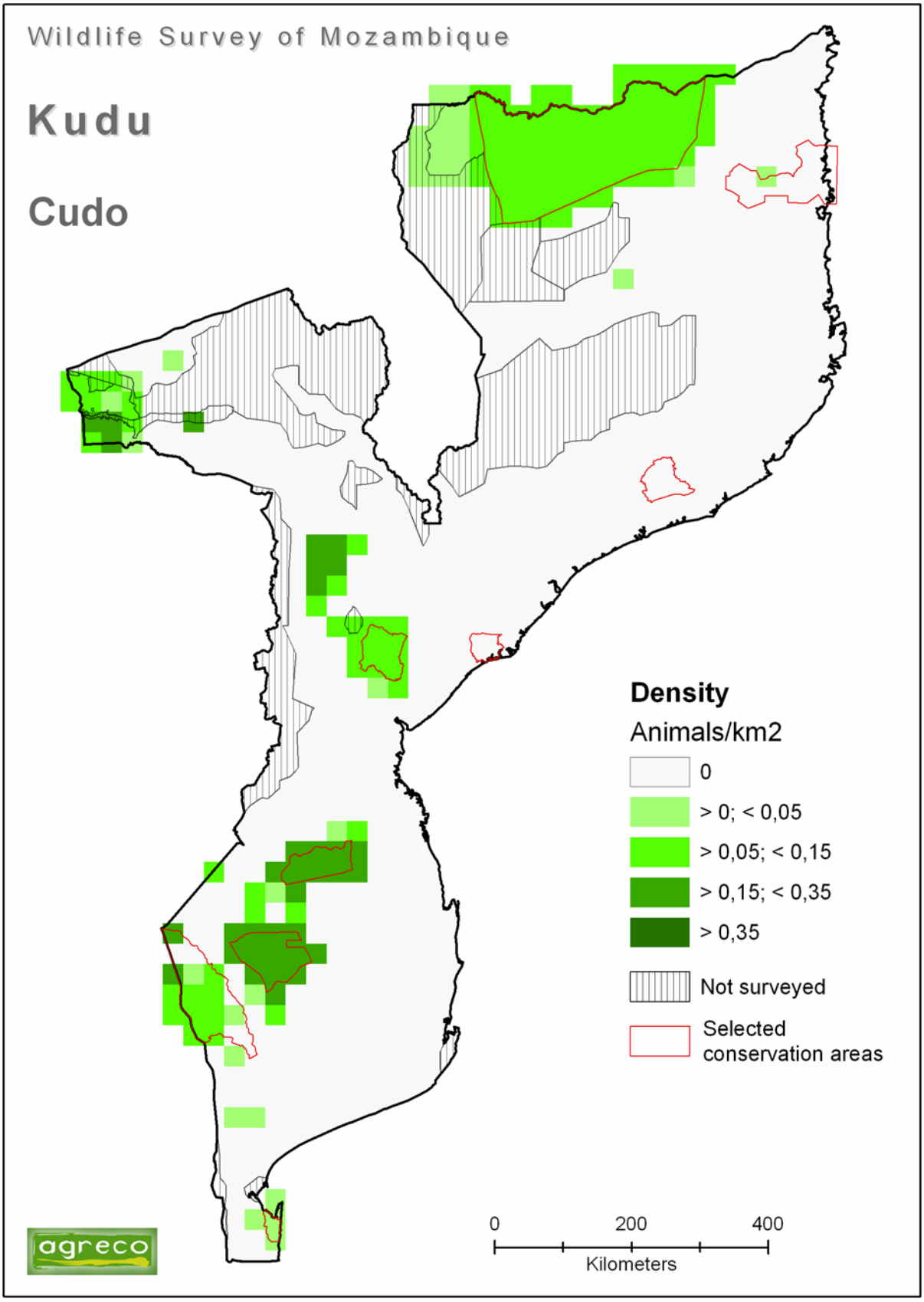
Map 11. Density distribution of Lichtenstein's hartebeest in Mozambique

There were estimated to be 5107 (± 27 %) hartebeests in Mozambique. More than 85 % of them are in the Niassa Reserve, with a smaller population in central Mozambique and a few animals in Limpopo NP.



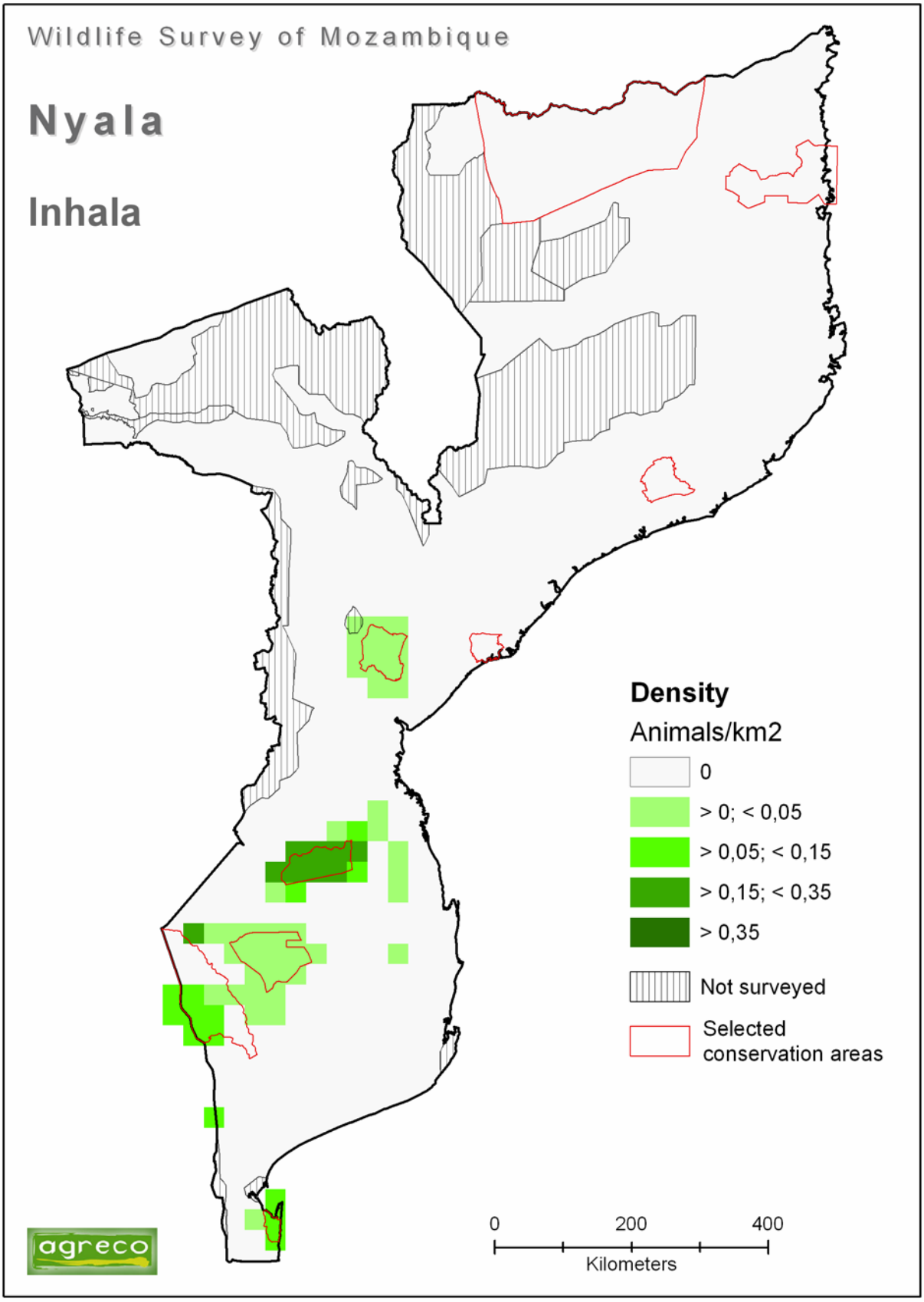
Map 12. Density distribution of impala in Mozambique

There were estimated to be 11677 (± 83 %) impalas in Mozambique. Impala occur in most previously surveyed areas and in the coutadas west of the Buffalo Reserve, as well as in Magoe region and around the national parks of southern Mozambique (Limpopo, Banhine, Zinave).



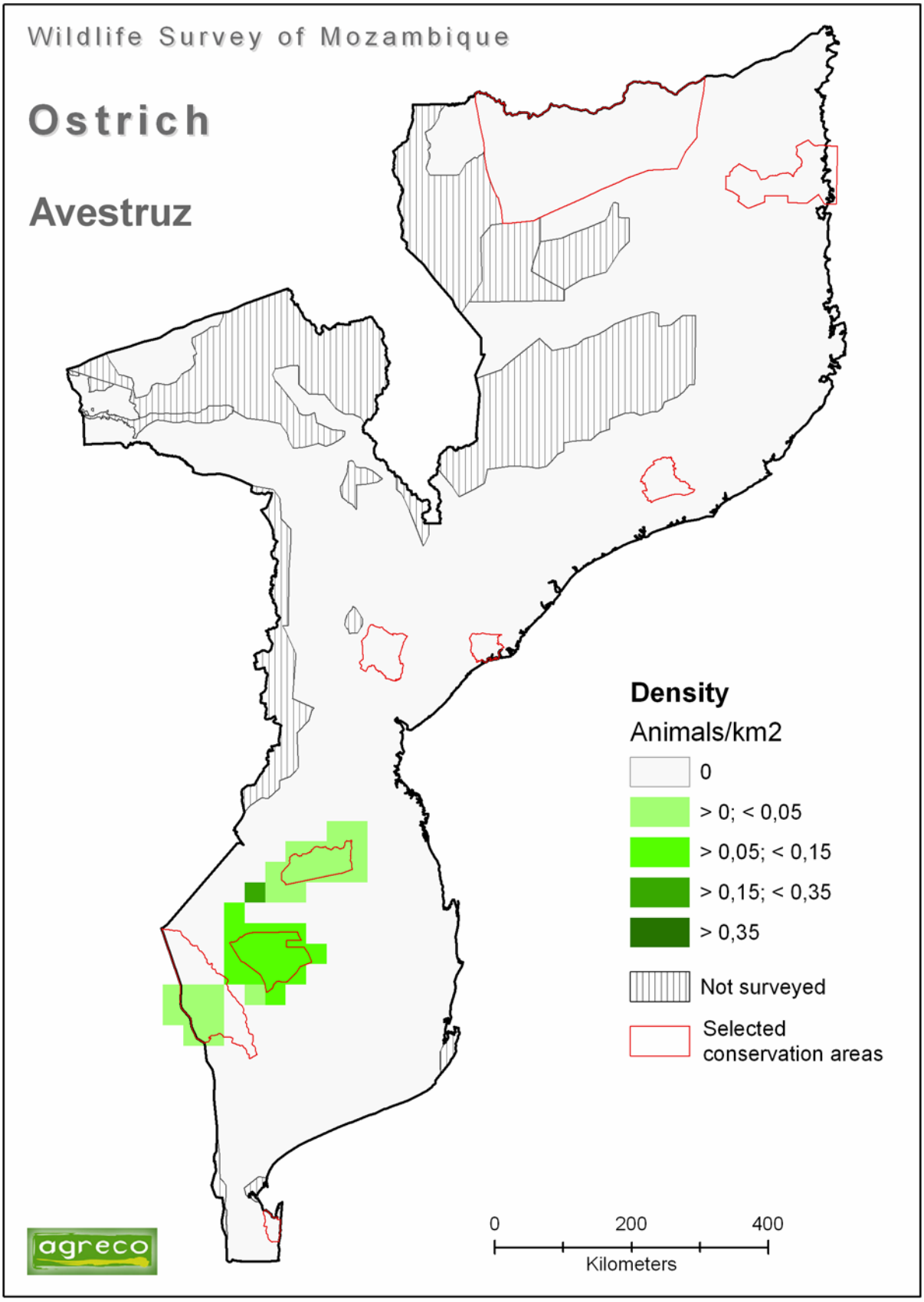
Map 13. Density distribution of kudu in Mozambique

There were estimated to be 15764 (± 18 %) kudus in Mozambique. There are populations in the north (in and around Niassa Reserve), in the south (in and around the Limpopo, Banhine and Zinave NPs) and in central Mozambique (in the Gorongosa-Coutada 9 region and in Magoe).



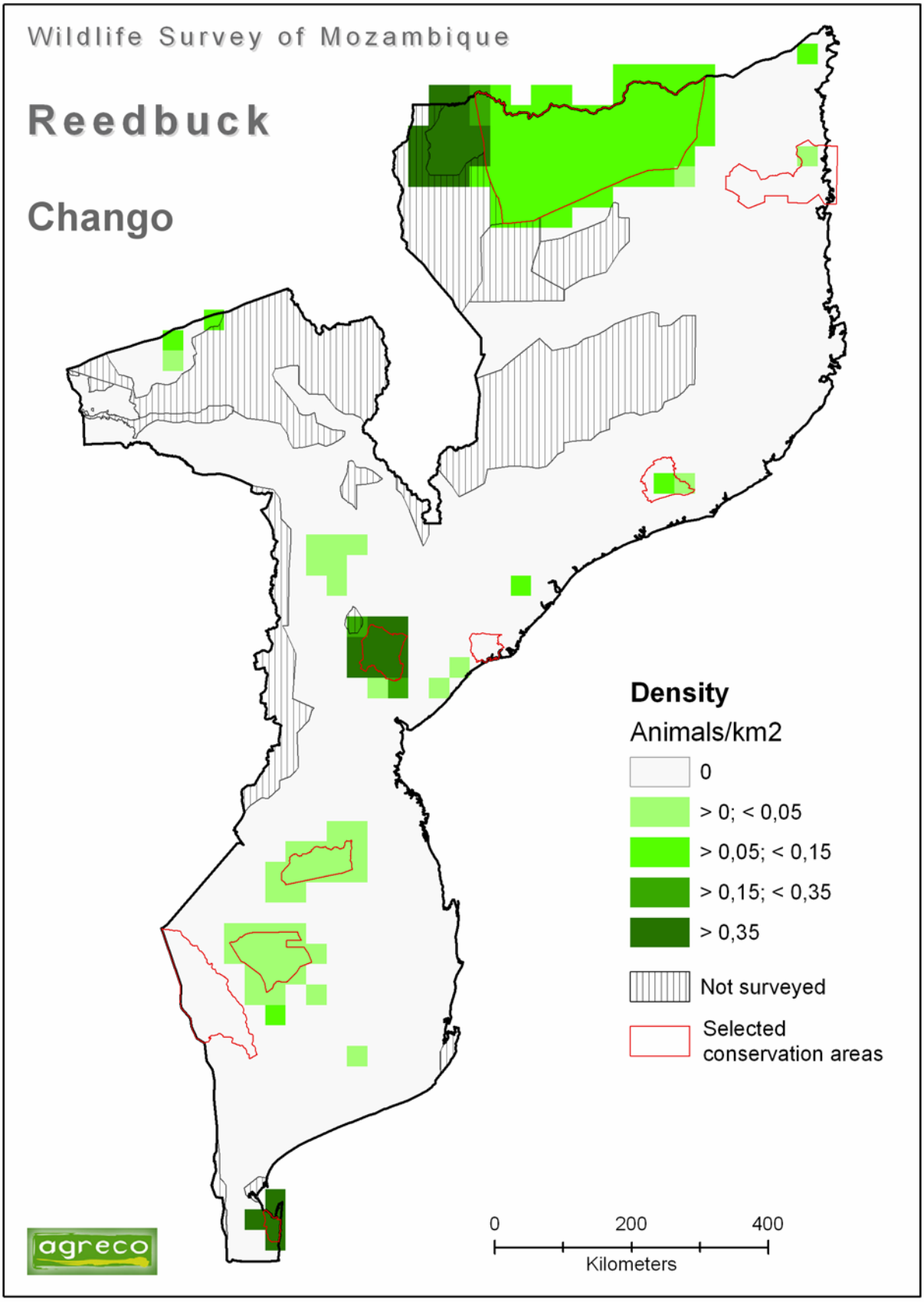
Map 14. Density distribution of nyala in Mozambique

There were estimated to be 3435 (± 44 %) nyalas in Mozambique. Nyalas were seen only south of the Zambezi River.



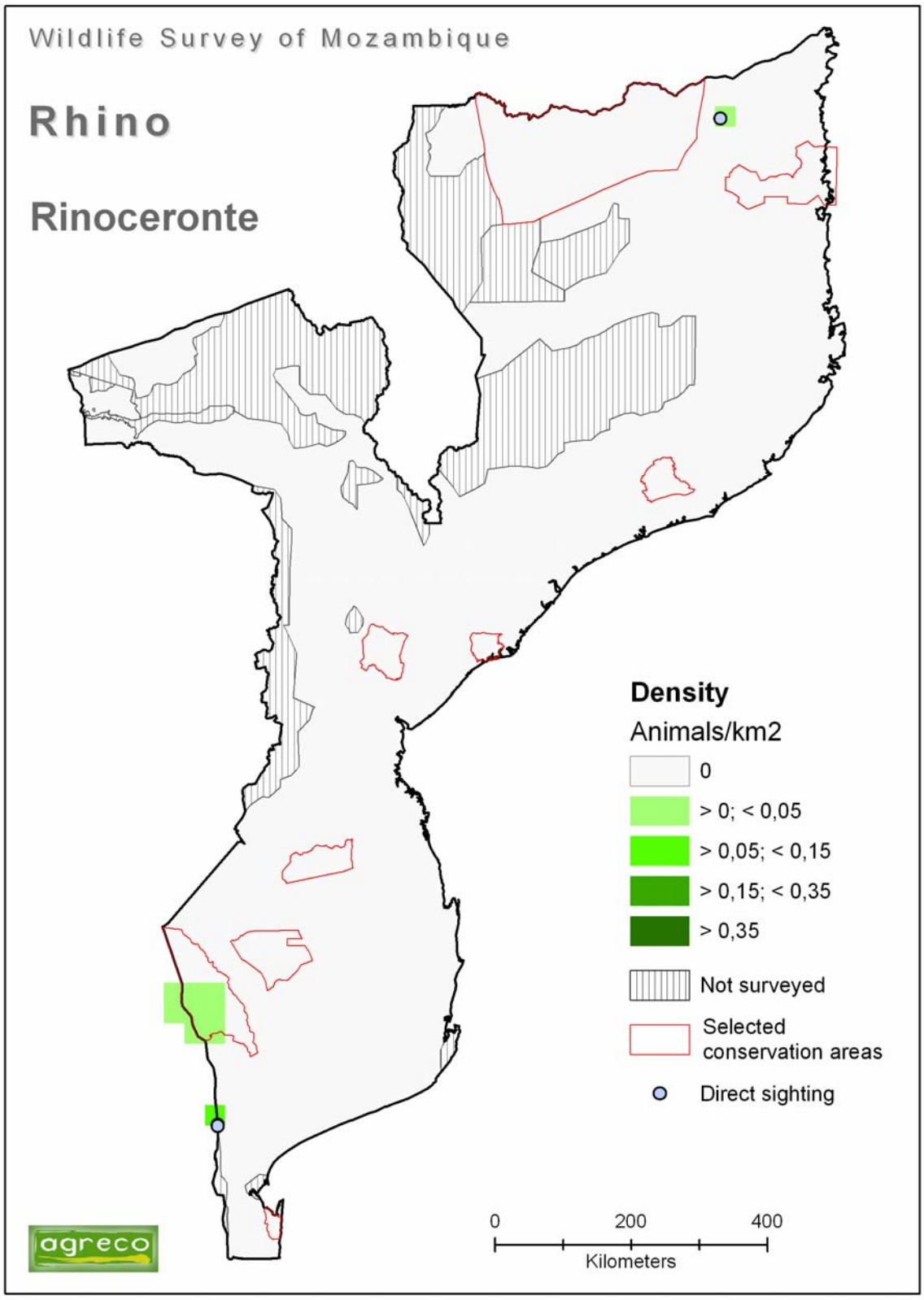
Map 15. Density distribution of ostrich in Mozambique

There were estimated to be 1566 (± 67 %) ostriches in Mozambique and all are in southern Mozambique, in the Limpopo, Banhine and Zinave NPs, or the areas linking these parks.



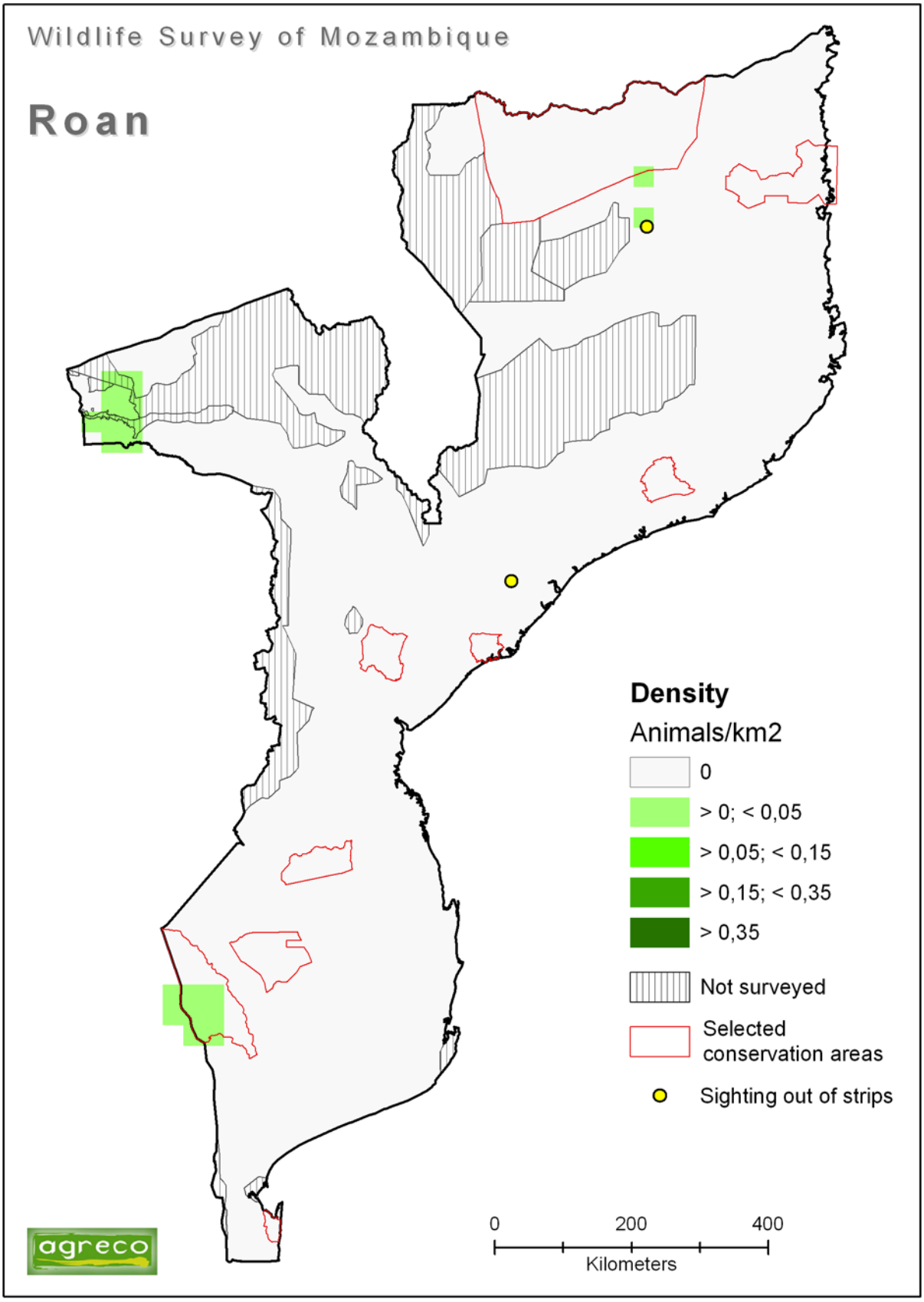
Map 16. Density distribution of reedbuck in Mozambique

There were estimated to be 12293 (± 19 %) reedbucks in Mozambique. While most of these were in the conservation areas previously surveyed, reedbuck were observed in all regions of Mozambique.



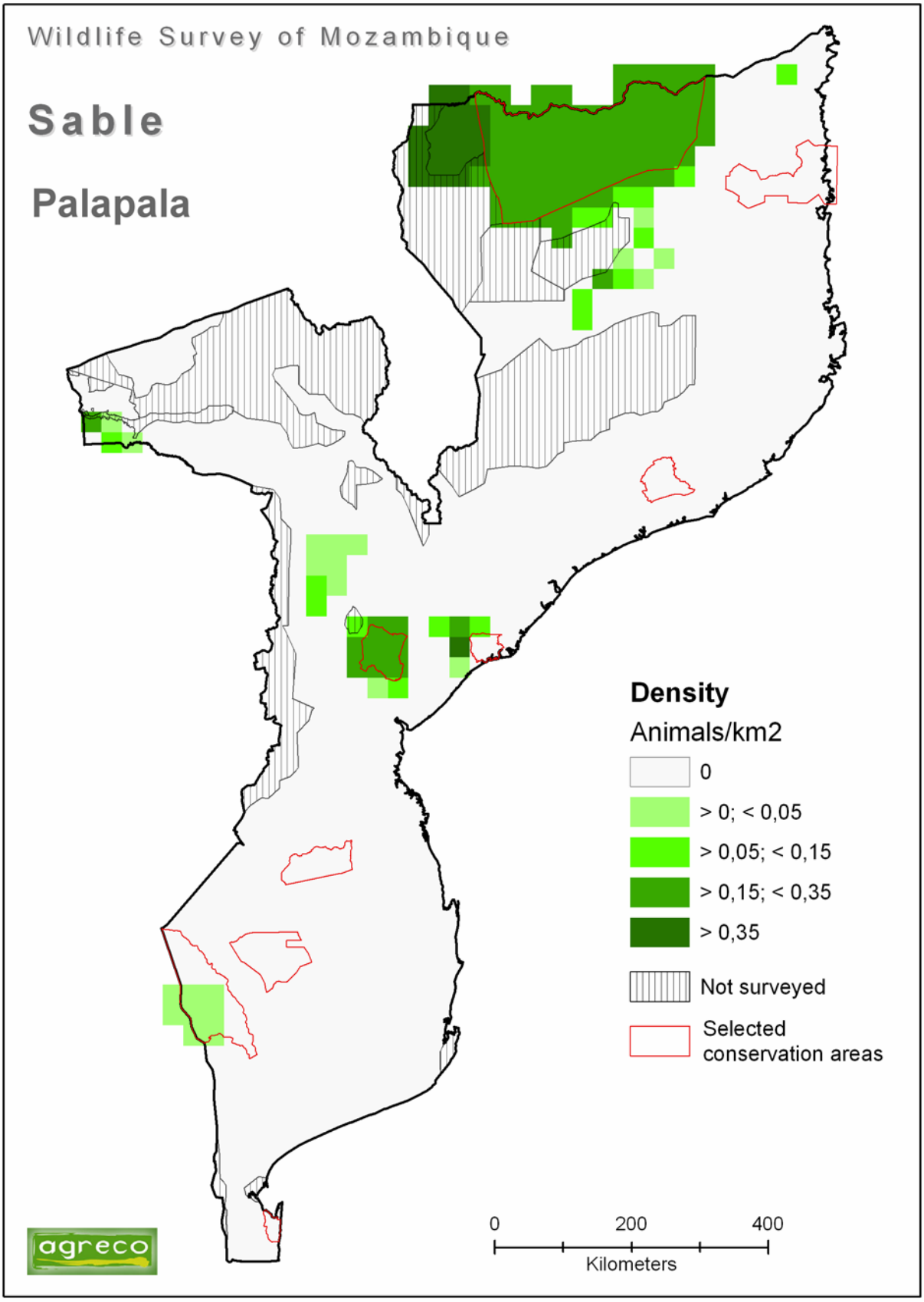
Map 17. Density distribution of rhinoceros in Mozambique

Two species of rhinoceros may occur in Mozambique, the black rhinoceros and the white rhinoceros. The white rhinoceros was recently reintroduced to Limpopo NP, where 16 were seen during the last survey there. During the 2008 survey, there were two sightings each of 2 rhinos south of Limpopo NP (but close to Kruger NP) – two of these animals were identified as white rhinos and it is likely that the other two were also white rhinos. Taken together, these observations suggest a population of approximately 20 white rhinoceros in Mozambique. During the 2008 survey, a solitary rhino was also seen in northern Mozambique and was most likely a black rhinoceros. There is no information from the surveys to suggest that there are additional black rhinos in Mozambique.



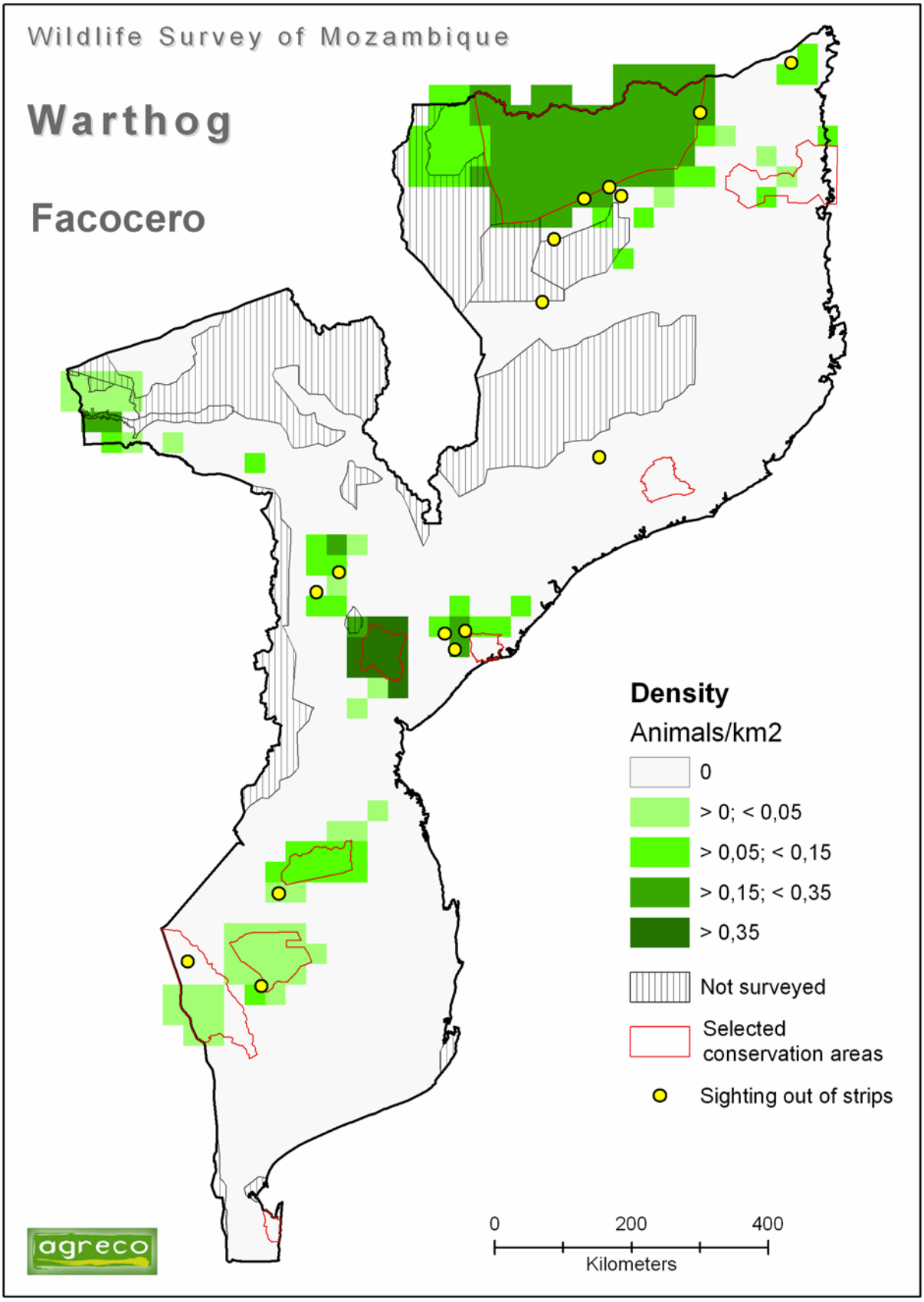
Map 18. Density distribution of roan antelope in Mozambique

There were estimated to be 525 (± 238 %) roan antelopes in Mozambique. But with such a large confidence interval, any population estimate must be treated with considerable caution. A few roan antelopes were seen south of Niassa Reserve and – during previous surveys – in Limpopo NP, in the Magoe area and northwards of Magoe. During the 2008 survey, there was a single sighting outside the search strip northwards of Marromeu Reserve.



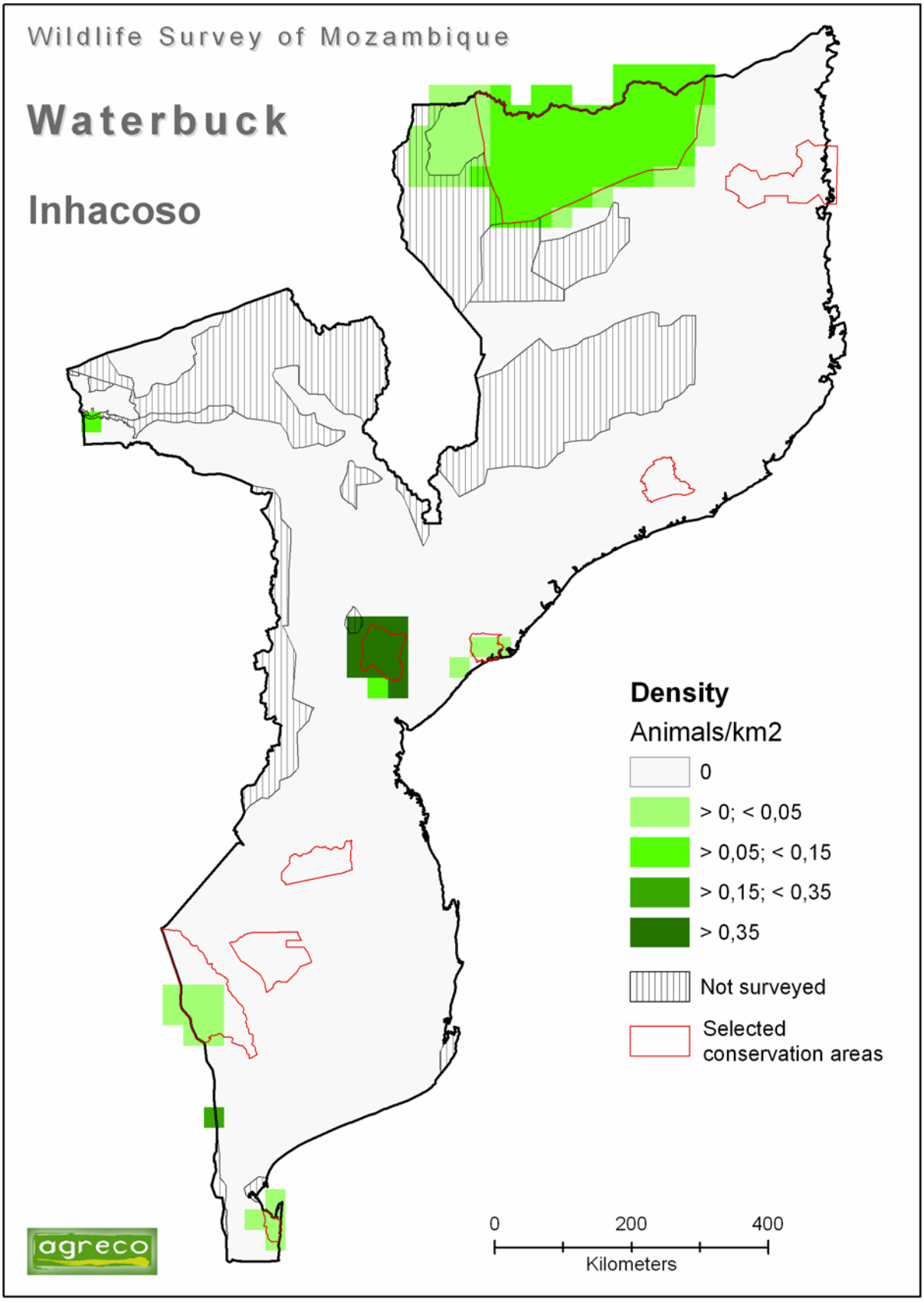
Map 19. Density distribution of sable antelope in Mozambique

There were estimated to be 32393 (± 33 %) sable antelopes in Mozambique. Most are in northern Mozambique, in and south of Niassa Reserve, with a second population in central Mozambique, including Gorongosa NP and Marromeu Reserve, and a few animals in Limpopo NP and Magoe.



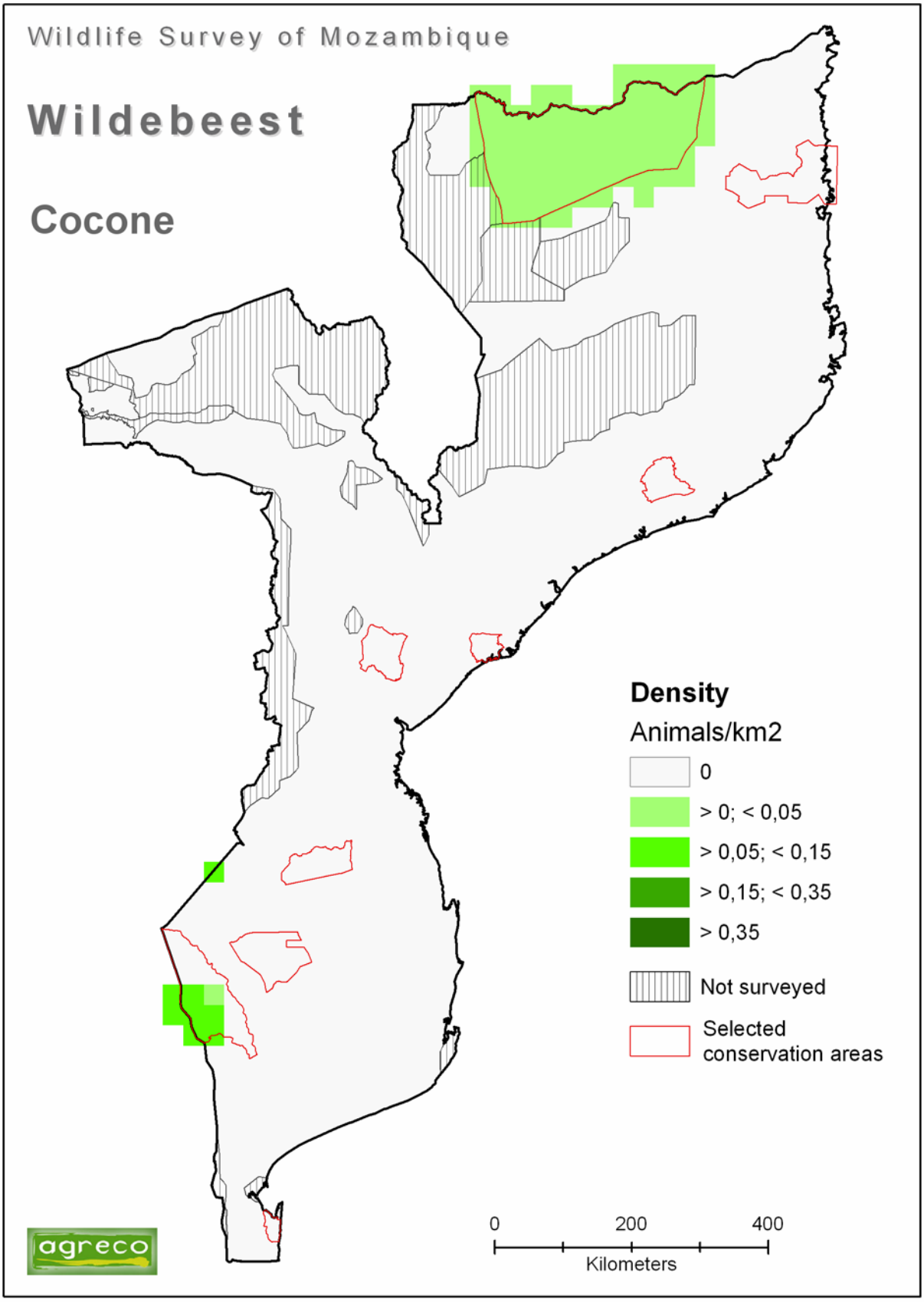
Map 20. Density distribution of warthog in Mozambique

There were estimated to be 18880 (± 17 %) warthogs in Mozambique. There are populations in and around Niassa Reserve in northern Mozambique, in the Zambezi and Rift Valleys in central Mozambique (including Gorongosa NP and Marromeu Reserve), and in the Limpopo, Banhine and Zinave NPs in southern Mozambique.



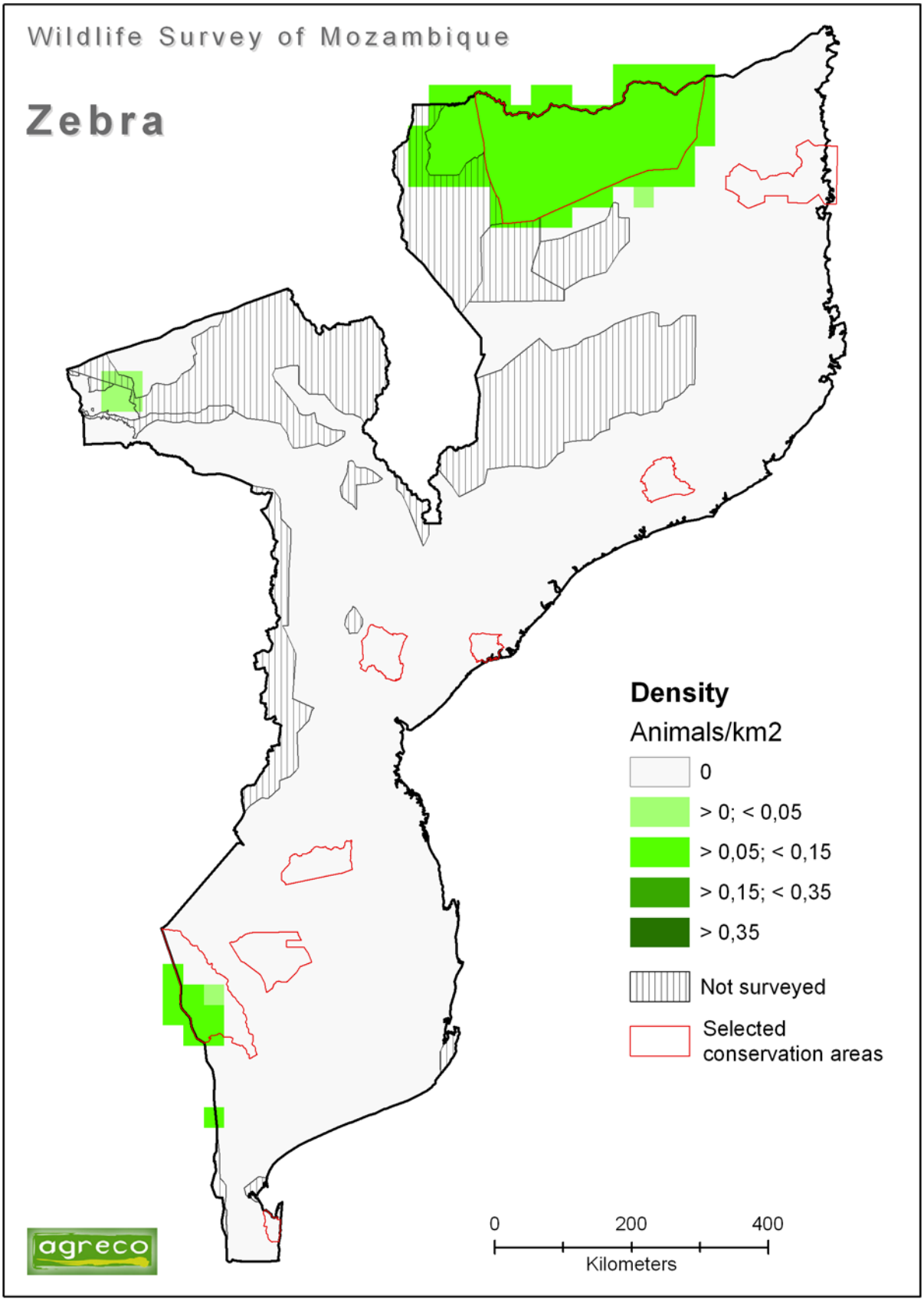
Map 21. Density distribution of waterbuck in Mozambique

There were estimated to be 9956 (± 58 %) waterbucks in Mozambique. Most were in Gorongosa NP, Marromeu Reserve and Niassa Reserve, but with small numbers in the Magoe area, Limpopo NP and Maputo Elephant Reserve.



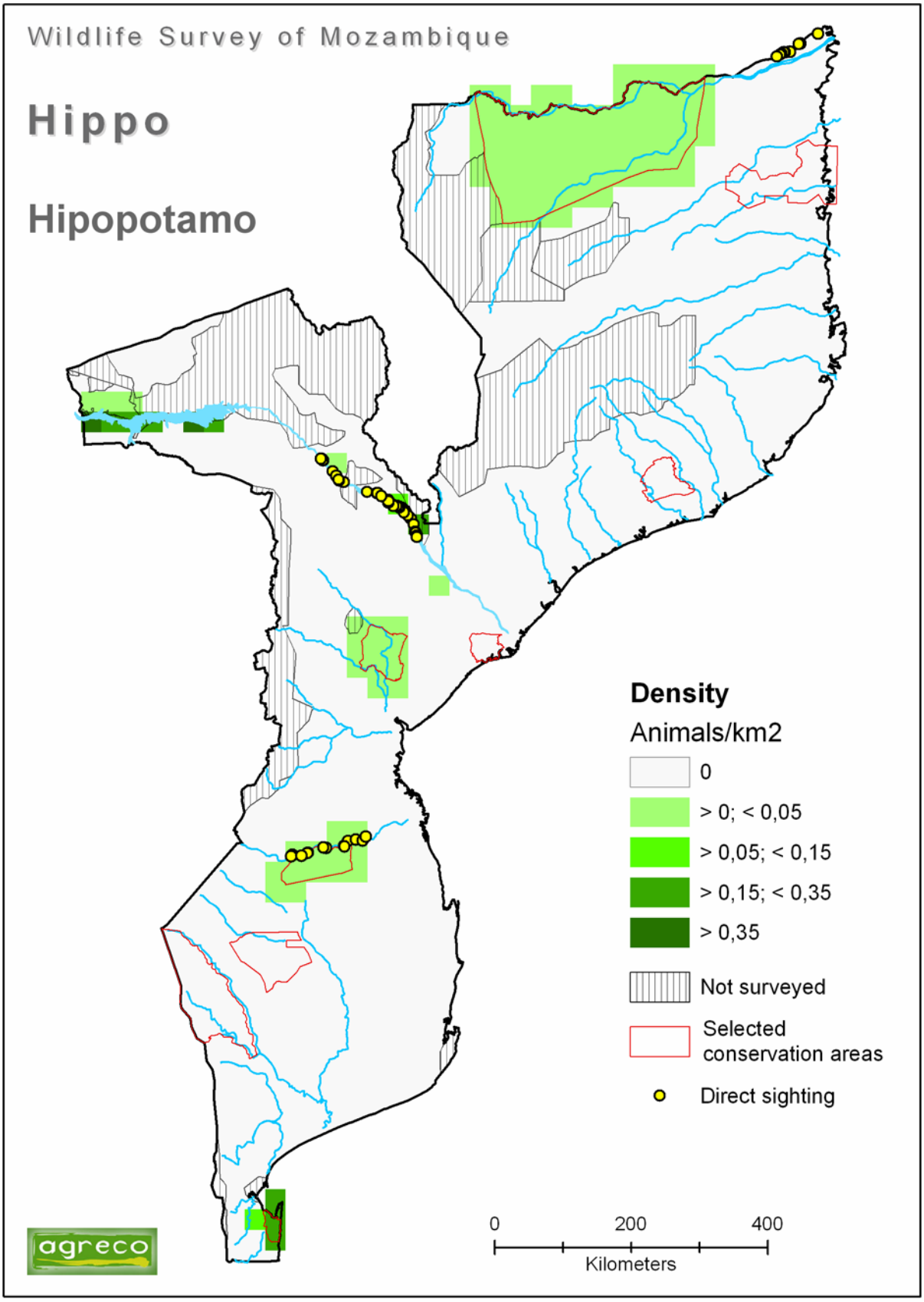
Map 22. Density distribution of wildebeest in Mozambique

There were estimated to be 2031 (± 46 %) wildebeests in Mozambique. There are two discrete populations, the larger one, comprising 75 % of the national population, in Niassa Reserve and a small population in Limpopo NP.



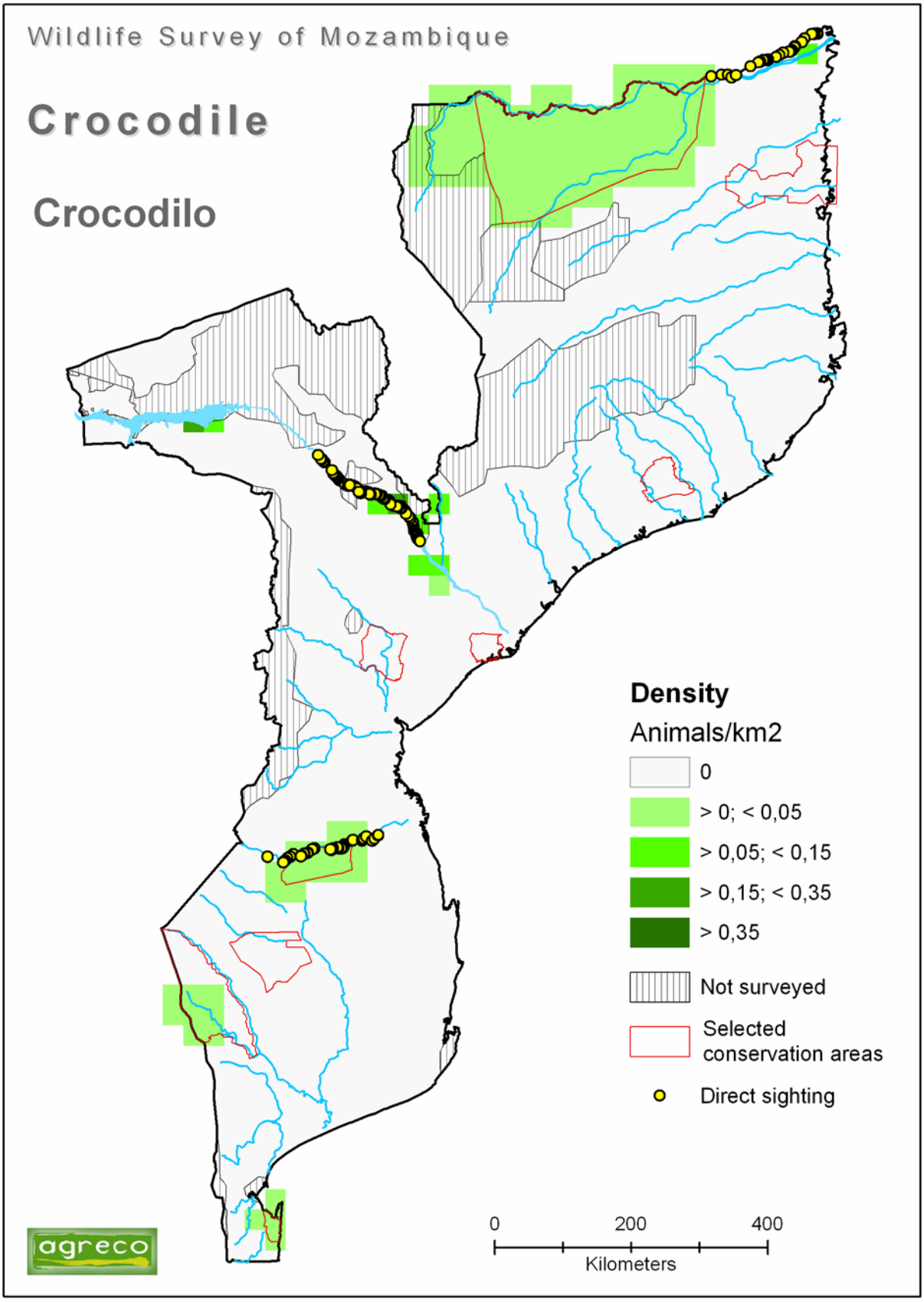
Map 23. Density distribution of zebra in Mozambique

There were estimated to be 7480 (± 22 %) zebras in Mozambique. Most were in or near Niassa Reserve, with additional animals in Limpopo NP, or near the border with Kruger NP, and a few in Magoe.



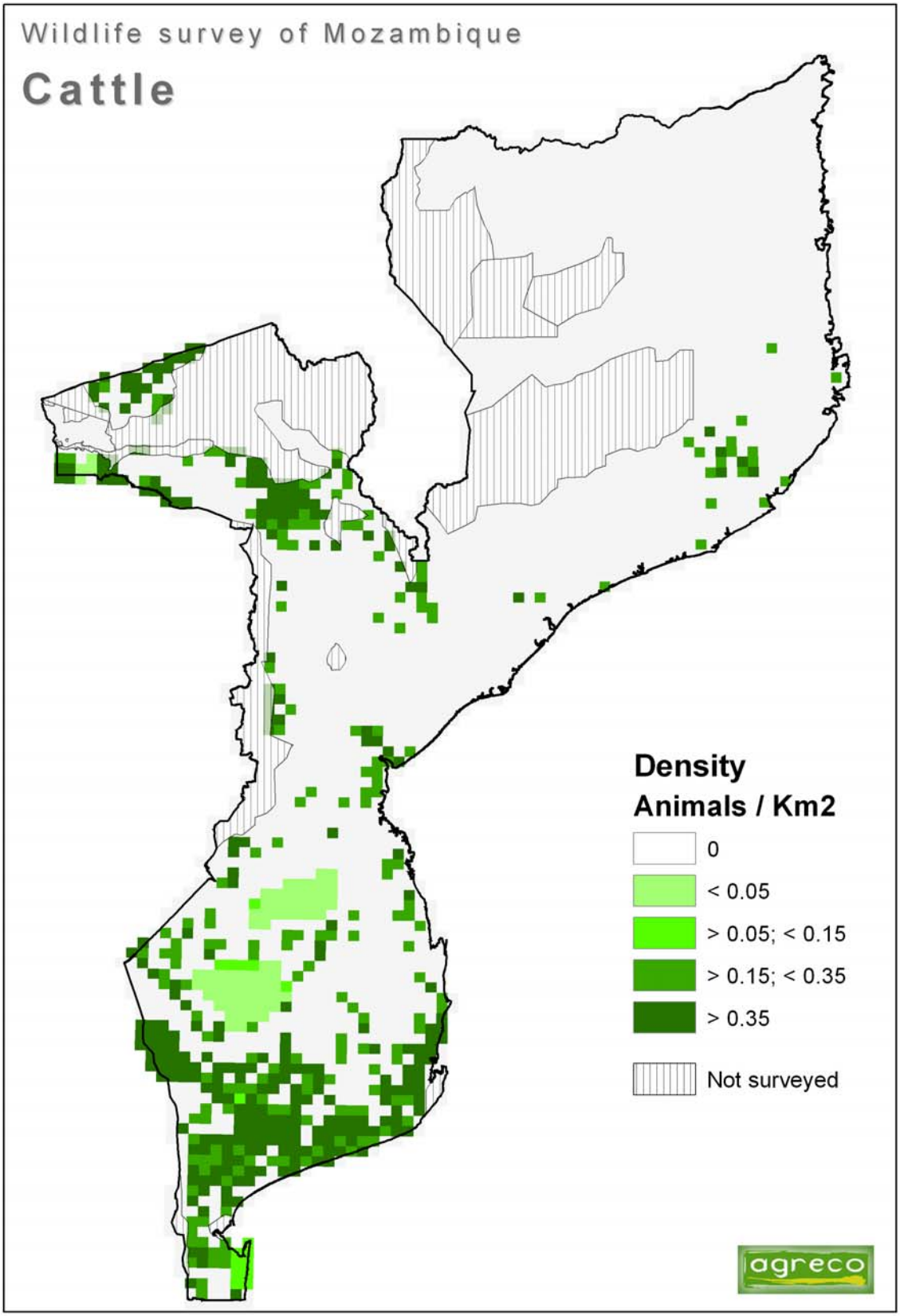
Map 24. Distribution of hippopotamus in Mozambique

There were estimated to be 8388 (± 54 %) hippos in Mozambique, with about 50 % of these animals in East Magoe, in other words along the southern shore of Lake Cabora Bassa. There were special hippopotamus counts along the Save River, the lower Rovuma River, and along the north and south banks of the Zambezi River between Tete and Mutarara. Sightings of hippos during these surveys are indicated on this map by yellow dots.



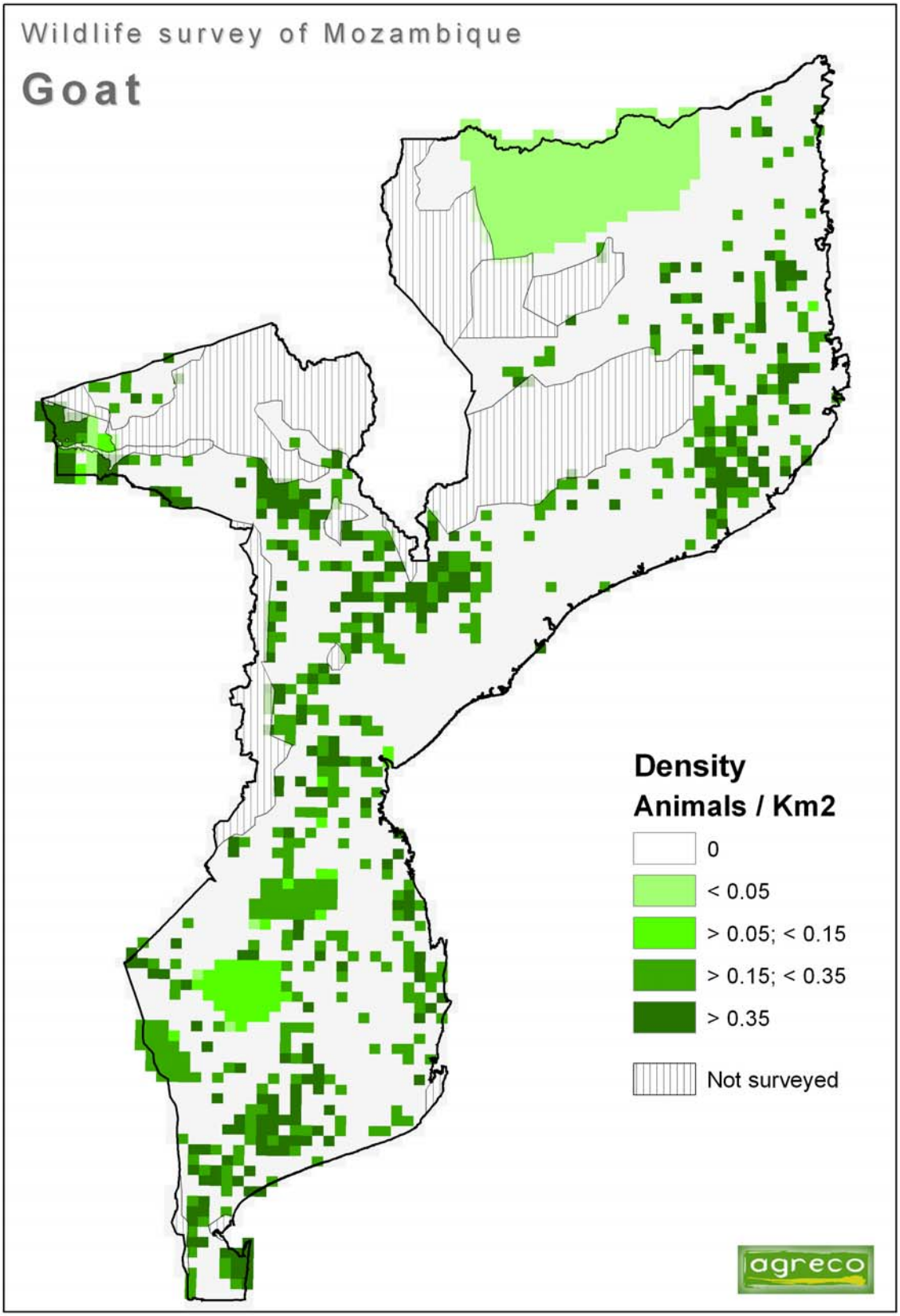
Map 25. Distribution of large crocodiles in Mozambique

There were estimated to be 1511 (± 63 %) large crocodiles in Mozambique. There were special crocodile counts along the Save River, the lower Rovuma River, and along the north and south banks of the Zambezi River between Tete town and Mutarara. Sightings of crocodiles during these surveys are indicated on this map by yellow dots.



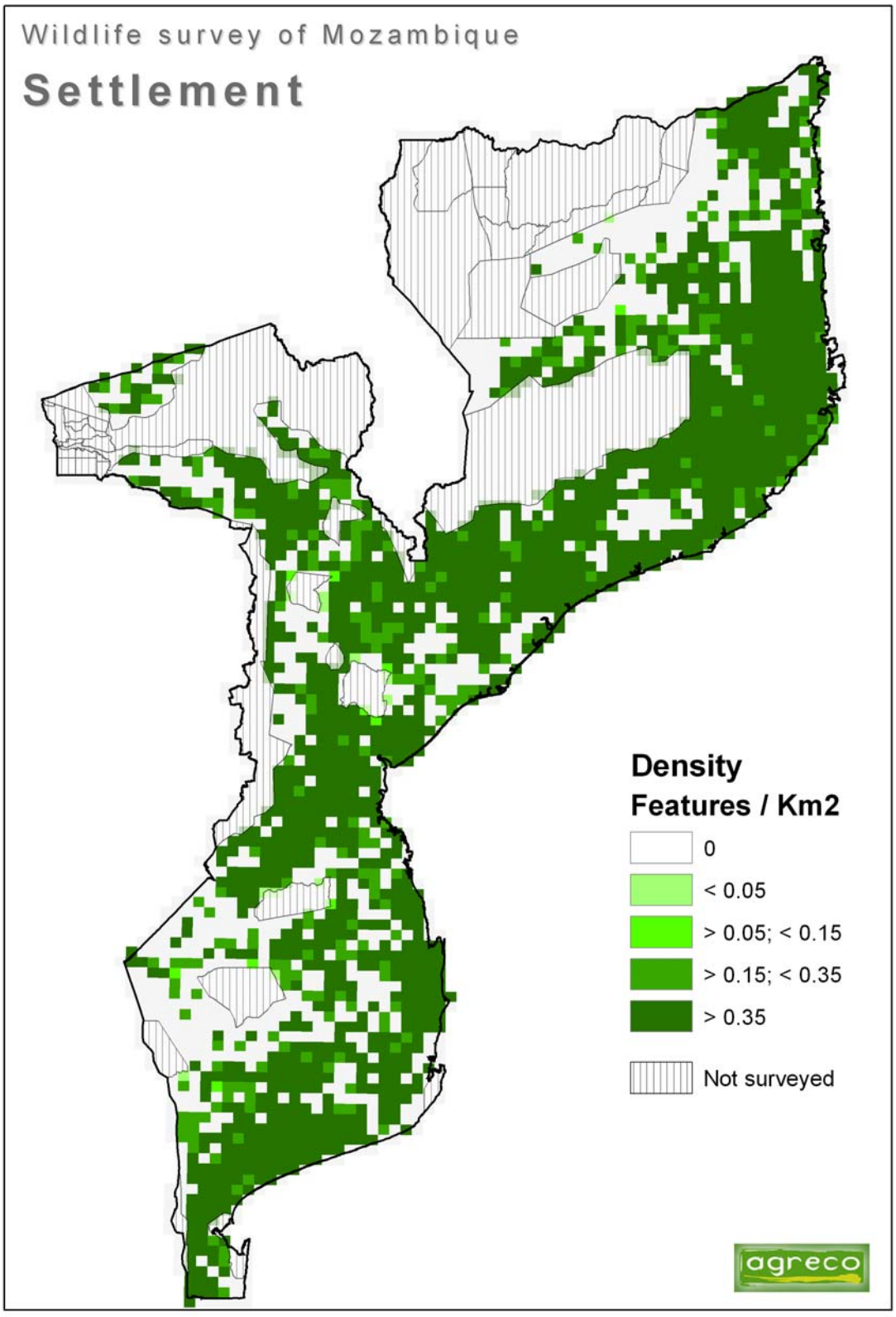
Map 26. Density distribution of domestic cattle in Mozambique

There were estimated to be 593476 (± 15 %) domestic cattle in Mozambique. Most were in southern and central Mozambique. It is particularly noticeable that there were few cattle in northern Mozambique.

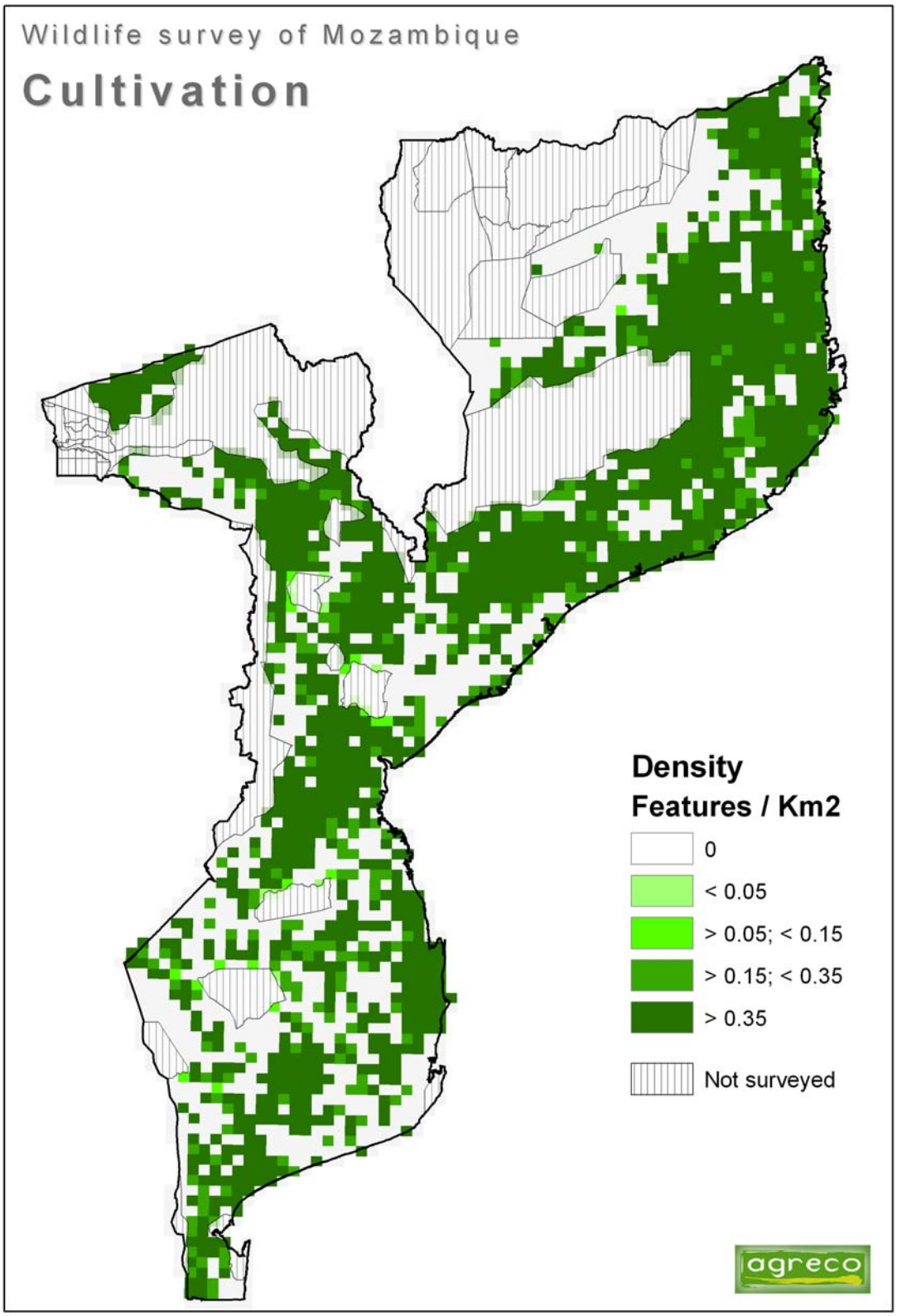


Map 27. Density distribution of domestic goats in Mozambique

There were estimated to be 501762 (± 13 %) goats in Mozambique (although this number may include some sheep, which are not readily distinguished from goats from the air). Goats occur widely throughout most of the country, but with a noticeable scarcity in the coastal region northwards of Beira.

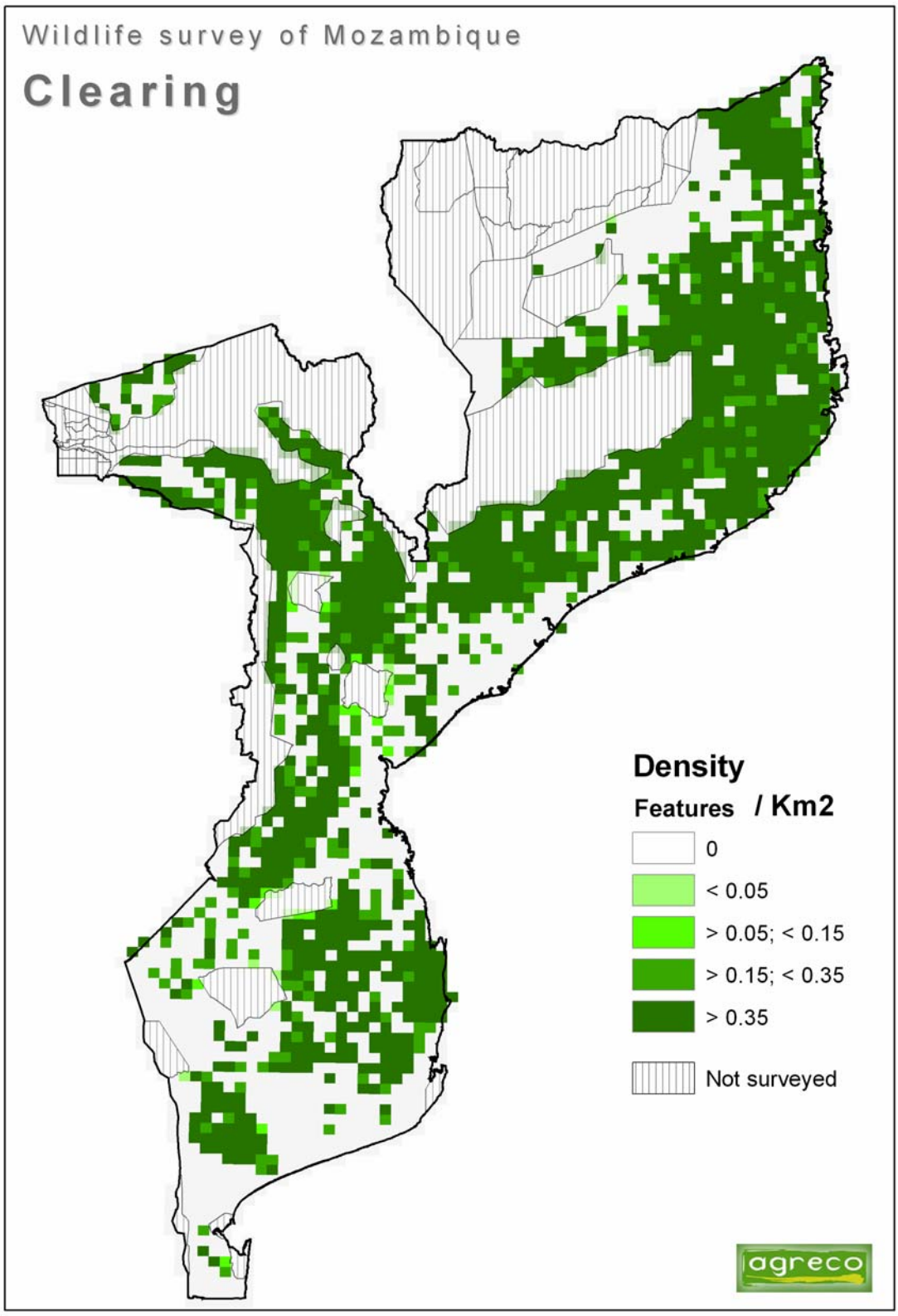


Map 28. Density distribution of human settlement in Mozambique
No spatial data were available for the Maputo, Limpopo, Banhine, Zinave, Gorongosa, Magoe or Niassa survey areas and so the apparent absence of settlement in these areas may not be real.



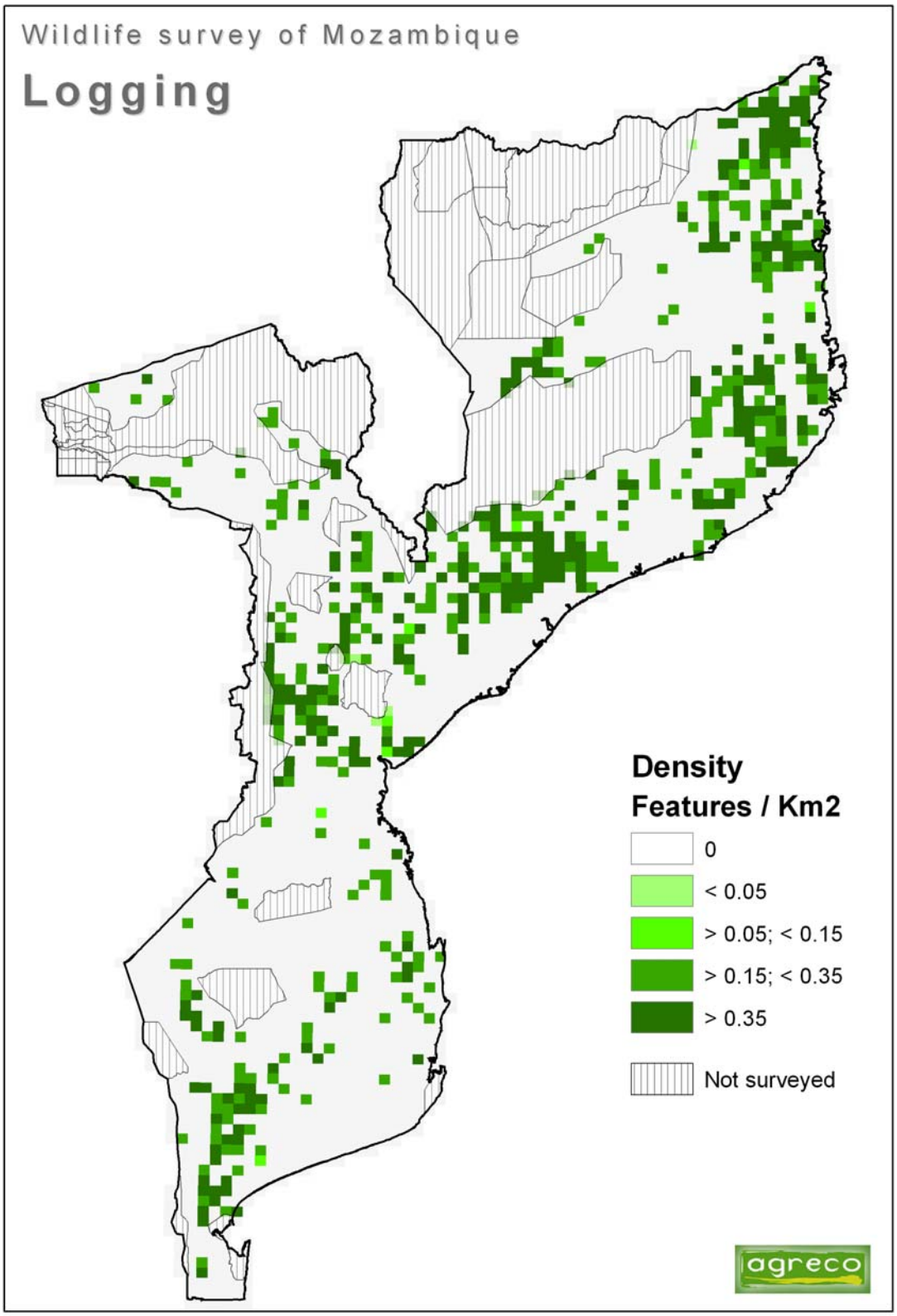
Map 29. Distribution of cultivation in Mozambique

The diameter of many agricultural fields in Mozambique is of a similar order of magnitude as the width of the search strips. For this reason, aerial surveys designed to census wildlife are not an ideal means to determine the density of fields. For this reason, the 'density' estimates on which this distribution map is based should be regarded as relative measures of density, rather than absolute ones. No spatial data were available for the Maputo, Limpopo, Banhine, Zinave, Gorongosa, Magoe or Niassa survey areas and so the apparent absence of settlement in these areas may not be real.



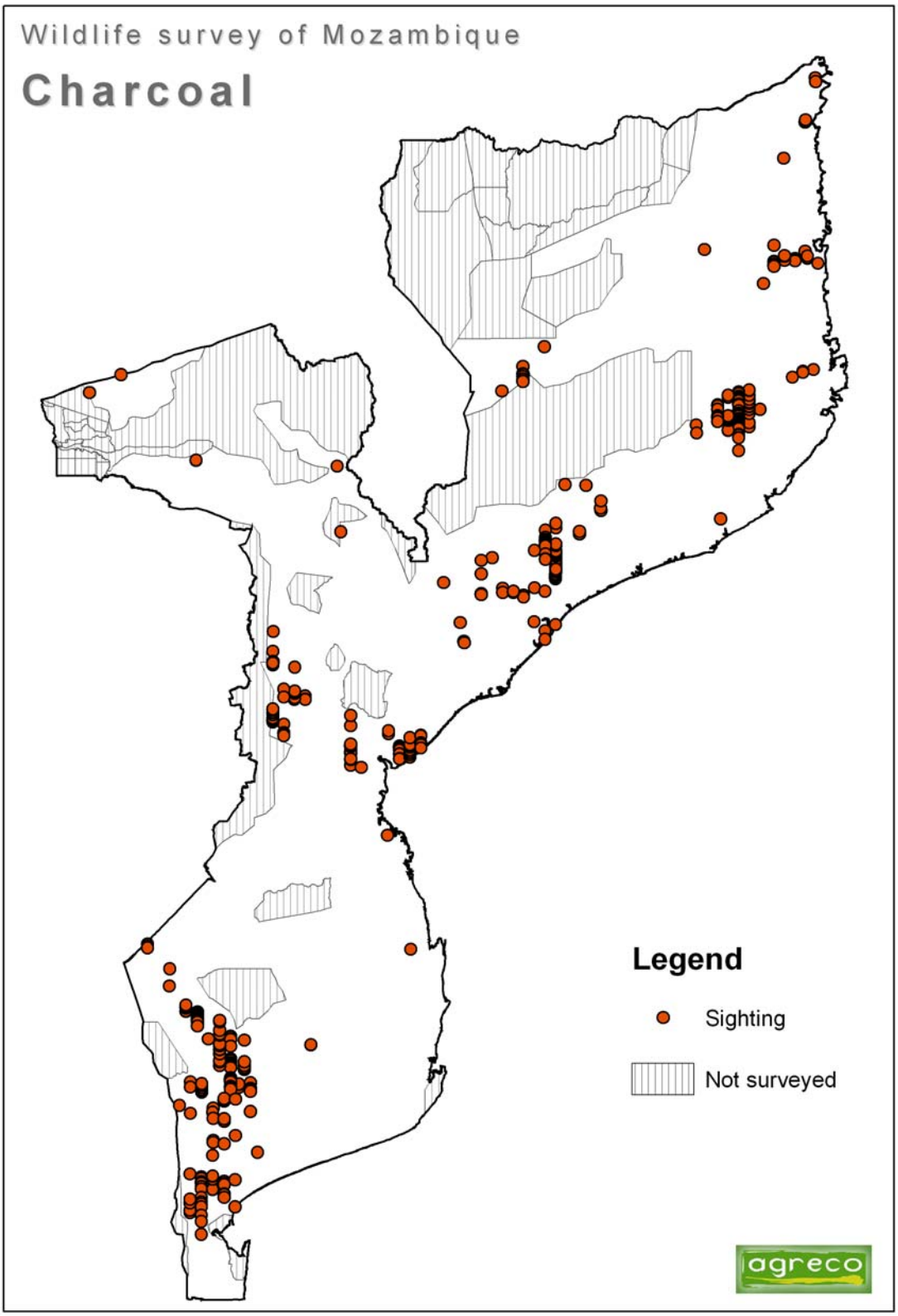
Map 30. Density distribution of vegetation clearance in Mozambique

A clearing was defined as an area where vegetation had been removed by people for purposes other than to create a field that was in current use to grow crops. As explained in the caption for the map of cultivation, the density estimates for clearings should be regarded as relative rather than absolute measures. No spatial data were available for the Maputo, Limpopo, Banhine, Zinave, Magoe or Niassa survey areas and so the apparent absence of settlement in these areas may not be real.



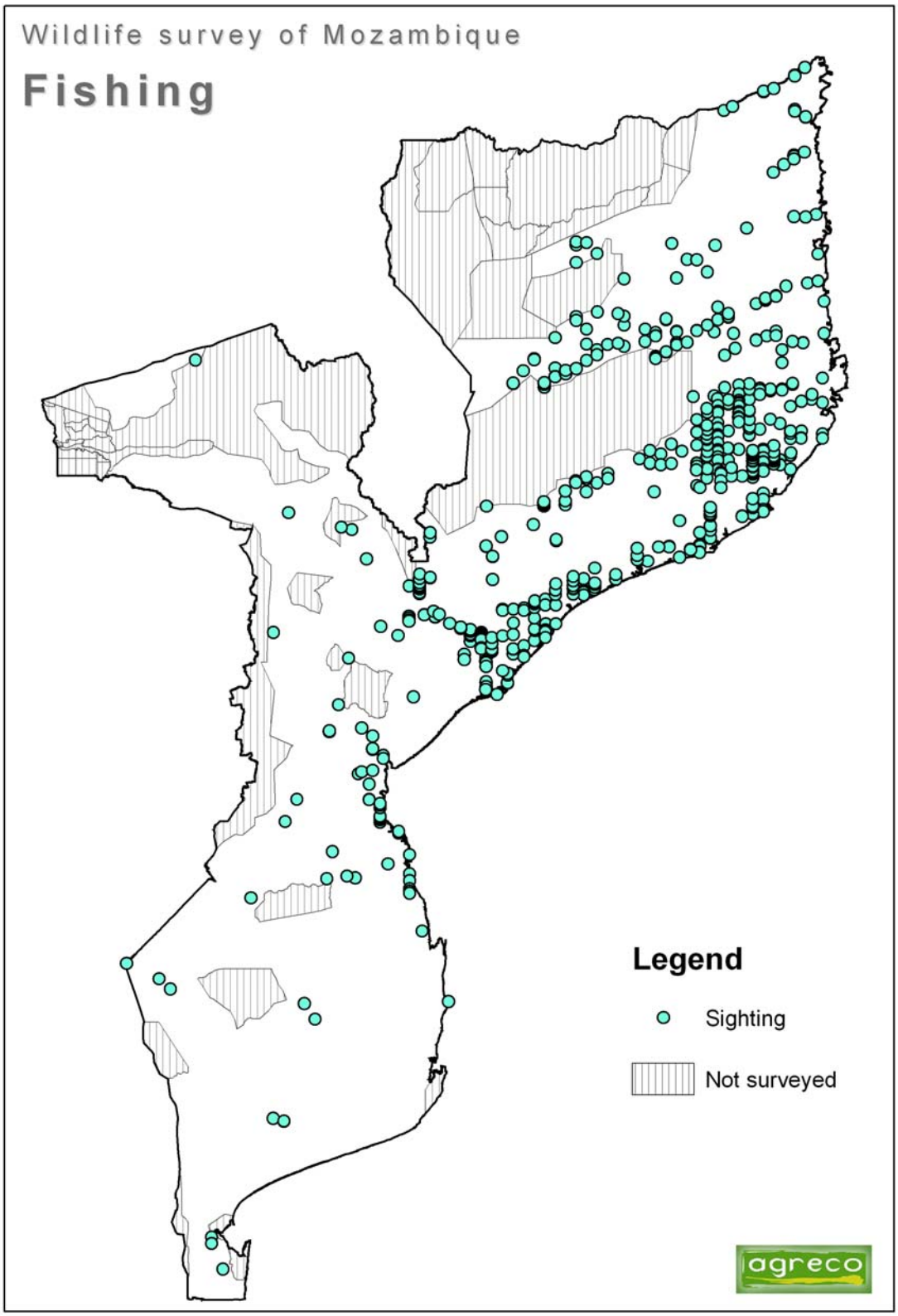
Map 31. Density distribution of logging in Mozambique

Logging sites were indicated by the presence of trees apparently felled by people, or by tree trunks sawn into large logs. No data on logging were available for the Maputo, Limpopo, Banhine, Zinave, Gorongosa, Magoe or Niassa survey areas and so the apparent absence of logging in these areas may not be real.



Map 32. Distribution of charcoal production in Mozambique

Each point on this map indicates a site where some sign of charcoal production (such as a kiln, or sacks of charcoal) was seen during the aerial survey. Charcoal production was concentrated in the vicinity of the towns of Pemba, Nampula, Mocuba, Quelimane, Beira, Chimoio, Chokwe and Maputo, and northwards from Maputo, along the railway to Zimbabwe.



Map 33. Distribution of fishing in Mozambique

Each point on this map indicates a site where some sign of fishing (such as a fishing net, trap, or fishermen in a canoe) was seen during the aerial survey.

3 Reported Human-Wildlife Conflicts

The DNTF keeps records of human-wildlife conflict and these records were used during this Project to provide a description of human-wildlife conflict in Mozambique.

Prior to mid-2006, the records were mainly summaries, each summary covering a period ranging from four months to seven years. Since July 2006, human-wildlife conflicts have been reported monthly to the DNTF. These latest records usually included:

- the numbers of persons killed or injured by wildlife;
- additional details of conflicts (including those in which people were not reported killed or injured), often including the type and number of domestic animals killed, or the area of crops damaged or destroyed;
- the month and year during which the conflict occurred;
- the province and district in which the conflict occurred.
- the species of wildlife responsible; and
- the number and species of any wild animals killed in response to conflicts.

The completeness of the records was not easily determined, but a high proportion of records related to the death or injury of a person, or the killing of an animal, perhaps suggesting that conflicts were more likely to be reported to, or recorded by, the DNTF if a person or animal was killed. It would not be surprising if conflicts in which a person was not killed or injured, for example crop-raiding by elephants, were under-recorded in these DNTF records.

Seasonal trends in conflicts were examined using records for two complete years, October 2006, to September 2008 inclusive. Records were combined into two-month periods (for example, January-February, March-April, etc.), because sample sizes were too small to permit analysis at the monthly level.

For analysis of longer-term trends in conflicts, the DNTF records were divided into two 12-month periods (July 2006 to June 2007, and July 2007 to June 2008). The records for these two years could be compared with each other and with the annual means for the years 1997-2003. Records for 1997-2003 were not available for individual years, but simply as totals for the seven-year period. Thus, the annual means for the period 1997-2003 were calculated simply as these totals divided by seven, the number of years to which the records refer.

3.1 People Killed or Injured by Animals

3.1.1 Numbers of people killed or injured

During the 27 months from July 2006 to September 2008 inclusive, 265 people were reported killed and 82 injured during conflicts with wildlife. Crocodiles, lions, elephants and hippos were responsible for most deaths (Table 3), but crocodiles killed more people than all other species combined. Crocodiles killed 66 % of the people for whom the responsible species was reported.

Table 3. Summary of the numbers of people killed or injured by wildlife during July 2006 to September 2008 inclusive, as reported in the human-wildlife conflict records of the DNTF.

Number of persons	Animal species responsible									
	Elephant	Lion	Crocodile	Hippo	Buffalo	Snake	Monkey	Jackal	Dog	Not stated
Killed	31	24	134	12	1	1	1			61
Injured	6	20	36	10	7			2	1	

3.1.2 Mortality rate of people attacked

The mortality rate of victims was calculated as the reported number of people killed by a given species of wildlife as a percentage of the total number of people killed or injured by that same species. It reflects the probability of a person dying as a consequence of an attack.

The mortality rate was high (approximately 80 %) for people attacked by elephant or crocodile. For people attacked by lions or hippos, the mortality rate was less, although still high at 55 % (Figure 1). Only for attacks by buffalo could the mortality rate be regarded as relatively low (approximately 10 %).

3.1.3 Long-term trend in number of people killed

The number of people reported killed by wildlife was greater during July 2007–June 2008 (106 people killed by crocodiles, lions, elephants or hippos) than during the previous year (69 people reported killed during July 2006-June 2007). And the number killed in both these years was much greater than the mean number killed annually during 1997-2003 (19 people). When the figures were examined by the species responsible for the deaths (Figure 2), there had been a clear increase in the number of people killed annually by hippos and a very big rise in the number of people killed annually by crocodiles.

The increases in the number of people killed by wildlife may be, in part, an artefact of better record-keeping during more recent years. However, some of the figures (for example, those for the people killed of lions) do not show a straight forward increase, which suggests that better record-keeping is not the only explanation for the increases. It seems likely that at least part of the increase reflects a real increase in the number of conflicts.

3.1.4 Seasonal trends in number of people killed or injured

Attacks on people by lions were clearly more common during March-August, the period that includes the harvest season, than during other months of the year (Figure 3). For the other species that attacked people – crocodile, elephant and hippopotamus – there were no obvious seasonal trends. It is possible that in fact there were seasonal trends, but that these were masked by the fact that just two years of data were available for this analysis.

3.2 Other Conflicts

Although this analysis of the DNTF records concentrated on conflicts during which people were killed or injured, the other principal conflicts were the killing of domestic livestock by wild predators, and the raiding of crops by wild herbivores. Other conflicts recorded included:

the destruction of grain stores by elephants, and canoes by hippos; and damage to homes by elephants, and to fishing nets by crocodiles.

3.2.1 Killing of domestic livestock

Lions were responsible for killing most domestic animals that were reported killed by wild animals (Figure 4). Crocodiles were the second most frequent predator. Cattle and goats formed the majority of the domestic animal prey. Lions killed more cattle or goats monthly during March to October than during other months of the year, while crocodiles killed more domestic animals monthly during July to October (Figure 5).

3.2.2 Crop-raiding

Most of the reports of crop-raiding were of crop-raiding by elephants or hippos (Figure 6), although it is likely that crop-raiding by smaller species, such as bushpig, baboon and monkeys, was under-reported. Some records included estimates of the area of crops damaged within a district during the month when damage was reported, and these estimates varied from a median of 3 hectares damaged by hippos (range of estimates 0.2-47.5 ha, n = 29 records) to a median of 9 ha damaged by elephants (range 0.5-446.9 ha, n = 62). How each area estimate was derived is not know to the authors of this report and the precision of the some estimates (for example, the estimate of 446.9 ha) does cause one to question the accuracy of some figures. Nonetheless, the records suggest that not only do elephants damage crops more often than do hippos, but also that when they cause damage, they damage a larger area of crops. Because the estimates of areas of crops damaged are reported on a district by month basis, it is not possible to establish how many incidents of crop-raiding occurred within a given district during a given month.

Crop-raiding by elephants was more common during the months March to October (Figure 7), which coincides with the period when crops ripen and are harvested.

3.3 Wild Animals Killed

3.3.1 Numbers and species killed

Crocodile, elephant and hippopotamus were the species most frequently shot in response to conflicts (Figure 8). Elephant and hippopotamus were shot more often in relation to the number of their human victims than the other species (Figure 9), presumably reflecting – at least in part - that elephant and hippopotamus were shot not only in response to attacks on people, but also in response to crop-raiding. One leopard was recorded killed, although the records did not include any incidences of leopards killing or injuring people, or killing domestic livestock.

3.3.2 Seasonal variation in numbers killed

The number of elephants killed monthly in response to conflicts was greater during March to October than during other times of the year (Figure 10). Similarly, the number of lions killed monthly was greater during May to August than at other times of the year. There was no obvious seasonal variation in the numbers of crocodiles or hippos that were shot.

3.3.3 Long-term trend in numbers killed

There was a clear increase in the numbers of each of the major species – crocodile, elephant, hippopotamus and lion - killed annually in response to conflict between 1997-2003 and the past two years (Figure 11).

3.4 Spatial distribution of conflicts

3.4.1 Human-crocodile conflict

Crocodiles attacked people in numerous districts across the country, although with a concentration along the Zambezi River (Map 34). Perhaps surprisingly, crocodile attacks on people were more widespread than crocodile attacks on domestic animals (Map 35). This is possible that many attacks on domestic animals are not reported and thus not recorded.

3.4.2 Human-hippopotamus conflict

Hippos damaged crops mainly in districts along the Zambezi, Save and Limpopo Rivers, and in the southern districts on Gaza and Inhambane provinces, where there are a number of large lakes (Map 37). Attacks on people by hippos were less widespread than crop damage (Map 36) and occurred mostly on Lake Cabora Bassa, or along the Zambezi, Save, or Limpopo Rivers.

3.4.3 Human-lion conflict

The districts where lions attacked people were mainly in northern Mozambique, in Niassa or Cabo Delgado provinces (Map 38). The districts where lions killed domestic livestock were more widespread across the country, with a noticeable concentration along the international border with Kruger NP (Map 39). Recent other research (Chardonnet *et al*., 2008) suggests that in some areas (for example, Tete province) human-lion conflicts are not reported to DNTF. This observation may also suggest that other conflicts are under-reported to DNTF and hence that their database should be regarded as the minimum level of conflict in Mozambique.

3.4.4 Human-elephant conflict

Elephants damaged crops across much of Mozambique (Map 41). Crop damage was particularly common in northern Mozambique, southern Tete province and southern Mozambique (in districts bordering Gonarezhou NP in Zimbabwe, or Kruger NP in South Africa, and in southern Inhambane). The districts where people were killed by elephants occurred across the country, but most attacks were in northern Mozambique (Map 40).

3.4.5 Other human-wildlife conflicts: buffalo, hyaena and leopard

Conflicts with buffalo were reported only from central and southern Mozambique, but with a noticeable concentration along the international border with South Africa's Kruger NP (Map 42).

Conflicts with hyaena were also concentrated along the international border with South Africa's Kruger NP, or along the border Zimbabwe's Gonarezhou NP (Map 43). There was just one report of a conflict with leopard (Map 43).

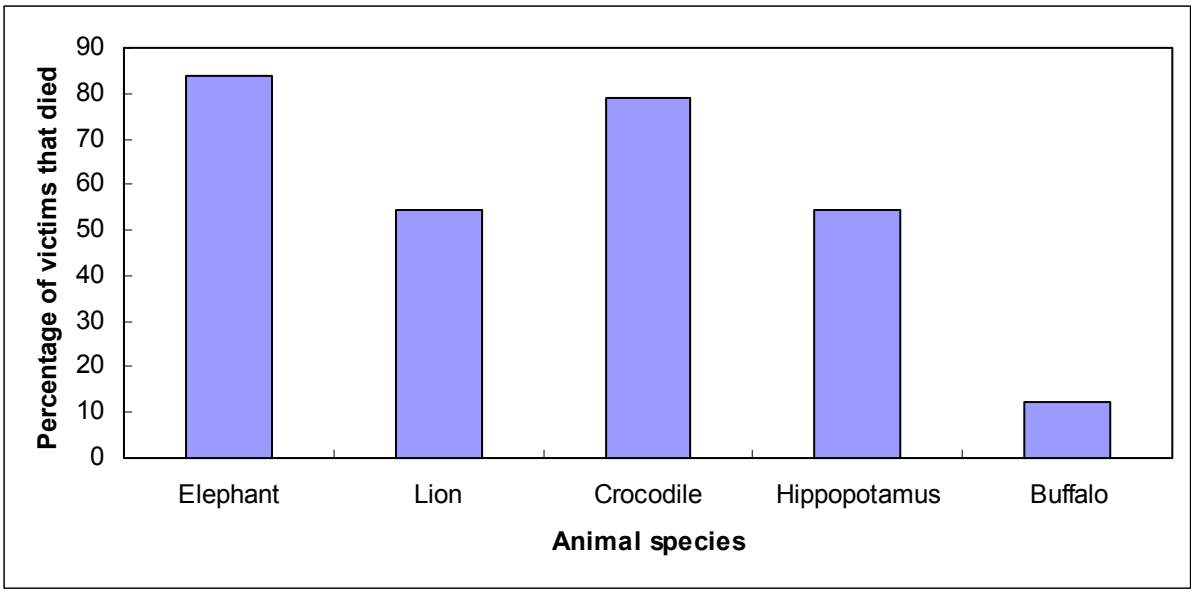


Figure 1. Variation in the mortality of people attacked by different species of large animal

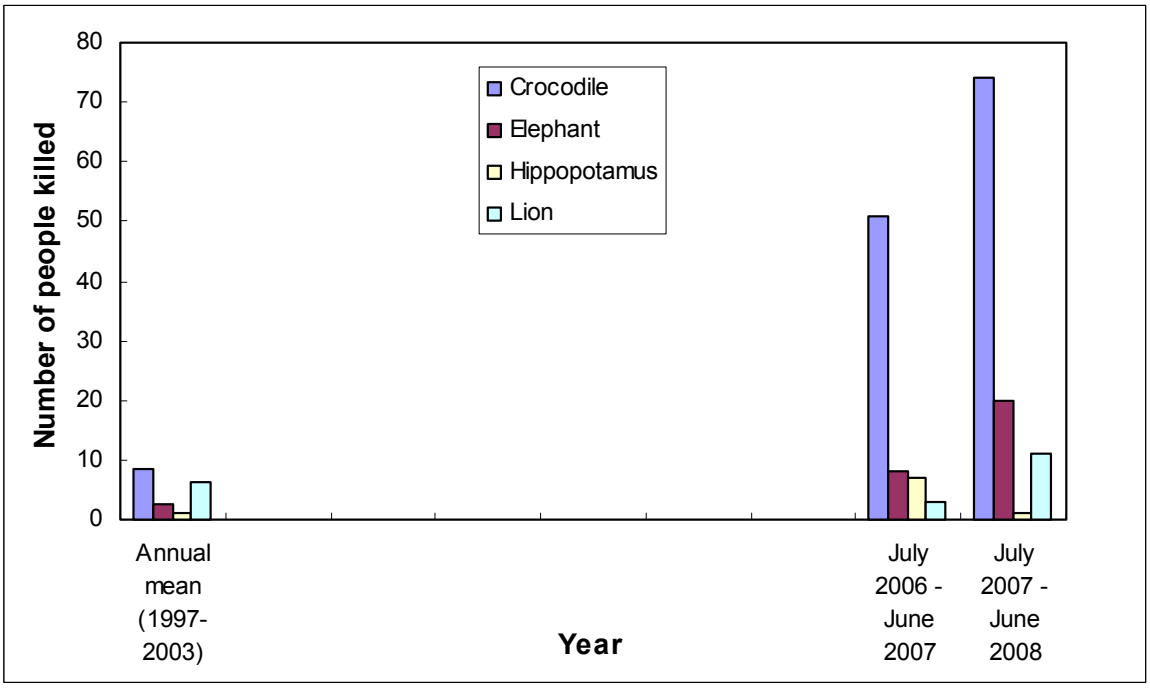


Figure 2. Long-term trend in human-wildlife conflict in Mozambique

The numbers of people killed by crocodiles, elephants, hippos, or lions during two recent 12-month periods were compared with the mean annual numbers of deaths from the same causes during 1997-2003.

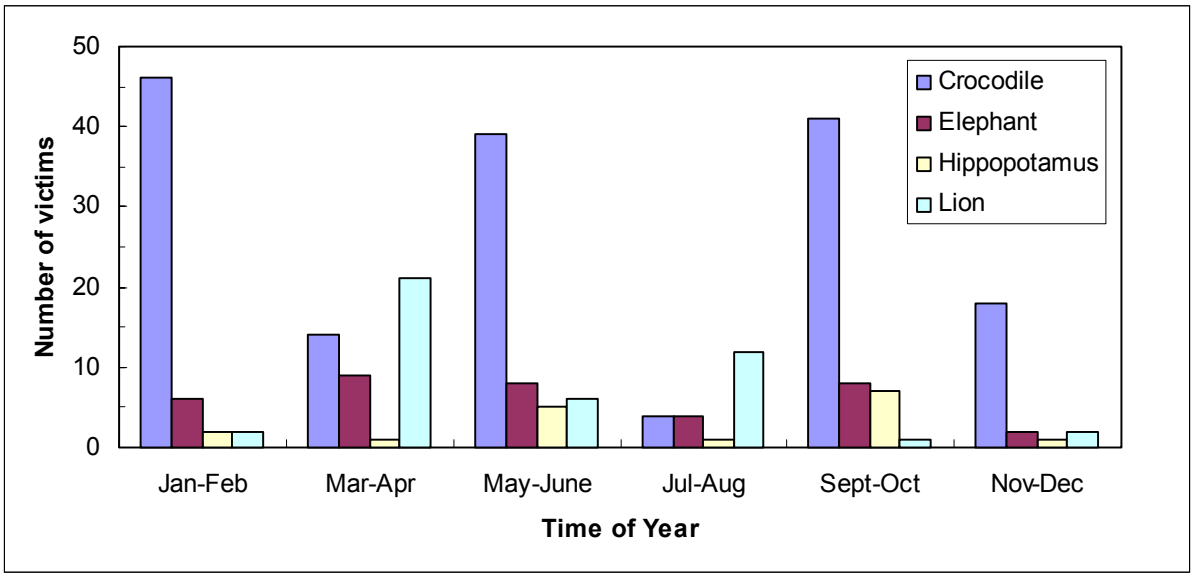


Figure 3. Seasonal trend in human-wildlife conflict in Mozambique
The numbers of people killed or injured by crocodiles, elephants, hippos, or lions during each two-month period of the year. Data are for October 2006 to September 2008 inclusive.

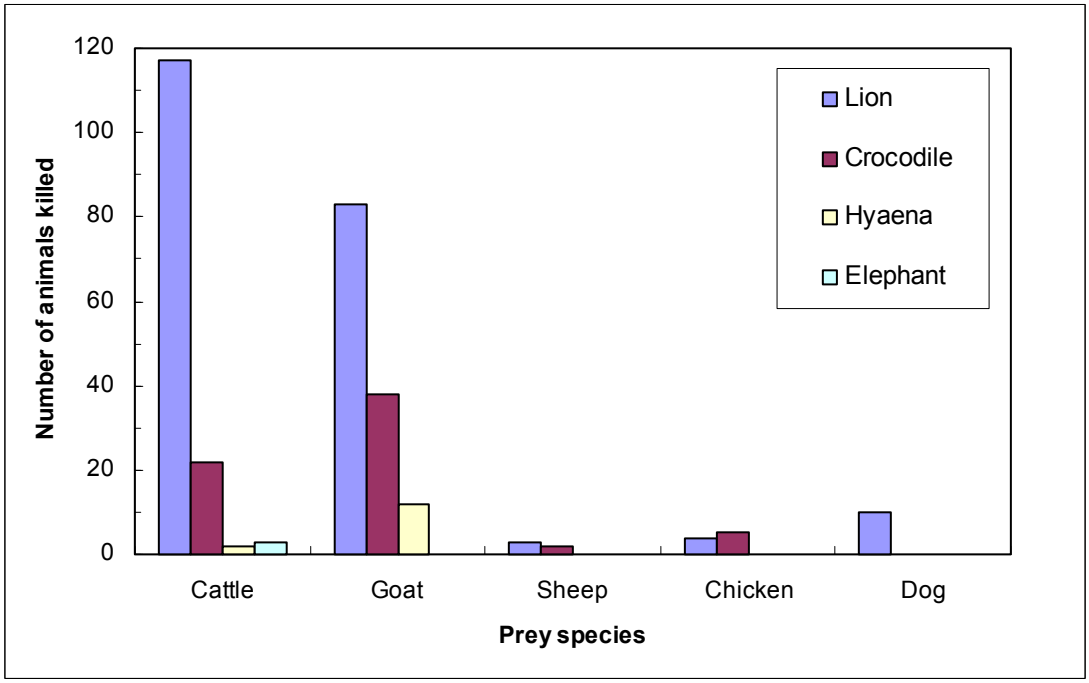


Figure 4. Numbers of domestic livestock recorded killed by wild animals

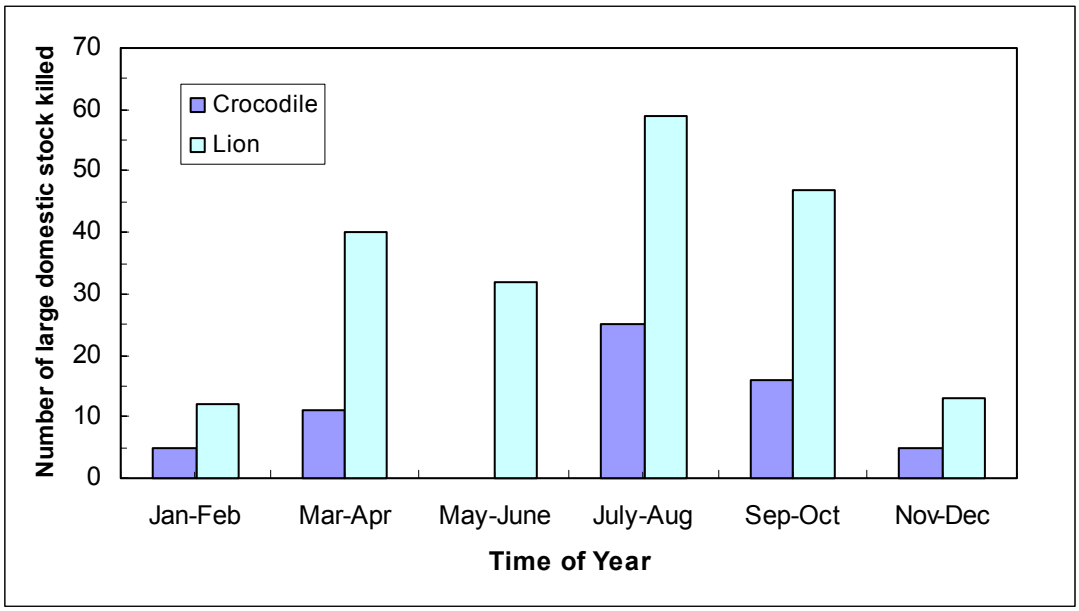


Figure 5. Seasonal trends in the numbers of cattle and goats killed by lions or crocodiles
The numbers of cattle and goats killed during each two-month period of the year. Data are for October 2006 to September 2008 inclusive.

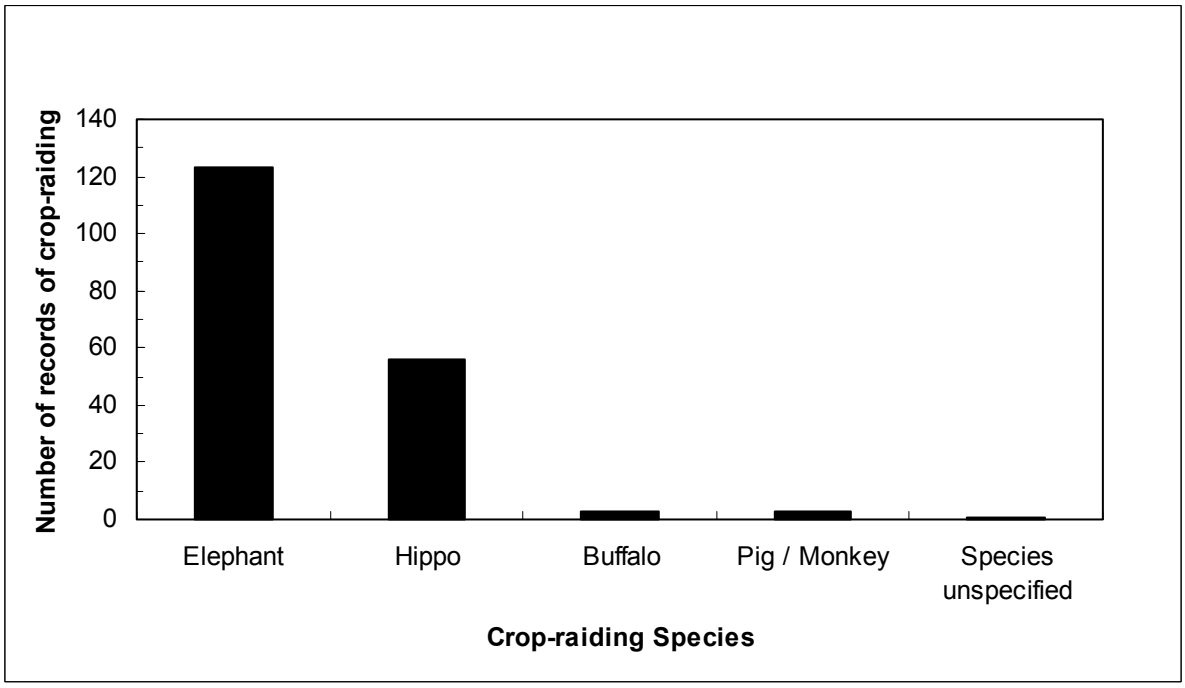


Figure 6. Reports of crop-raiding by different species of wild animals
Reports of crop-raiding are recorded by district by month by species. Hence, one report means that there is a record of the given species raiding crops in a stated district during a given month. It is not recorded how many fields were raided in that district during that month.

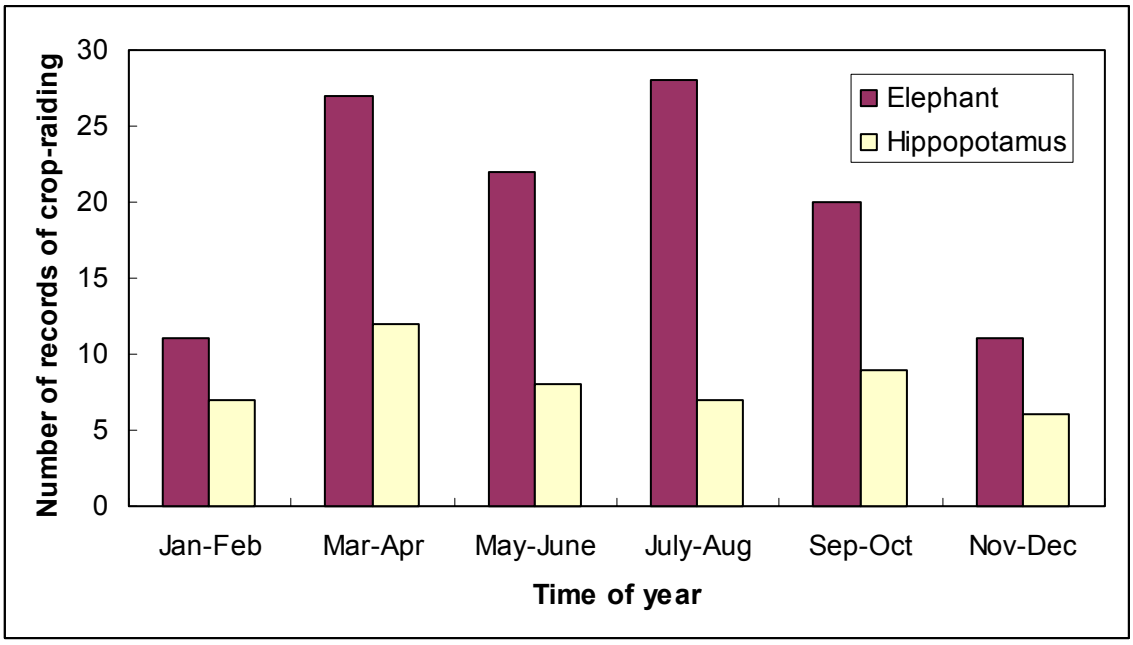


Figure 7. Seasonal trends in crop-raiding by elephant and hippopotamus

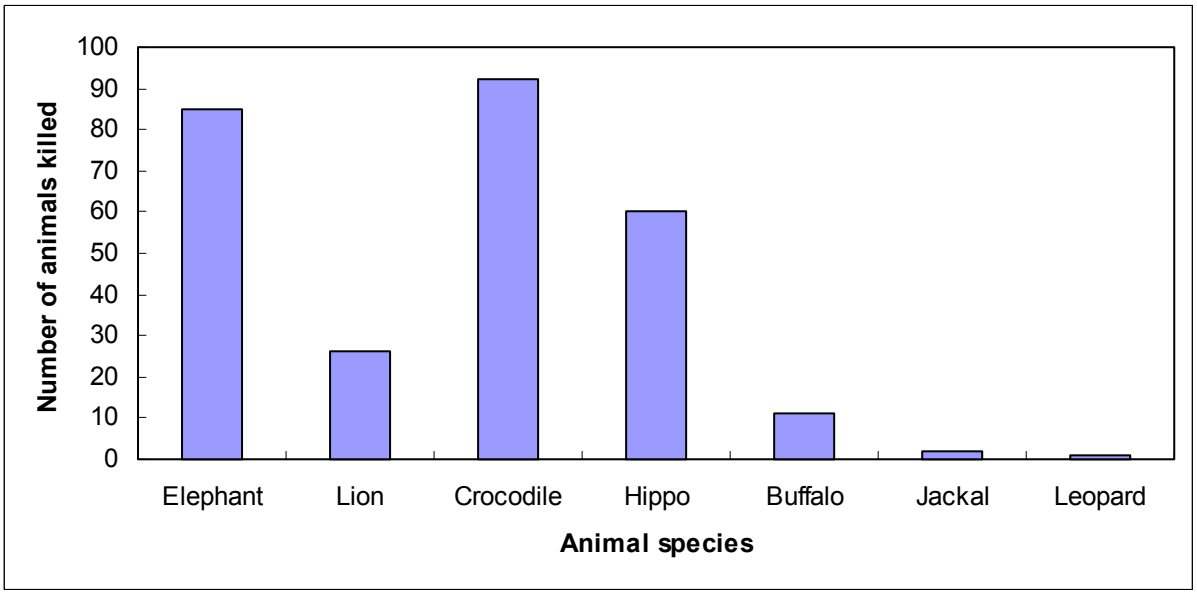


Figure 8. Numbers of different species of wild animals killed in response to conflicts

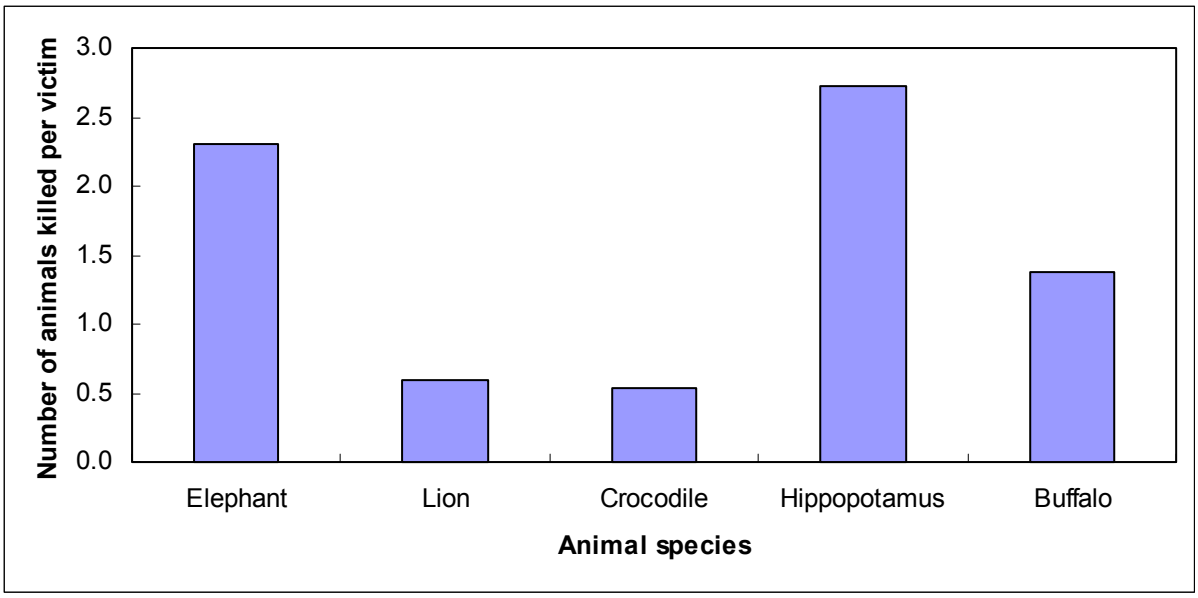


Figure 9. Numbers of animals killed in response to conflicts, in relation to the number of human victims of conflict caused by the same species

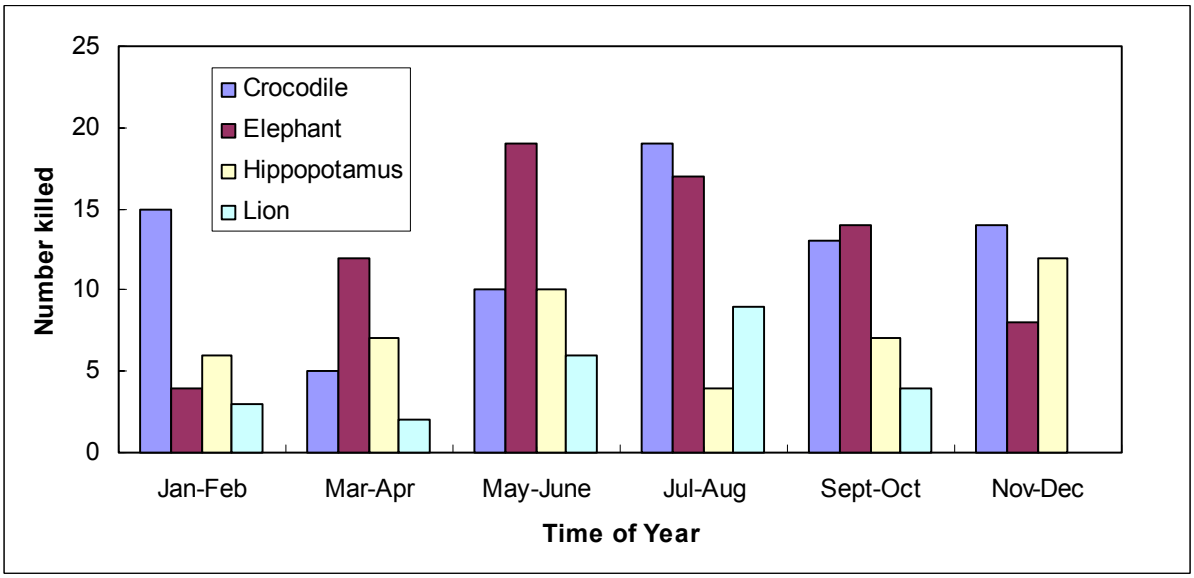


Figure 10. Seasonal variation in the numbers of different species killed in response to conflicts
The numbers of wild animals killed during each two-month period of the year. Data are for October 2006 to September 2008 inclusive.

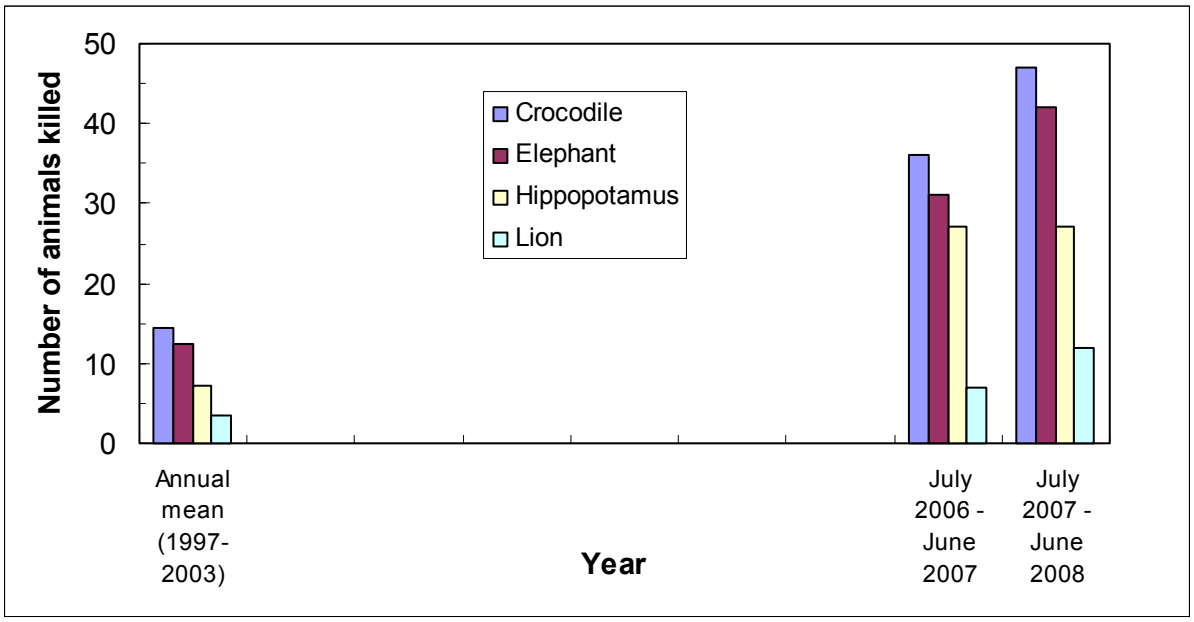
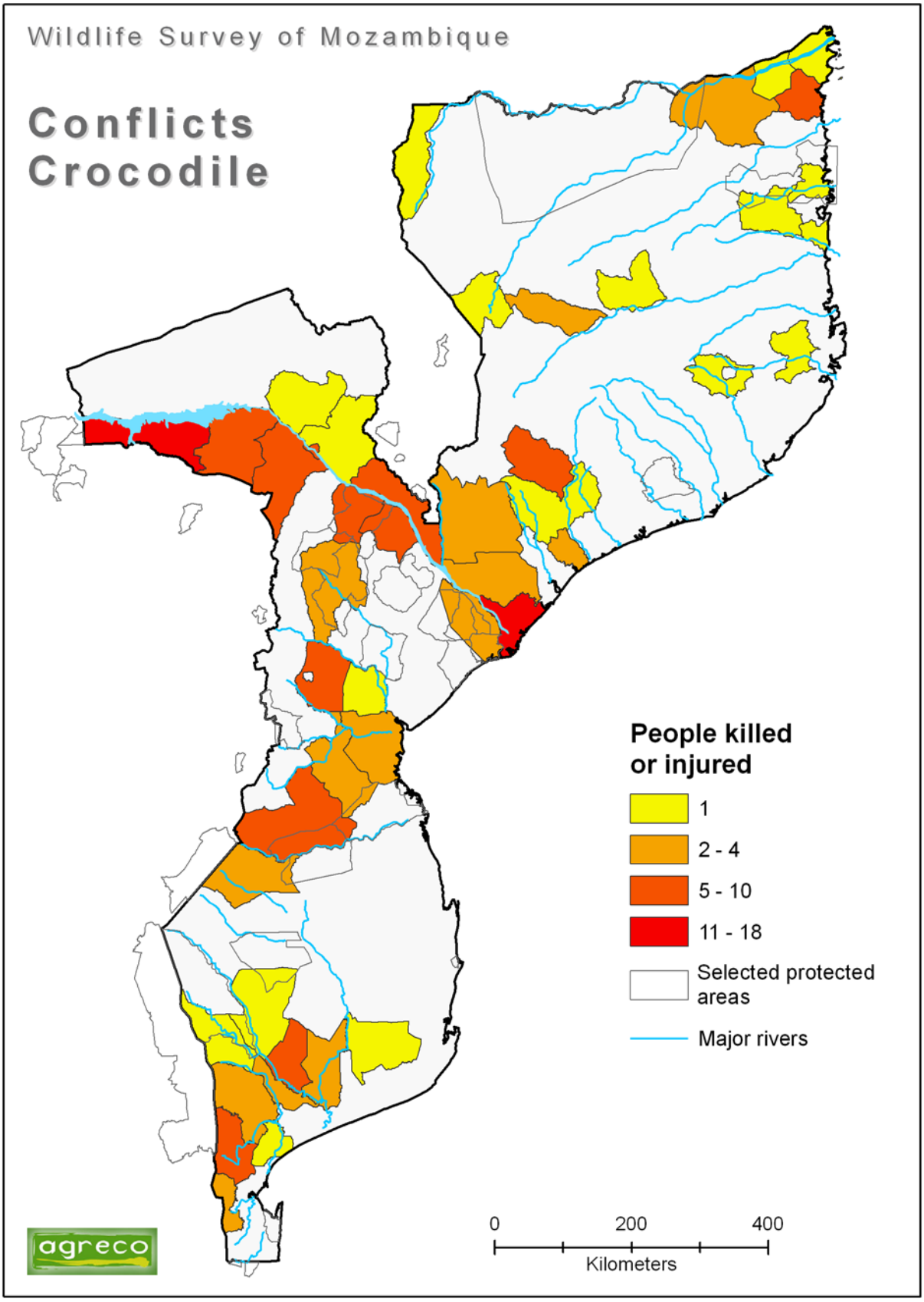
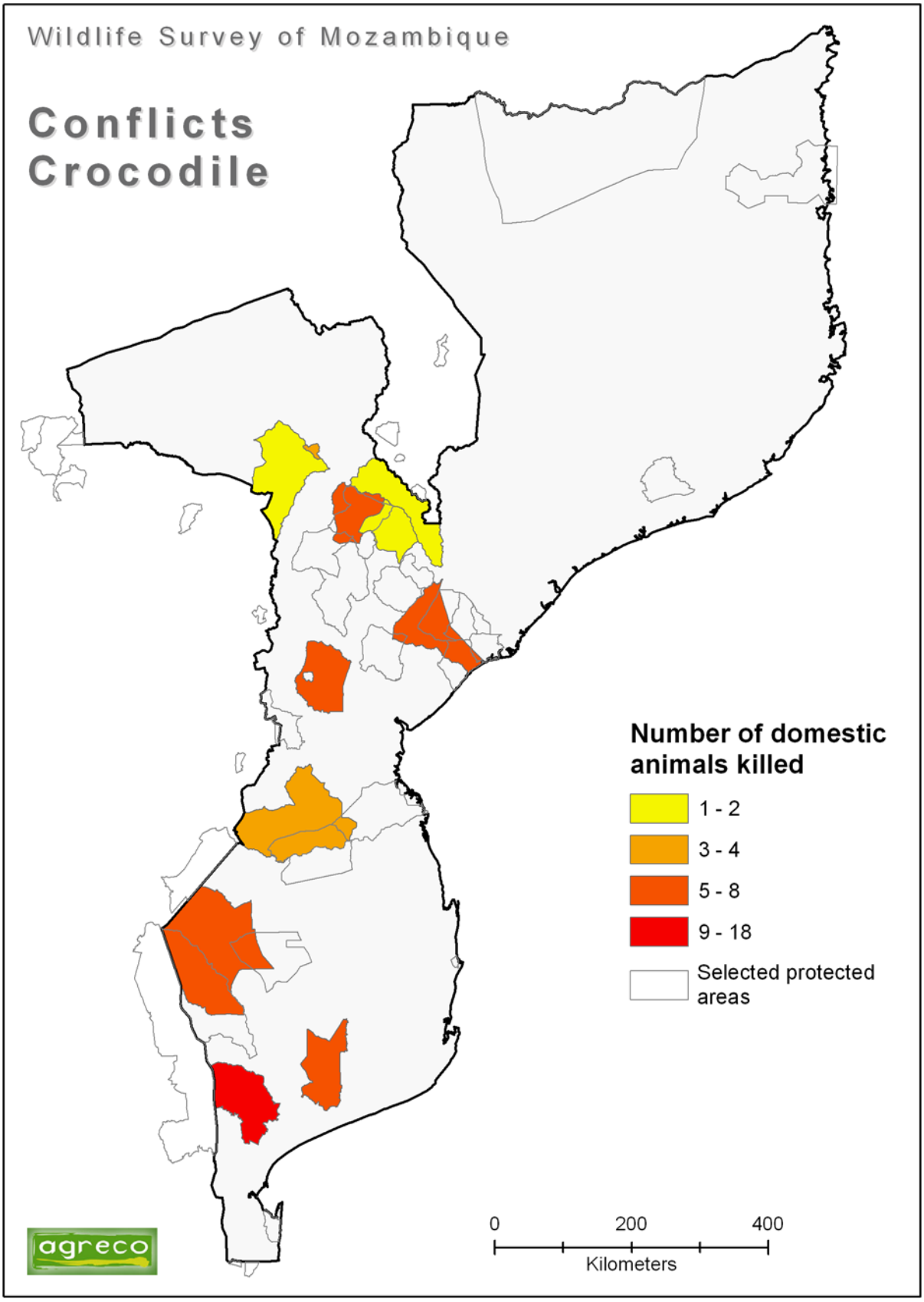


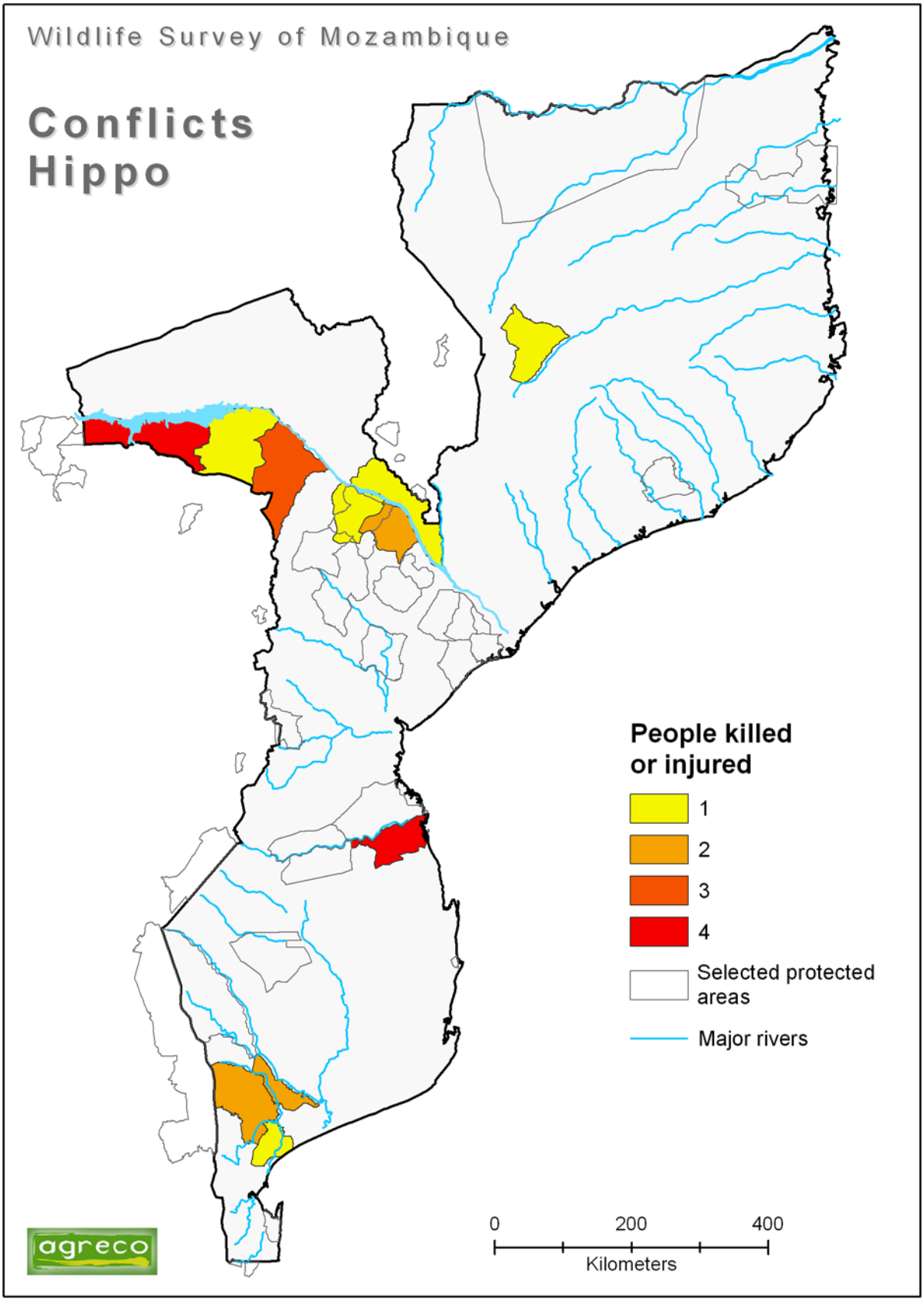
Figure 11. Long-term trend in numbers of different species killed in response to conflicts
The numbers of animals reported killed during two recent 12-month periods are compared with the mean numbers killed annually during 1997-2003.



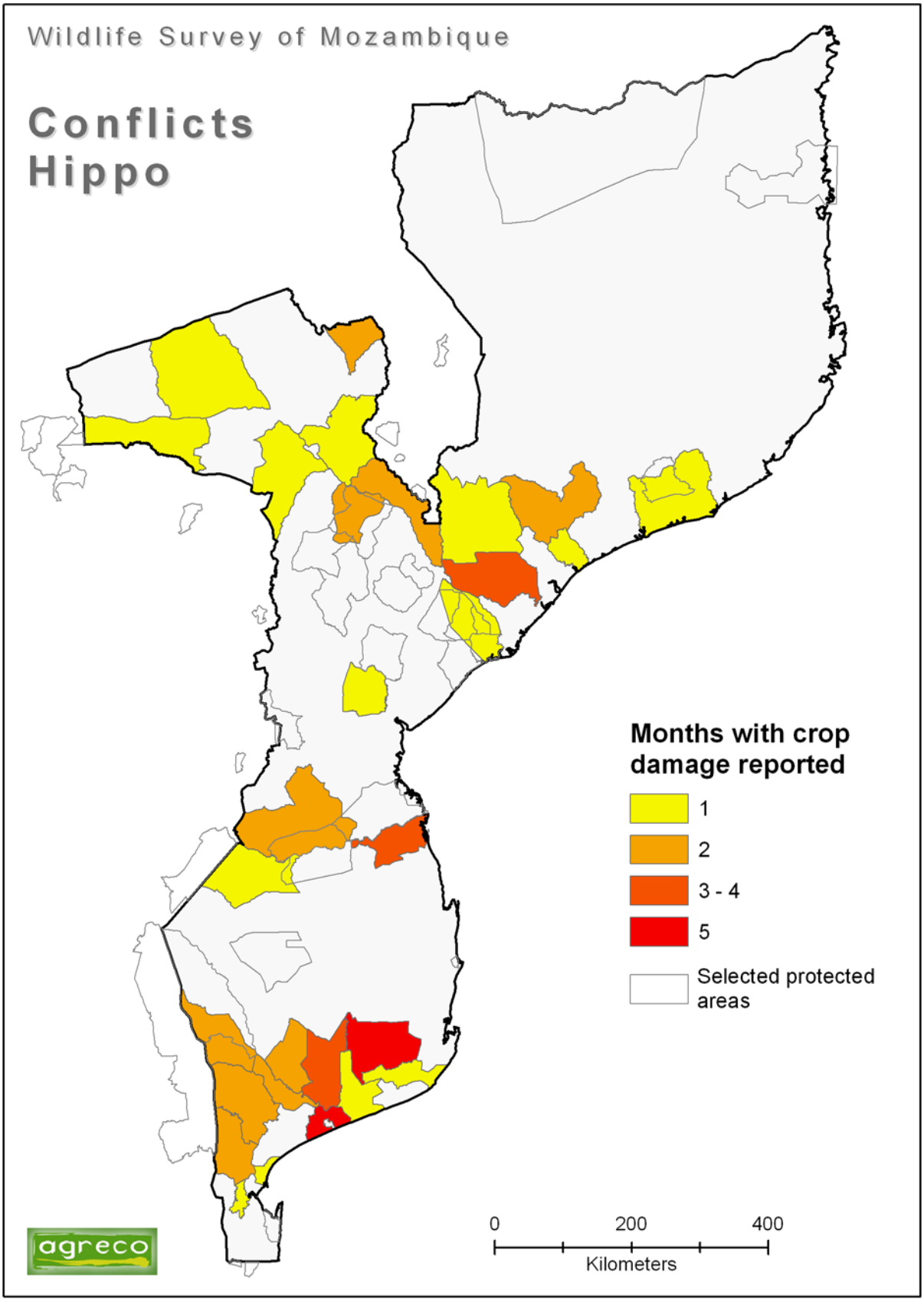
Map 34. Distribution of human-crocodile conflict (people attacked) in Mozambique
The districts where people were noted in the DNTF records as killed or injured by crocodiles during the period July 2006 to September 2008 are coloured according to the number of victims.



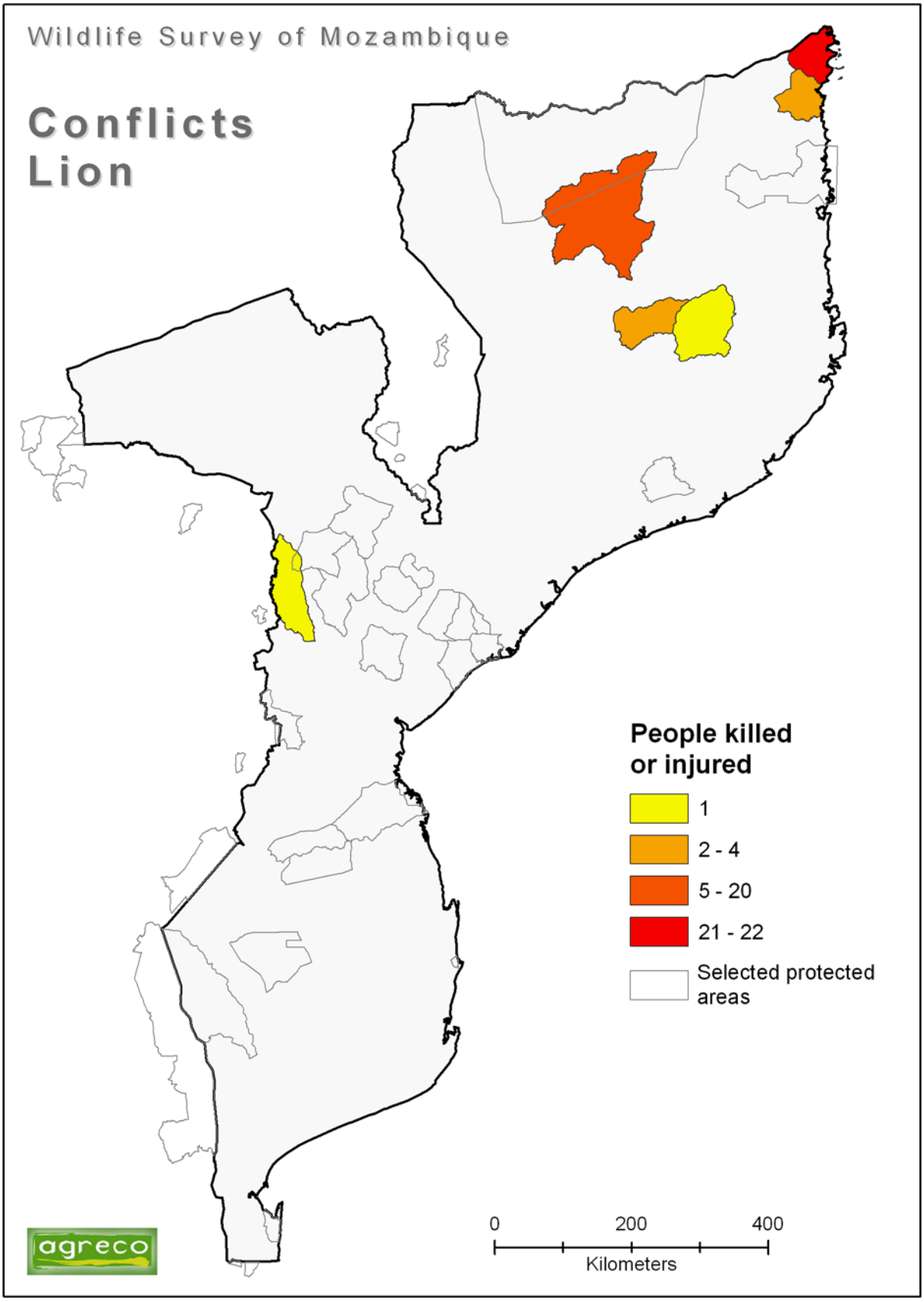
Map 35. Distribution of human-crocodile conflict (domestic animals killed) in Mozambique
The districts where animals (mostly goats and cattle) were noted in the DNTF records as killed by crocodiles during the period July 2006 to September 2008 are coloured according to the number killed.



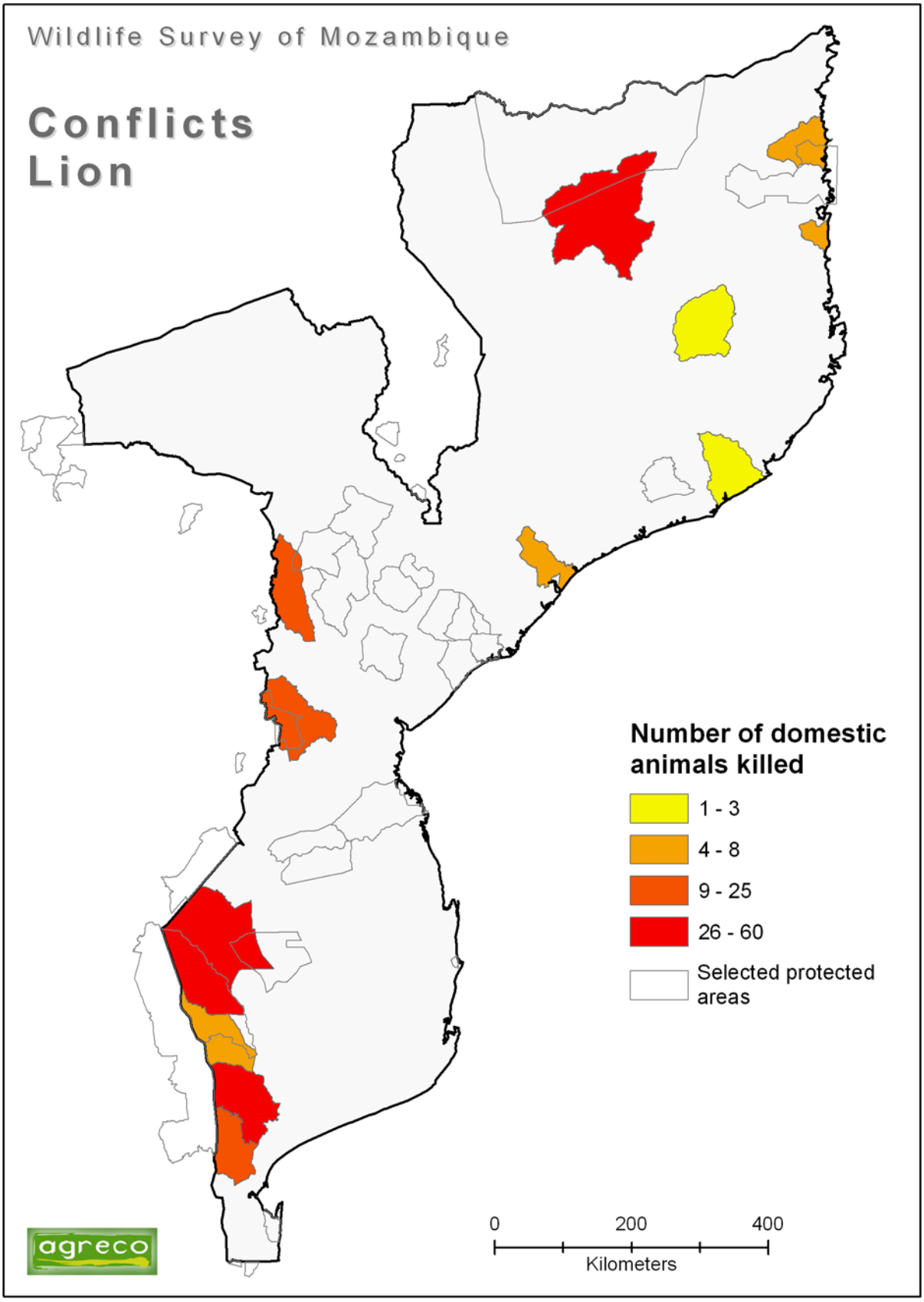
Map 36. Distribution of human-hippopotamus conflict (people attacked) in Mozambique
The districts where people were noted in the DNTF records as killed or injured by hippos during the period July 2006 to September 2008 are coloured according to the number of victims.



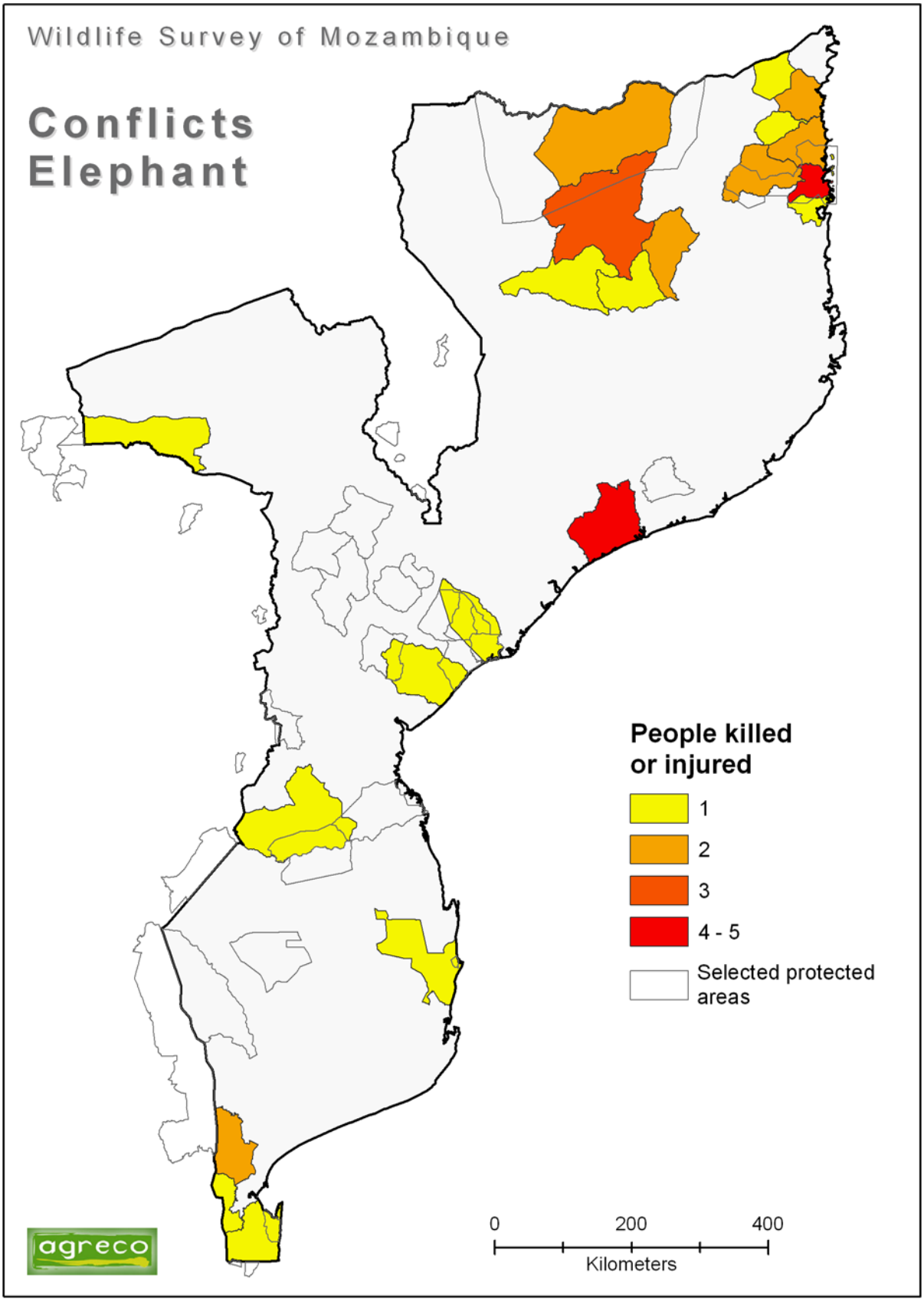
Map 37. Distribution of human-hippopotamus conflict (crop damage) in Mozambique
The districts where crops were noted in the DNTF monthly records as damaged by hippos during the period July 2006 to September 2008 are coloured according to the number of months when damage was reported.



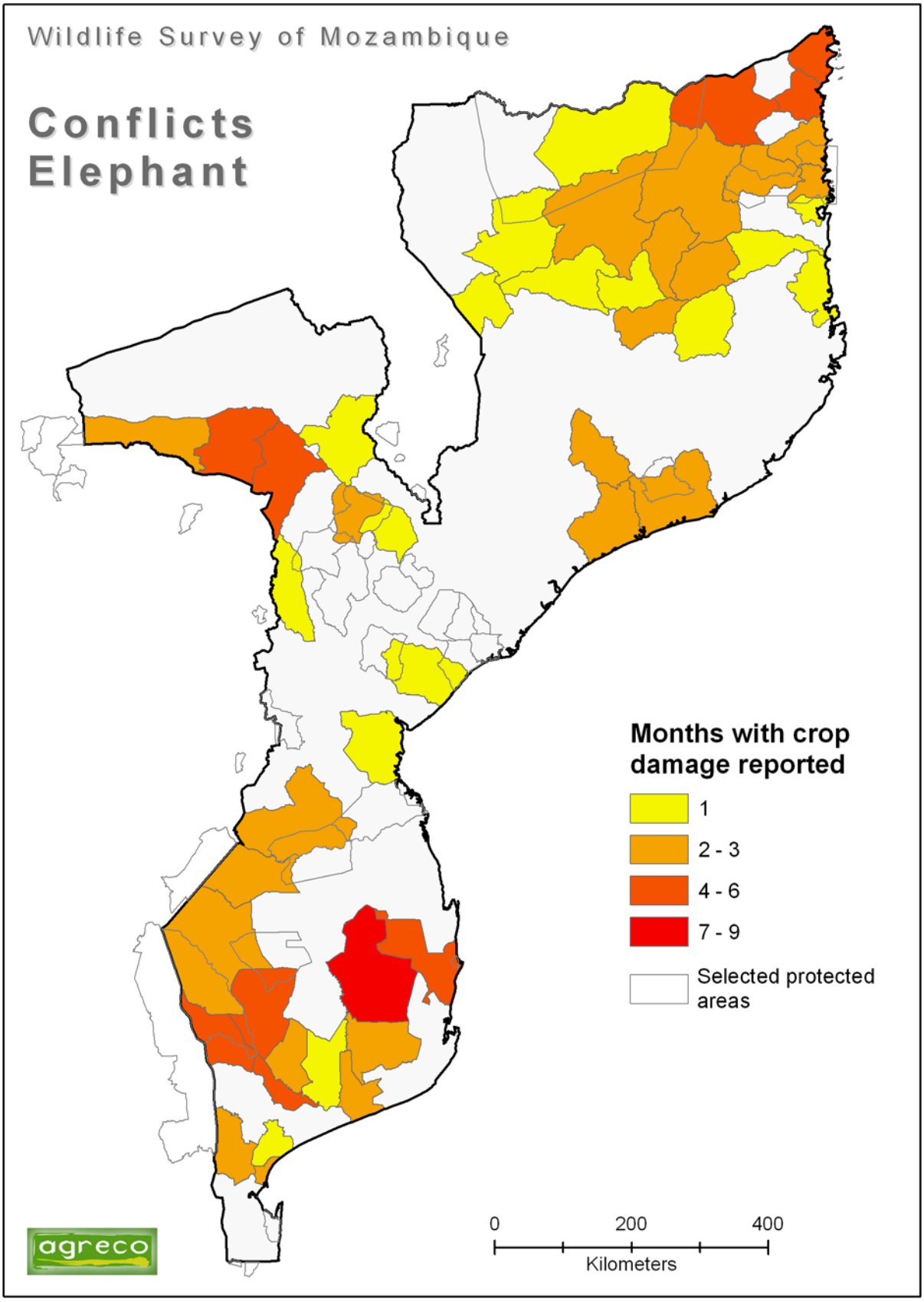
Map 38. Distribution of human-lion conflict (people attacked) in Mozambique
The districts where people were noted in the DNTF records as killed or injured by lions during the period July 2006 to September 2008 are coloured according to the number of victims.



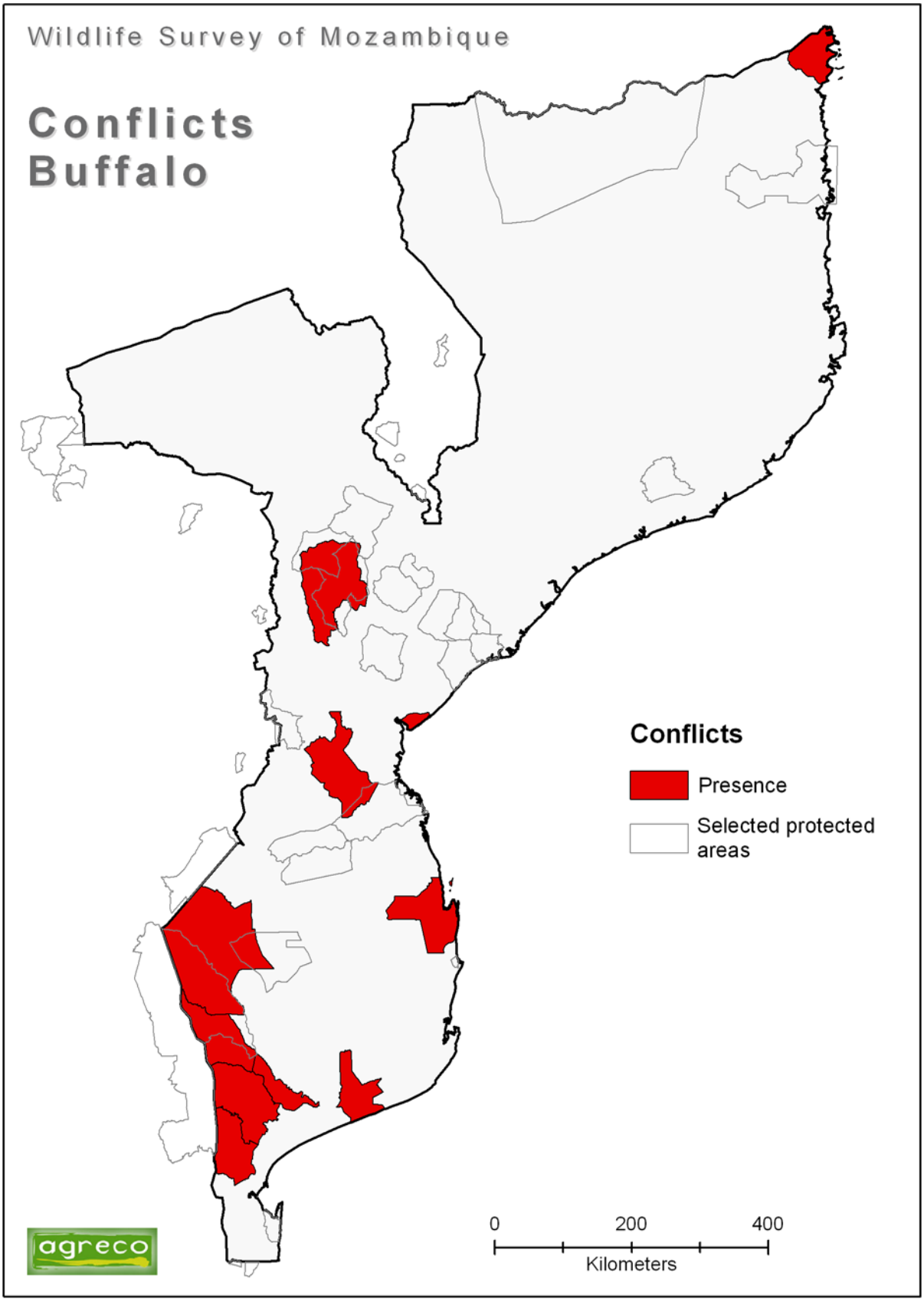
Map 39. Distribution of human-lion conflict (domestic animals killed) in Mozambique
The districts where domestic animals (mostly cattle and goats) were noted in the DNTF records as killed by lions during the period July 2006 to September 2008 are coloured according to the number killed.



Map 40. Distribution of human-elephant conflict (people attacked) in Mozambique
The districts where people were noted in the DNTF records as killed or injured by elephants during the period July 2006 to September 2008 are coloured according to the number of victims.

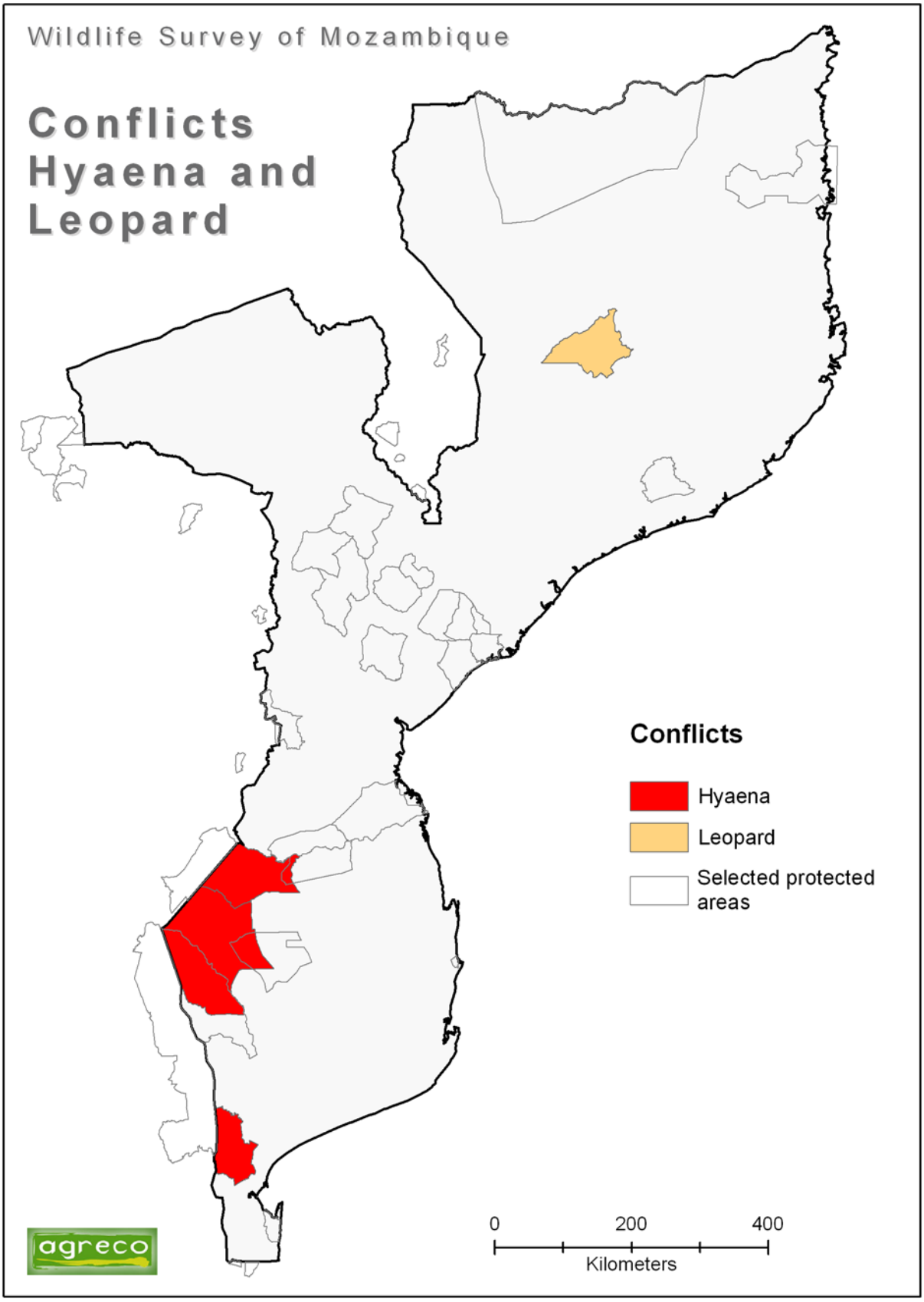


Map 41. Distribution of human-elephant conflict (crop damage) in Mozambique
The districts where crops were noted in the DNTF monthly records as damaged by elephants during the period July 2006 to September 2008 are coloured according to the number of months when damage was reported.



Map 42. Distribution of human-buffalo conflicts in Mozambique

The districts where human-buffalo conflicts were noted in the DNTF records during the period July 2006 to September 2008 are coloured according to the presence or absence of conflict.



Map 43. Distribution of human-leopard and human-hyaena conflicts in Mozambique
The districts where any human-leopard or human-hyaena conflicts were noted in the DNTF records during the period July 2006 to September 2008 are coloured according to the presence or absence of conflicts with the stated species.

4 Questionnaires and Structured Interviews

4.1 Objectives of the Activity

The objectives of this activity were to provide descriptions of:

1. the spatial distribution within Mozambique of large predators (lion, leopard, hyaena) that cause, or have the potential to cause, human-wildlife conflicts;
2. the existing human-wildlife conflicts in Mozambique; and
3. the migration routes of the large wildlife species in Mozambique.

4.2 Methods

4.2.1 Provincial questionnaires

During mid-2008, each of the ten provincial offices of the Ministry of Agriculture was sent a questionnaire by this Project. The questionnaires were designed to seek information at the district level about: the presence of seven major wildlife species that cause, or might cause, human-wildlife conflicts (elephant, hippopotamus, buffalo, crocodile, lion, leopard and hyaena); existing conflicts caused by these species; and the temporal trends in the numbers of both wildlife and conflicts. After despatch of the questionnaires, telephone calls were made and emails sent to ensure that the questionnaires had been received and to determine the names and contact details of the officials who would be responsible for completing and returning the questionnaires

4.2.2 Structured interviews

During 2008, Project staff visited selected districts throughout Mozambique and conducted and reported on approximately 60 structured interviews with local people and officials in these districts. The districts visited (a total of 32 in the ten provinces of Mozambique) were selected because the DNTF record of conflicts showed that human-wildlife conflicts were commonly reported in these districts. The number of people that attended each interview ranged from 1 to 12. Where more than one person attended an interview, the interview report recorded the consensus opinions of the group. The unit of analysis was the interview report, with one report being completed for each interview, regardless of the number of people in the group interviewed.

The interviews sought to determine which species of wildlife occurred in the selected district, whether these were resident there and their movements, the conflicts that they caused and the temporal trends in their numbers and conflicts. Interviewees were asked to rank the major wildlife species according to their belief of the number and intensity of the conflicts that each species caused in their district. The interviews were intended to determine the local people's perceptions of human-wildlife conflicts in their district.

Interviewees were asked to list the measures that they took to prevent or mitigate human-wildlife conflicts caused by elephant, hippopotamus, crocodile and lion. During analysis, the measures were grouped into six categories, namely: informing the authorities; harassment (using noise and fires to drive the animals away); guarding crops; using rope fences around crops to deter crop-raiders; block-farming (establishing fields in close proximity to each other, rather than having individual fields scattered in bushland); and trapping problem animals. During most interviews, more than one measure was mentioned and all were counted. Hence, the total number of measures for each species may be greater than the number of interviews listing measures.

Interviewees were asked to suggest appropriate responses to human-wildlife conflicts caused by elephant, hippopotamus, crocodile and lion. During analysis, the suggested

responses were grouped into six categories, namely: harassment (presumably to drive the animals away); killing (either to reduce numbers generally, or of problem animals); relocation (of problem animals, or of those with the potential to cause problems); fences (to separate people and/or their crops from the problem species); guarding crops; and use of water pumps (a response specific to human-crocodile conflicts). During some interviews, more than one response was suggested and all were counted. Hence, the total number of responses for each species may be greater than the number of interviews suggesting appropriate responses.

4.3 Results

4.3.1 Distribution of large carnivores in Mozambique

By early December 2008, just four of the ten provincial offices of the Ministry of Agriculture had returned completed questionnaires to the Project. The Ministry's decision to end this Project two months earlier than originally planned complicated efforts to ensure the return of all questionnaires. In particular, it has not been possible to use data from the provincial offices to map the distribution of large predators in Mozambique. Nevertheless, a provisional map of lion distribution in Mozambique was produced using the conflict records and survey reports (Map 44).

In any case, the part of the Project has been overtaken by events, including a recent study of the distribution of lion in Mozambique by the DNAC (Chardonnet *et al*., 2008). Their map is reproduced here (Map 45). Their study suggests that lions occur across northern Niassa and Cabo Delgado provinces, in western Tete province, throughout the coutadas and Gorongosa NP and Marromeu Reserve in central Mozambique, in Gaza province, north-east Inhambane province and along the northern side of the Save River.

4.3.2 People's perceptions of human-wildlife conflicts

4.3.2.1 Severity of conflicts caused by different species

Conflicts caused by elephants were usually considered by local people to be the most serious (rank 1) of the human-wildlife conflicts that they encountered, although human-elephant conflict was often ranked 2 or 3 in Gaza and Maputo provinces (Figure 12). Human-crocodile conflicts were also often ranked the most serious, while human-hippopotamus conflicts were commonly ranked 2. Since the habitats of hippos and crocodiles overlap in Mozambique's large rivers and major water bodies, this implies that local people perceive crocodiles to present a greater conflict problem than hippos. This is confirmed by the observation that in districts where both crocodile and hippopotamus were ranked as problem species, 87 % of interviews (n = 30) noted that crocodiles caused more serious conflicts than hippos. In just a few districts were lions perceived to cause the most serious problems. In districts where both lion and elephant were ranked as problem species, 65 % of interviews (n = 20) noted that elephants caused more serious conflicts than lions. Conflicts caused by buffalo and leopard were relatively unimportant compared with the conflicts caused by other species (Figure 12).

4.3.2.2 Types of conflicts

The interviewees reported that elephant and hippopotamus were often responsible for serious crop damage and were difficult for them to deal with. Both species sometimes killed or injured people, and elephant occasionally damaged houses. Crocodile and lion sometimes killed or injured people and domestic livestock.

The DNTF records reveal that crocodiles killed 62 people and injured 20, lions killed 15 and injured 18, elephants killed eight and injured one, hippos killed two and injured three, and buffaloes injured four people, in the 32 visited districts during the 18 months (January 2007 to June 2008 inclusive) preceding the interviews.

Some interviewees said that several people that were killed by elephants were trying to defend their crops at the time they were killed. Crop-guarding was also mentioned as the activity at the time when some people were killed by lions. Sleeping in flimsy shelters – as people often do when guarding crops at night – would leave people more vulnerable to attack by lions.

4.3.2.3 Origins of animals causing conflicts

The interviewees often believed that the elephants causing conflicts in their district came from nearby National Parks or Game Reserves, for example, from Kruger NP, Limpopo NP, Gonarezhou NP, Banhine NP, Niassa GR and Gile GR. While some of their beliefs were probably correct, some were not so. For example, recent surveys have revealed that there are no elephants resident in Banhine NP (Stalmans, 2004; 2007a). Interviewees in Cabo Delgado were believed (probably correctly) that the elephants in their district were resident there.

4.3.2.4 Temporal trends in conflicts

Conflicts caused by elephant, hippopotamus and crocodile were perceived as having increased in frequency during the last five years by 100 % of the interviewees that expressed an opinion on the temporal trend in conflicts (for elephant, number of interviews indicating trend (n) = 32; for hippopotamus, n = 37; for crocodile, n = 33). Only for lion was there a divergence of opinion, with 79 % (n = 28) saying that the frequency of human-lion conflicts had increased and 21 % believing that it was stable.

4.3.2.5 Current responses to conflicts

For all human-wildlife conflict, the commonest response of the local people was to inform the government authorities. Some people attempted to reduce crop-raiding by elephant and hippopotamus by block farming (grouping fields together), using rope barriers to deter crop-raiders, guarding fields, or using noise and fire to drive off crop-raiders (Figure 13). In some districts, attempts were made to trap lions.

The interviewees never mentioned the killing of problem animals as a current measure to mitigate human-wildlife conflicts, possibly because they themselves did not attempt to kill large animals in response to conflicts. The DNTF records reveal that 25 lions, 24 crocodiles, 11 lions, 7 hippos and 3 buffaloes were killed in the 32 visited districts during the 18 months (January 2007 to June 2008 inclusive) preceding the interviews.

4.3.2.6 Proposed responses to conflicts

Killing – either of problem individuals, or in the form of culling to reduce the number of that species in the district – was the most popular suggestion for the most appropriate way of responding to human-wildlife conflicts, regardless of which species caused the conflicts (Figure 14). A few people suggested relocating elephants or lions to national parks or game reserves. Fencing was often suggested as a response to human-hippopotamus conflict, or at least the crop raiding dimension of it. Hippos can easily be excluded by fences of simple design, but these fences must be strong, which can make their construction expensive. The installation of water pumps was sometimes suggested as a response to human-crocodile conflicts, to enable people to obtain water without having to collect it directly from rivers or lakes inhabited by crocodiles.

4.3.2.7 Benefits of wildlife to local people

Nearly all interviewees believed that they received little benefit from wildlife, except occasionally in the form of bush meat (in those districts where interviewees admitted that hunting of small animals occurred), or meat from animals killed in response to human-wildlife conflicts.

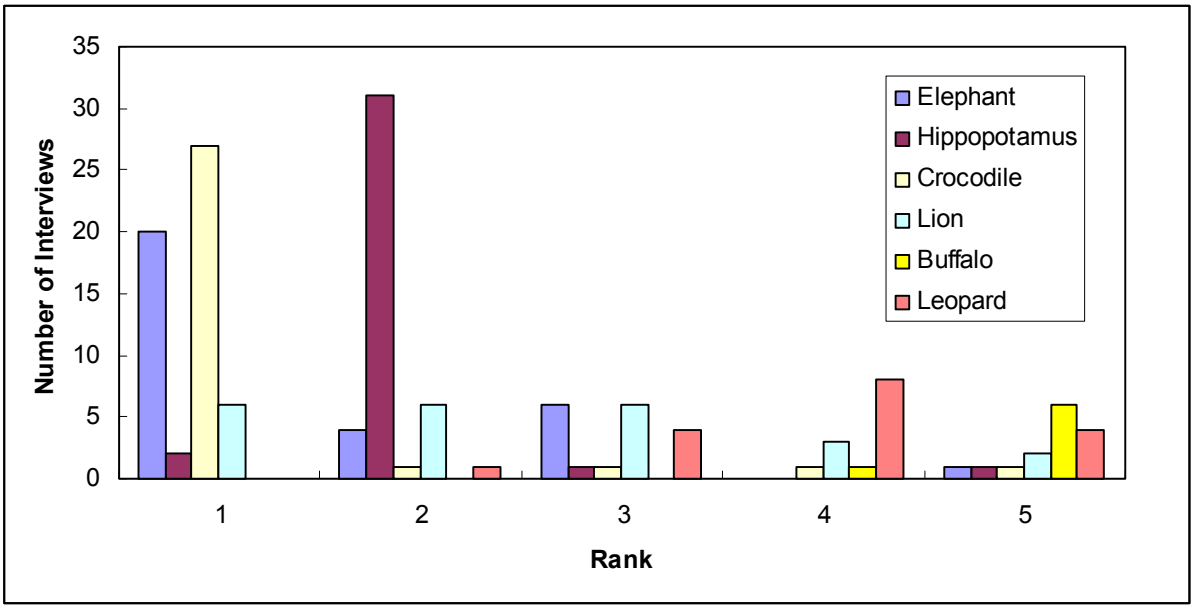


Figure 12. Local people's perceptions of the severity of conflicts caused by different wildlife species

Local people ranked wildlife species according to the severity of the conflicts that the different species caused in their district: a species was ranked as 1 if the interviewees regarded the conflicts caused by that species in their district to be the most serious human-wildlife conflicts that they encountered. The total number of interviews varies between species, because not all species were present in all districts and not all species were perceived to cause conflicts.

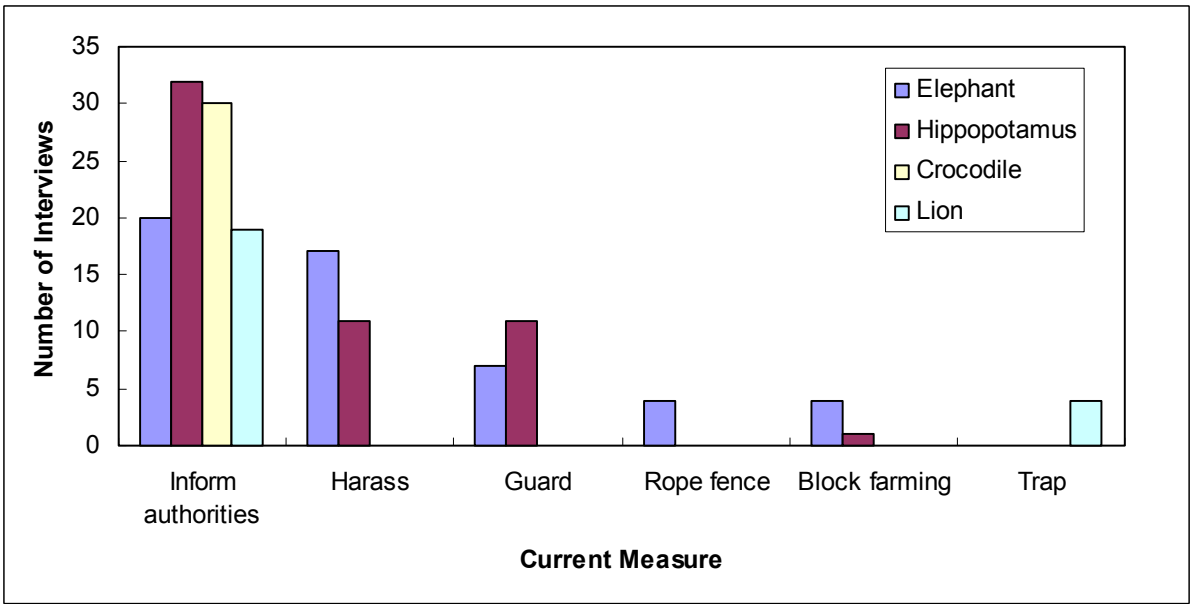


Figure 13. Measures currently used by local people to counter human-wildlife conflicts caused by different wildlife species

Harassment was mainly in the form of noise to frighten the animals and could be seen as a form of crop guarding.

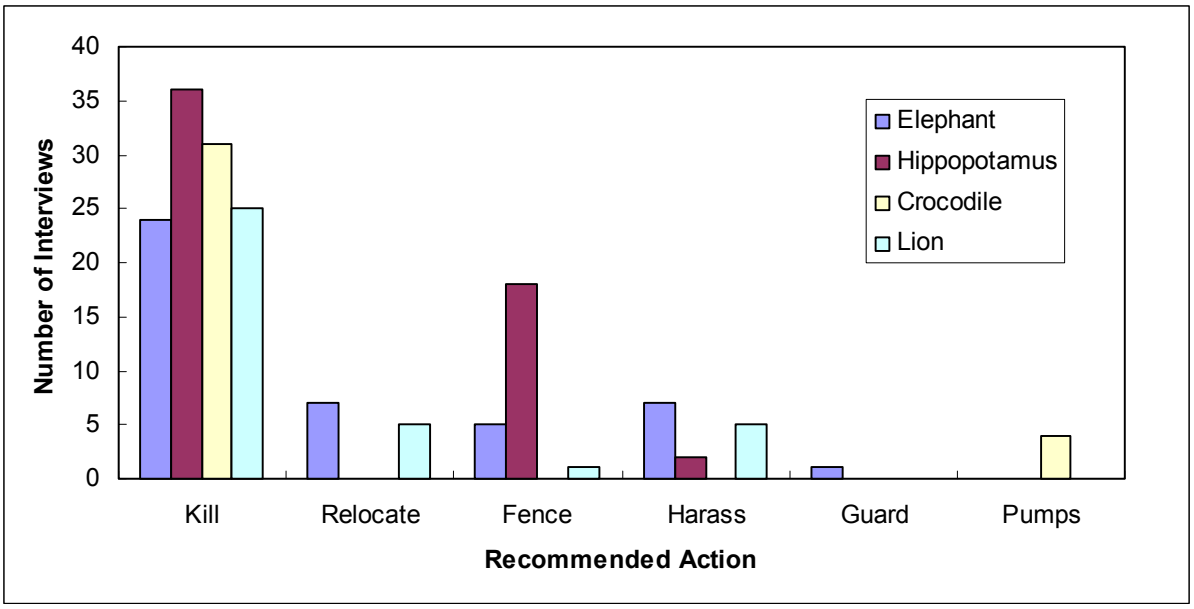
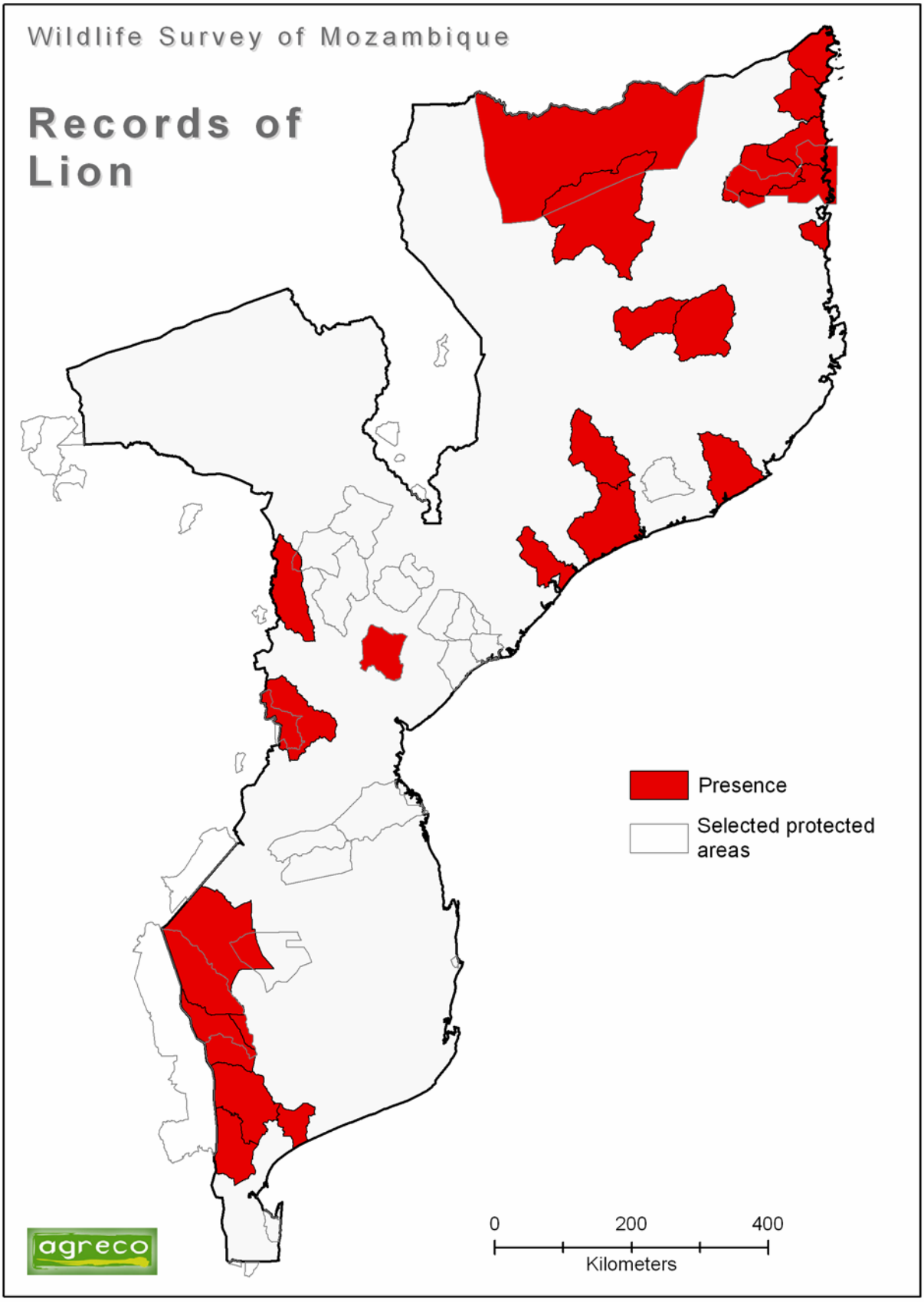
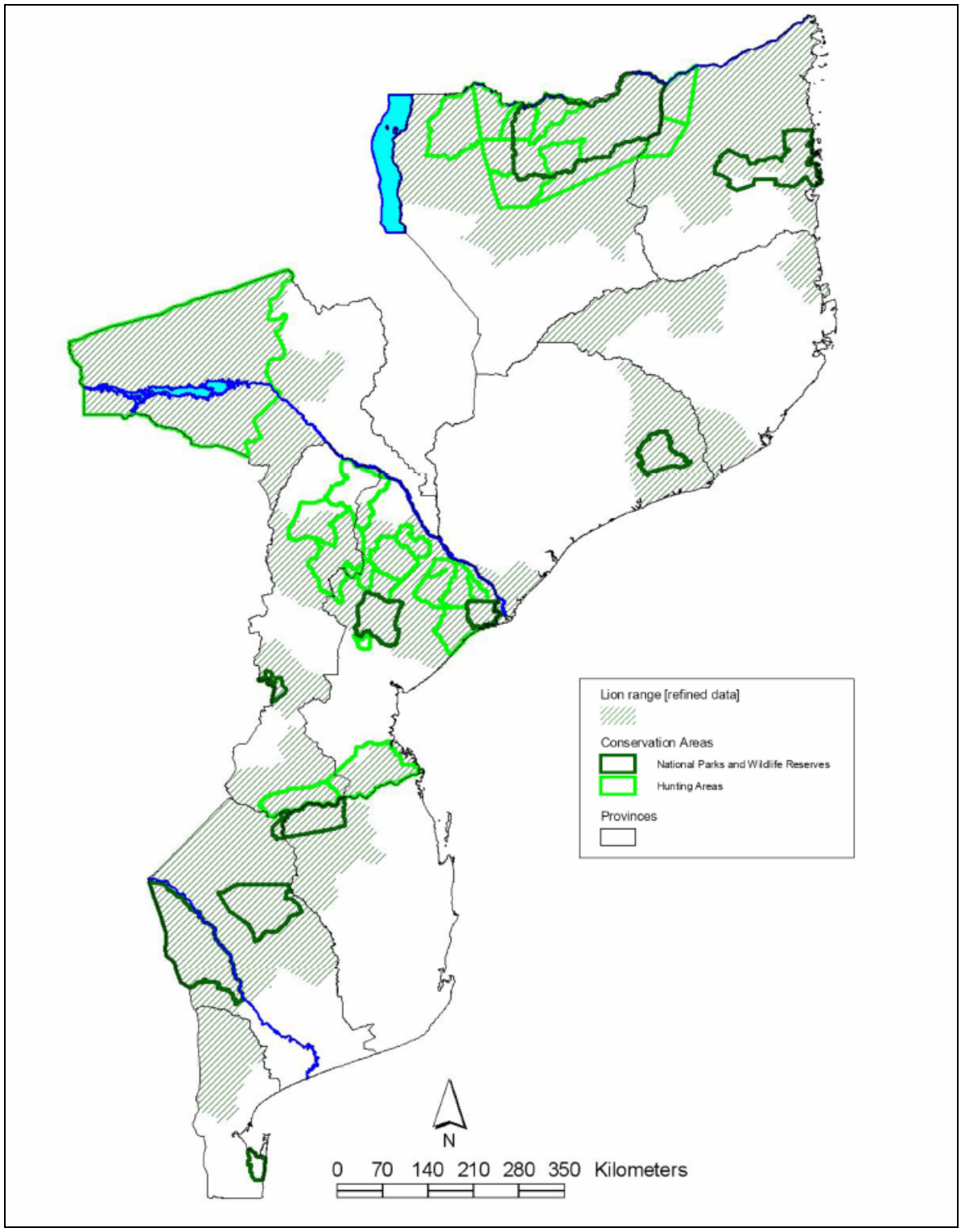


Figure 14. Local people's proposals for the most appropriate responses to conflicts caused by four major wildlife species



Map 44. Distribution of records of lions in Mozambique

The districts where human-lion conflicts were noted in the DNTF records during the period July 2006 to September 2008 are coloured to indicate the presence of conflict. Protected areas that were surveyed during recent years and where lions were reported present are similarly coloured.



Map 45. The current distribution of lion in Mozambique
Map courtesy of DNAC and Chardonnet *et al*. (2008).

5 Geodatabase

5.1 Objective of the Activity

The objective of this activity was to support the other activates of the Project with a geographic information system in the frame of the Forest Inventory (AIFM) information system already established at UIF. The big advantage of integrating the results, data and tools from this Project into the AIFM information system was that this process would ensure that the data sets developed during two separate projects for the same Ministry were 100 % compatible.

5.2 Geodatabase Preparation

All tabular and spatial data from the aerial survey and the records of human-wildlife conflicts were integrated with all the other relevant environmental and socio-economic information (administrative boundaries, strata layers, demographic data, land cover, land regions, digital elevation model). All the available information was cleaned and normalized in a temporary personal geodatabase (Access + ArcGIS). The data model still has to be refined and moved to the final spatial database at the UIF office (SQLserver + ArcSDE + ArcGIS).

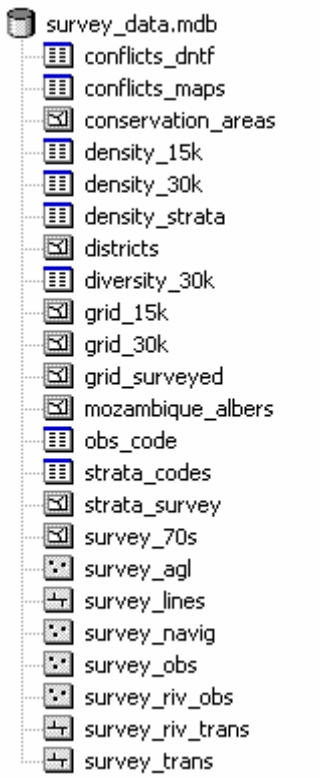


Figure 15. The catalogue of the geodatabase

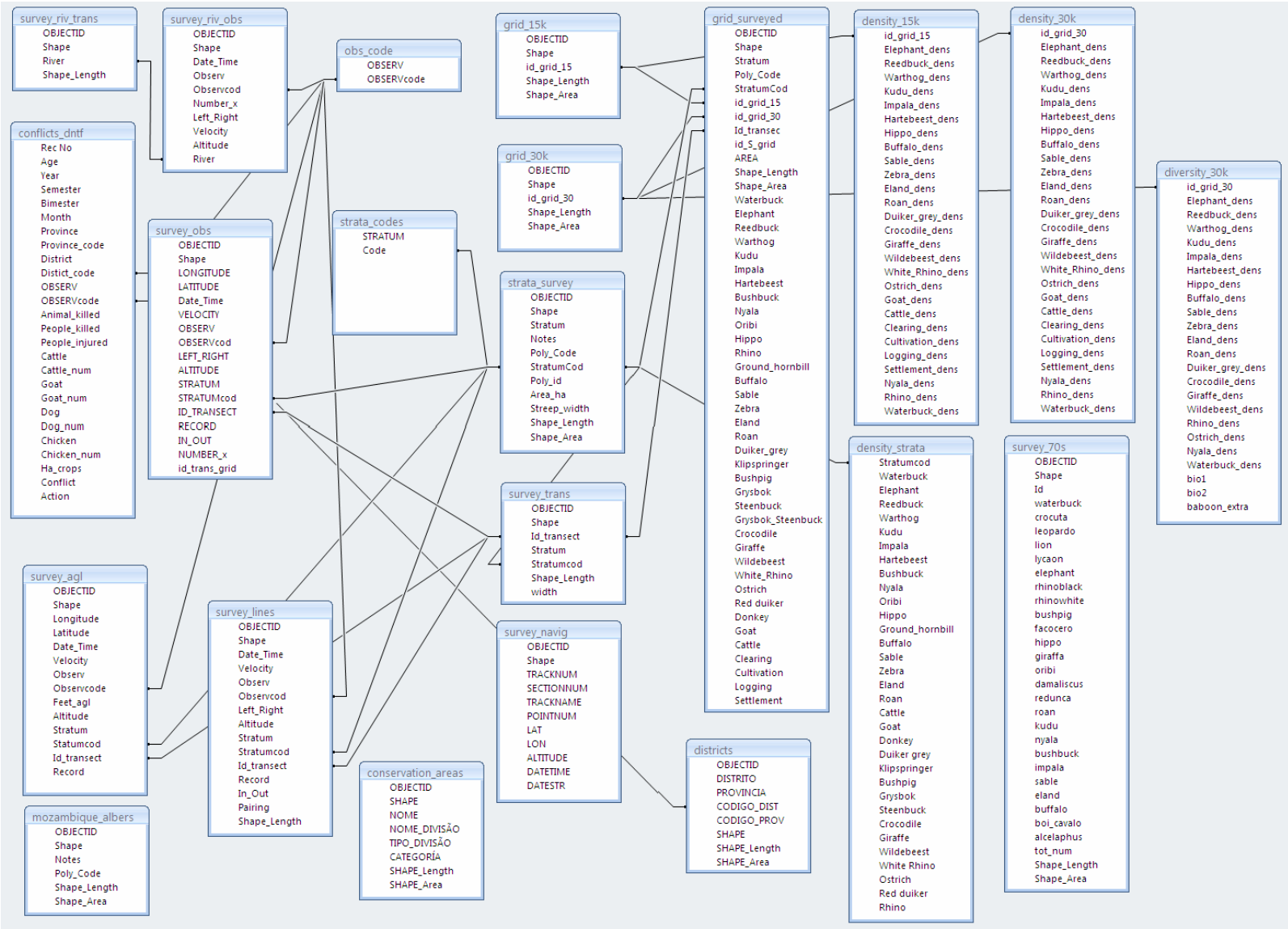


Figure 16. A representation of the data and the relationships between data layers in the geodatabase

6 Discussion

6.1 Areas of Major Wildlife Presence and Diversity

The maps of density distribution for the wildlife species have been combined to determine the number of wildlife species recorded in each 30x30 km map grid square, in order words to determine the species richness, which is one measure of biodiversity, of the large wildlife in each square.

Two maps were prepared. The first (Map 57) shows the variation across Mozambique in the species richness of the largest wildlife species (elephant, rhino (both species), hippopotamus, buffalo, eland, giraffe, roan antelope, sable antelope, waterbuck, wildebeest, zebra and hartebeest). The second (Map 58) shows the species richness for these species together with the smaller species of wildlife (baboon, crocodile, grey duiker, impala, kudu, nyala, ostrich, reedbuck and warthog).

Both maps suggest that species richness (diversity) of wildlife is greatest in the previously surveyed areas (Niassa Reserve, western Magoe, coutada 9, Gorongosa NP, Zinave NP, Limpopo NP, Maputo Elephant Reserve) than elsewhere. This is likely true, at least in part, because when only the areas surveyed during 2008 are considered, it is noticeable that species richness is greater in Gile Reserve, Marromeu Reserve and the coutadas north and west of Marromeu Reserve (coutadas 10, 11, 12 and 14) than in the surrounding areas.

However, the low species richness in the 2008 survey area, compared with the previously surveyed areas, is also partly an artefact. Because the sampling intensity in the previously surveyed areas was greater than the sampling intensity in the 2008 survey area, it was more likely that uncommon species would be seen in the previously surveyed areas than in any given map square surveyed during 2008.

There appear to be five principal areas of high wildlife diversity in Mozambique (Map 58):

1. northern Mozambique (Niassa Reserve, the Chipanje area and the surrounding lands, including Quirimbas NP);
2. western Tete province (north and south of Lake Cabora Bassa);
3. central Mozambique (Gorongosa NP, Marromeu Reserve and coutadas 6, 7, 9, 10, 11, 12, 13, 14 and 15);
4. the area encompassing the Limpopo, Banhine and Zinave National Parks and adjacent lands; and
5. Maputo Elephant Reserve.

Most of these areas consist largely of conservation areas. But the northern Mozambique high-diversity area includes a large area of communal land outside Niassa Reserve and the Chipanje area. And the western Tete high-diversity area is entirely communal land.

Three of the five high-diversity areas identified after the 2008 survey consist largely of conservation areas where the wildlife has been, or is likely to be, surveyed. It is proposed that the other two high-diversity areas – northern Mozambique excluding Niassa Reserve and the Chipanje area, and western Tete province – are resurveyed during 2009, in order both to fill in gaps in the existing survey coverage and to provide additional information on the species and densities of wildlife in these two high-diversity areas (Map 59). The total area of the land proposed for survey during 2009 totals 262300 km^2 and includes 130646 km^2 of mountainous terrain originally scheduled for block count surveys during 2008.

6.2 Status of Elephant

6.2.1 Poaching

The number of elephant carcasses and the proportion of dead to live elephants seen during aerial surveys can provide an index of the elephant mortality rate (Douglas-Hamilton & Burrill, 1991). The ratio of fresh and recent carcasses seen during the 2008 survey (the 1+2 carcass ratio) was 0.9 %, which is relatively high (Dunham, 2008), but it was based on a small number of carcasses. The all-carcass ratio of 4.4 % was within the range (0-9 %) generally regarded as normal for a population not subjected to heavy poaching. Hence, the 2008 aerial survey suggested that elephants within the area surveyed that year had not been subjected to heavy poaching pressure during recent years.

6.2.2 Number of elephants in 2008 survey area

The 2008 survey covered a large area of Mozambique where the wildlife had not been surveyed previously. However, the number of elephants in the 2008 survey area had been estimated previously, but mainly on the basis of guesses. The most recent version of the IUCN/SSC African elephant database (Blanc *et al*., 2007) suggested that there were a total of 6927 elephants in Cabo Delgado, Inhambane, Manica, Sofala, Tete and Zambezia provinces, Gile Game Reserve, Mecuburi Forest Reserve and Quirimbas National Park. This figure can be compared with the estimate of 7187 $\pm$ 73 % elephants from the 2008 survey, although it must be remembered that some areas of northern Tete province, western Niassa province and northern Zambezia province were not surveyed during 2008.

Although there is little difference between the numerical value of the above two estimates, the 2008 survey provided better quality data. The earlier estimate was based on guesses and so the estimate of elephant number was described – in the terminology of the IUCN SSC African Elephant Specialist Group (Blanc *et al*., 2007) - as 'speculative'. In contrast, the sample aerial survey during 2008 provided data in the categories 'definite' (= lower confidence limit), 'probable' (= mean estimate minus lower confidence limit) and 'possible' (= upper confidence limit minus mean estimate).

6.2.3 Number of elephants in Mozambique

As a consequence of the 2008 survey, the number of elephants 'definitely' in Mozambique has increased by more than 2000 animals (Table 4). And the numbers 'probably' and 'possibly' there have increased as the 'speculative' category has been largely eliminated.

The best estimate of the number of elephants in Mozambique during 2008 is 22144 (= the number 'definitely' there, plus the number 'probably' there = 16393 + 5751).

Table 4. Number of elephants in Mozambique during 2008, partitioned by data quality
Data categories are those used by the IUCN SSC African Elephant Specialist Group (Blanc *et al*., 2007). Figures for 2006 from Blanc *et al*. (2007). Data for 2008 from this survey and recent aerial surveys.

Data Category	2006	2008
Definite	14079	16393
Probable	2396	5751
Possible	3073	5750
Speculative	6980	22

6.2.3.1 Distribution of elephants in Mozambique

The information on sightings of elephants, elephant carcasses, elephant tracks and signs of their impact on trees collected during the 2008 (Map 8) has been combined with data from aerial surveys conducted during recent years (Table 1), Ghiurghi & Pariela's (2007) survey of wildlife in Machaze district and the AIFM survey of the presence or absence of wildlife at sites across Mozambique, to produce a map of Mozambique showing where elephants have been recorded during recent years (Map 9). The map shows simply the presence of elephants and does not attempt to distinguish between areas where elephants are resident and areas where elephants are simply occasional visitors.

6.2.3.2 Elephant subpopulations

Once, elephants probably occurred throughout Mozambique (Smithers & Lobão Tello, 1976), but now, on the basis of the current distribution map and previous studies (Anderson & Pariela, 2005; Blanc *et al*., 2007; De Boer & Ntumi, 2001; De Boer *et al*., 2000; Hofer & Mpanduji, 2004; Jackson & Erasmus, 2005; Ntumi *et al*., 2005; Zambezi Society & Mid Zambezi Elephant Project, 2000), one can speculate that there are currently six *de facto* subpopulations of elephant in Mozambique. They occupy the following areas:

1. Maputo Elephant Reserve

   In the absence of physical barriers such as fences, elephants in Maputo Elephant Reserve and the Futi corridor would likely be contiguous to elephants in Tembe Elephant Park in South Africa. After the 2006 survey of Maputo Elephant Reserve, Matthews & Nemane (2006) estimated that there were at least 329 elephants in Maputo Elephant Reserve.

2. Southern Inhambane province

   Although only the footprints of elephants were seen here during the 2008 survey, probably some elephants live in southern Inhambane province and, if so, this subpopulation is geographically isolated, although once it was probably contiguous to elephants to the west, in the Limpopo Valley. The size and range of this subpopulation is largely unknown.

3. Limpopo / Gaza

   The elephant was recently reintroduced to Limpopo NP and, with sections of the fence along this part of Mozambique/South Africa international border having been removed, the Limpopo population is contiguous to the elephant population in Kruger NP. Also, elephants are crossing into Mozambique from Kruger NP southwards of Limpopo NP. During the 2006 survey of the south-west section of Limpopo NP (the section with the highest density of wildlife), Whyte & Swanepoel (2006) counted 630 elephants there.

   In the north of Kruger NP, the elephant population is contiguous to elephants in south-eastern Zimbabwe, including Gonarezhou NP. Hence, elephants entering Mozambique from Zimbabwe between the Limpopo and Save Rivers should be seen as part of Mozambique's Limpopo/Gaza subpopulation. The status of elephants in the Machaze and Sussundenga (particularly in Moribane/Chimanimani) area is not clear area is not clear – if their distribution is contiguous to elephants to the west in Zimbabwe, then they form part of the Limpopo/Gaza subpopulation.

4. Zambezi Valley, Tete province and central Mozambique

   Elephant distribution in this area extends from Zumbo in the west, to the Zambezi delta at the Indian Ocean in the east. However, whether this distribution is continuous is uncertain. The number of elephants in this subpopulation is also uncertain – the current estimate is 5888 $\pm$ 84 %. The area includes Gorongosa NP and Marromeu Reserve. Elephants in the western Magoe region are contiguous to elephants in

Zimbabwe's Zambezi Valley population, occupying Dande and Chewore Safari Areas and other protected areas.

5. Northern Mozambique

   This subpopulation occupies northern Mozambique, including Niassa Reserve and the adjacent hunting areas and Quirimbas NP. It overlaps the Mozambique/Tanzania international border and is contiguous to elephants in southern Tanzania, which includes the Selous Game Reserve. In Mozambique, this subpopulation (the largest in the country) is estimated to number 15087 (± 21 %) elephants, with approximately 75 % of these in Niassa Reserve and the hunting areas.

6. Gile

   Although none were seen here during the 2008 survey, possibly some elephants live in the vicinity of Gile Reserve and, if so, this subpopulation is now geographically isolated, although once it was probably contiguous to elephants in northern Mozambique, or the Zambezi Valley, or both. The size and range of this subpopulation is largely unknown.

6.3 Status of Other Wildlife

When comparing the maps of wildlife presence during 2008 with the distributions pre-1970, it should be noted that the absence of a record cannot always be taken to indicate that a species is absent. However, if records are missing over a large portion of Mozambique, it is most likely that the species did (or does) not occur there, or was there only in very small numbers.

6.3.1 Baboon

There are two species of baboon in Mozambique, the Yellow Baboon in northern Mozambique and the Chacma Baboon in southern and central Mozambique and the Zambezi Valley (Smithers & Lobão Tello, 1976). While the difficulties of species identification from the air prevented the distribution of the two species in Mozambique during 2008 from being determined, the distribution of 'baboons' during 2008 was similar to that recorded prior to the 1970s (Smithers & Lobão Tello, 1976).

6.3.2 Buffalo

Prior to the 1970s, the buffalo was found across Mozambique (Smithers & Lobão Tello, 1976), but during 2008 its distribution was much more limited. It has apparently disappeared from southern Mozambique, except for a reintroduced population in Limpopo NP and a few animals (probably immigrants) near the Mozambique/South Africa international border. In central Mozambique, buffaloes were seen during 2008 only in the vicinity of Marromeu Reserve. In western Tete and northern Mozambique, the buffalo is not longer widespread, but appears to be largely confined to western Magoe, Niassa Reserve and the Chipanje area.

6.3.3 Crocodile

During aerial surveys, the only crocodiles likely to be seen are large ones, more than 2 m long. During 2008, significant numbers of large crocodiles were seen along the Rovuma, Zambezi and Save Rivers. But there are many lakes, dams and rivers in Mozambique where large crocodiles could and, judging by the distribution of human-crocodile conflicts (Map 34), probably do inhabit. A more intensive survey of crocodiles is expected during 2009 and this will help to provide better information on the status and distribution of crocodiles in Mozambique.

6.3.4 Grey duiker

Prior to the 1970s, the grey or common duiker was found across Mozambique (Smithers & Lobão Tello, 1976) and that was still the case during 2008. However, it appears that the grey duiker may be absent from the southern-most part of the country, except Maputo Elephant Reserve.

6.3.5 Eland

Prior to the 1970s, the eland was found across Mozambique (Smithers & Lobão Tello, 1976), but this was no longer the case during 2008. It has largely disappeared from southern Mozambique (just a single animal was seen there during the 2008 survey) and has a much reduced distribution in central and northern Mozambique. Approximately 70 % of the estimated population is in Niassa Reserve.

6.3.6 Giraffe

Prior to the 1970s, the giraffe was confined to southern Mozambique, south of the Save River and west of longitude 34° E (Smithers & Lobão Tello, 1976). During 2008, it had a much reduced distribution in this same area, being confined to Limpopo NP, where the species has been reintroduced.

6.3.7 Hartebeest

Prior to the 1970s, Lichtenstein's hartebeest was found northwards of the Save River; it was abundant in central Mozambique and occurred northwards to the Rovuma River (Smithers & Lobão Tello, 1976). Once, it was common between the Limpopo and Save Rivers. Now its distribution is much reduced. During 2008, there was a small reintroduced population in Limpopo NP and a sparse population in central Mozambique. In northern Mozambique, the hartebeest appeared to be confined to Niassa Reserve (which contained 86 % of the estimated national population) and Chipanje.

6.3.8 Hippopotamus

Prior to the 1970s, the hippopotamus was found widely distributed across Mozambique wherever there was suitable habitat, namely large rivers or lakes (Smithers & Lobão Tello, 1976). It was found across northern Mozambique, along the Zambezi Valley, in Gorongosa NP and Marromeu Reserve, along the Save and Limpopo Rivers and in southern Inhambane and Gaza provinces. During 2008, the hippopotamus was still found in Maputo Elephant Reserve, along the Save River (particularly within Zinave NP), in Gorongosa NP, along the Zambezi River and the shores of Lake Cabora Bassa, and along the Rovuma and Lugenda Rivers in the north. Hippos are know to occur in the Limpopo basin, but no specific river survey was carried out there during 2008 and no hippos were seen along transects there.

When the number of hippos was estimated using the results of sample surveys for areas for which total count data were not available, there were estimated to be 8388 (± 54 %) hippos in Mozambique, with more than 50 % of these animals along the southern shore of Lake Cabora Bassa. Sample surveys are less suitable for hippo than total counts and the southern shore of Cabora Bassa should be a priority for a total count during the next wildlife survey.

6.3.9 Impala

Prior to the 1970s, the impala was found throughout Mozambique, but with few records for southern Inhambane province and Zambezia and Nampula provinces (Smithers & Lobão Tello, 1976). During 2008, the distribution of impala in southern and central Mozambique was broadly similar to that recorded earlier, but in northern Mozambique none were seen except in Niassa Reserve.

6.3.10 Kudu

Prior to the 1970s, the kudu was found across Mozambique (Smithers & Lobão Tello, 1976). But this was no longer the case during 2008, with the kudu now largely absent from Inhambane, Zambezia and Nampula provinces. Sightings of kudu during the 2008 survey were often close to the borders of conservation areas. However, kudus are often difficult to see from the air and their distribution may well be wider than is shown in the map.

6.3.11 Lion

A provisional map of the distribution of lion in Mozambique was prepared for this project (Map 44). This map shows districts where lions are present, having been noted in the DNTF conflicts records as responsible for human-lion conflict, or having been seen during recent aerial or ground surveys within protected areas (Craig, 2006; Dunham, 2004a; Garnier *et al*., 1999; Whyte & Swanepoel, 2006). While this map shows areas were lions are known to occur, the absence of a record cannot always be taken to indicate that lions are absent. However, a more complete map has been produced recently by the DNAC (Chardonnet *et al*., 2008). This suggests that lions occur across northern Niassa and Cabo Delgado provinces, in western Tete province, throughout the coutadas and Gorongosa NP and Marromeu Reserve in central Mozambique, in Gaza province, north-east Inhambane province and along the northern side of the Save River (Map 45). Comparison of the two maps implies that there are no contradictions (in other words, there are no conflicts reported in places where the DNAC believes that lions do not occur). Instead, the comparison suggests that either there are many districts where lions occur but do not cause conflicts, or that there are many districts that do not report conflicts with lions even though such conflicts occur. The latter option seems more likely.

6.3.12 Nyala

Prior to the 1970s, the nyala was found throughout southern Mozambique, as far north as the Zambezi Valley, in areas of suitable habitat (Smithers & Lobão Tello, 1976). During 2008, it was recorded across northern Gaza and Inhambane provinces, in and around the Limpopo/Banhine/Zinave complex of national parks. It was absent from the southern parts of these provinces, and in central Mozambique it was recorded only from Gorongosa NP.

6.3.13 Ostrich

During 2008, the ostrich was confined to the Limpopo/Banhine/Zinave complex of national parks and the areas around them in southern Mozambique.

6.3.14 Reedbuck

Prior to the 1970s, the reedbuck was found in most parts of Mozambique where there was suitable habitat (Smithers & Lobão Tello, 1976). During 2008, its distribution was less widespread, with most records of it coming from conservation areas, but its range still stretched from Maputo Elephant Reserve in the south to Niassa Reserve in the north.

6.3.15 Rhinoceros

There used to be two species of rhinoceros in Mozambique, the white rhinoceros and the black rhinoceros (Smithers & Lobão Tello, 1976). But by the time of Smithers & Lobão Tello's (1976) study, the distribution of both was greatly reduced. The white rhinoceros, which was never found north of the Zambezi River, had become nationally extinct and had been reintroduced (introduced?) to Maputo Elephant Reserve and Gorongosa NP. Occasionally, white rhinos entered Mozambique from South Africa's Kruger NP. By the time of Smithers & Lobão Tello's (1976) study, the black rhinoceros was sparsely distributed across central and northern Mozambique and western Tete (although it may once have occurred throughout

most of Mozambique). By 2008, there were a small number of white rhinos in Limpopo NP, where some animals were released and others have emigrated from Kruger NP. The lone rhinoceros (species unspecified) seen in northern Mozambique during the 2008 survey can only have been a black rhino and is likely to be one of a very small number in Mozambique.

6.3.16 Roan

Prior to the 1970s, the roan antelope was sparsely distributed in western parts of southern Mozambique, in central Mozambique and western Tete and northern Mozambique (Smithers & Lobão Tello, 1976). During 2008, it was even more sparsely distributed, but records of a few animals from just south of Niassa Reserve, western Magoe, north of the Zambezi delta and Limpopo NP (where the roan was reintroduced).

6.3.17 Sable

Prior to the 1970s, the sable antelope was widely distributed across Mozambique, except for south-eastern Gaza and Inhambane provinces (Smithers & Lobão Tello, 1976). During 2008, it was still present in central and northern Mozambique and Limpopo NP (where it has been reintroduced). The 2008 survey estimated that there were 32393 (± 33 %) sable antelopes in Mozambique, with approximately 15000 animals outside the previously surveyed areas, in the coutadas of central Mozambique and in the area to the south of Niassa Reserve.

6.3.18 Warthog

Prior to the 1970s, the warthog was widely distributed across Mozambique, except in parts of southern Mozambique (Smithers & Lobão Tello, 1976). During 2008, it was still found in and around Niassa Reserve in northern Mozambique, in the Zambezi and Rift Valleys in central Mozambique, including Gorongosa NP and Marromeu Reserve, and in the Limpopo, Banhine and Zinave NPs in southern Mozambique.

6.3.19 Waterbuck

Prior to the 1970s, the waterbuck was widely distributed across Mozambique, but by the 1970s it was largely absent from southern Mozambique, except for occasional immigrants from Kruger NP (Smithers & Lobão Tello, 1976). During 2008, there were significant populations in Gorongosa NP, Marromeu and Niassa Reserves, and small numbers in the Magoe area, Maputo Elephant Reserve and Limpopo NP (where the waterbuck was reintroduced).

6.3.20 Wildebeest

Prior to the 1970s, the wildebeest was found in northern Mozambique, in Gile Reserve and Gorongosa NP, in the Save Valley, Banhine and Zinave NPs and along the border with Kruger NP (Smithers & Lobão Tello, 1976). During 2008, there was a small national population existing as two discrete subpopulations, the larger one, comprising 75 % of the population, in Niassa Reserve and a small one in Limpopo NP (where the wildebeest was reintroduced).

6.3.21 Zebra

Prior to the 1970s, the zebra was found throughout most of Mozambique, except that it was largely absent from Maputo and Inhambane provinces (Smithers & Lobão Tello, 1976). During 2008, there was a northern subpopulation in or near Niassa Reserve, a small population along the border with Kruger NP and Limpopo NP (where the zebra was reintroduced) and a few in the Magoe area.

6.4 Management of Elephant

6.4.1 Elephant management and action plan

The IUCN SSC African Elephant Specialist Group has been contracted to assist during 2009 in the preparation of an elephant management and action plan for the conservation of the elephant in Mozambique. In effect, this plan will be an update of an earlier elephant management strategy (DNFFB, 1999). The Specialist Group will be providing technical input, along with the Department of Biological Science at the University Eduardo Mondlane in Maputo, the National Directorate of Conservation Areas and the National Directorate of Land and Forestry. Preparation of the plan will include meetings at provincial level and a workshop with protected area managers, representatives of non-government organisations, and private operators of hunting areas. Given the wide-ranging consultation that will accompany preparation of this plan, it would be presumptuous for the authors of this report to comment on elephant management in Mozambique except in relation to the results of the 2008 survey.

6.4.2 CITES export quota for elephant tusks

The improved quality of the data for estimating the number of elephants in Mozambique may have important implications for determining the CITES export quota for Mozambique.

During 2006, the United States government denied applications for CITES import permits for some tusks originating from areas of Mozambique outside Niassa Reserve, on the grounds that there were insufficient data for these areas to set hunting quotas (Jackson (2006) cited by Blanc *et al*., 2007).

As a consequence of the 2008 survey, the number of elephants definitely or probably in Mozambique has increased from 16475 during 2006 to 22144 during 2008, an increase of 34 %. (It is important to realise that the number of elephants in Mozambique has not increased by 34 %. It is the number of elephants that one can confidently believe to be in the country that has increased by 34 %.)

6.4.3 Killing of elephants in response to conflicts

The DNTF records reveal that 85 elephants were killed in response to human-elephant conflicts during July 2006 to September 2008. This figure, which should probably be regarded as a minimum, is equivalent to approximately 40 elephants per year. This is similar to Mozambique's CITES export quota, which is 80 tusks, equivalent to 40 elephants annually (UNEP-WCMC (2006), cited by Blanc *et al*., 2007).

The circumstances in which the problem elephants were killed are not known to the authors of this report and it is possible that some of them were killed by safari operators or their clients and thus that the tusks of these problem elephants became part of the country's export quota. But it is most likely that most of the problem elephants were not killed in this way. In other words, most, if not all, elephants killed as problem animals were additional to those killed by safari (trophy) hunters.

Anderson & Pariela (2005) reported that the hunting of elephants by community hunters was being commercialized by them and other parties, and that community hunters wounded many elephants without killing them. Anderson & Pariela (2005) recommended that: the hunting of elephants by community hunters should be phased out; the Government should develop its own Problem Animal Control units; and the value of the benefits that local people received from elephants hunted in their districts should be increased. Increasing the value of benefits could be done by: requesting CITES to allocate additional CITES export permits, so that a number of the elephants currently shot in response to human-elephant conflicts can be sold to safari hunters; and increasing the proportion of the license fee that the communities receive when an elephant is shot in their area.

6.4.4 Elephant subpopulations

1. Maputo Elephant Reserve

   There is a long history of human-elephant conflict in the vicinity of Maputo Elephant Reserve (Osborn, 1998; De Boer & Ntumi, 2001; Anderson & Pariela, 2005). Anderson & Pariela (2005) recommended the erection of an elephant-proof fence along the Futi corridor, as previously proposed by the Ministry of Tourism, in order to reduce human-elephant conflict outside the reserve. The Futi corridor is intended to facilitate the movement of elephants between Maputo Reserve and the Tembe Elephant Park in South Africa. However, elephants can move across the international border only after the removal of the fence that demarcates Tembe Park's northern boundary.

2. Southern Inhambane province

   The DNTF records report human-elephant conflicts in four districts in southern Inhambane province and the killing of seven elephants during 27 months in response to these conflicts. If, as seems likely, this is a small subpopulation isolated by human settlement and cultivation, then one can speculate that human-elephant conflict will continue here until the human and elephant populations are separated, either by the elimination of the elephants, or by the implementation of a suitable land-use plan.

3. Limpopo / Gaza

   The DNTF records report human-elephant conflicts in the districts north, east, or south of Limpopo NP and the killing of ten elephants during 27 months in response to these conflicts. Anderson & Pariela (2005) recommended the erection of an elephant-proof fence along the eastern boundary of Limpopo NP, in order to prevent elephants crossing this river and causing conflict on the east bank. However, the current management plan for the park does not include fencing the eastern park border.

4. Zambezi Valley, Tete province and central Mozambique

   The number and distribution of elephants in this area, which includes nine coutadas, is uncertain. When further information is available on numbers and distribution, it is possible that – at least for management purposes – more than one subpopulation will be recognised. There is human-elephant conflict in this area, with two people killed by elephants and ten elephants killed in response to conflicts during 27 months.

5. Northern Mozambique

   The Niassa Reserve, the hunting areas adjacent to it, and Quirimbas NP are settled by people and so perhaps it is not surprising that there is significant human-elephant conflict in northern Mozambique. The DNTF records (covering 27 months) report human-elephant conflicts in 22 districts in northern Mozambique, as well as the deaths of 20 people due to elephants and the killing of 37 elephants in response to these conflicts.

6. Gile

   The DNTF records report human-elephant conflicts in two districts west of Gile Reserve and the killing of six elephants there during 27 months in response to these conflicts. This small subpopulation is surrounded by human settlement and cultivation and one can speculate that human-elephant conflict will continue around Gile Reserve until the human and elephant populations are separated, either by the elimination of the elephants, or by the implementation of a suitable land-use plan (which might include fencing some or all of the reserve boundary).

6.5 Management of Other Wildlife

In the next section, the types and seriousness of the human-wildlife conflicts caused by the major wildlife species are discussed, together with the potential for mitigating these conflicts and the options for managing the conflict species. Hence the current section considers management other than the actual mitigation or prevention of human-wildlife conflicts.

6.5.1 Reduction in distributional range by many species

This study has shown that the distributions of many large wildlife species have contracted during recent decades. It is likely that the population numbers have declined along with the distributions. Government authorities may reasonably ask what, if anything, they can do to restore the populations that have declined.

Other studies (for example, Fusai & Carpaneto, 2006; Ghiurghi & Pariela, 2007) have suggested that the hunting of small and medium-sized animals for food – although illegal - is common in the rural communities of Mozambique. Ghiurghi & Pariela (2007) emphasized the important contribution that this bush meat made towards food security for these people. In these circumstances, it is not surprising that the distributions of many larger species of wildlife have contracted greatly during the past 40+ years, especially given that civil war was fought during many of those years: it is likely that larger species of wildlife would have been – and probably still are (Fusai & Carpaneto, 2006) - eaten by rural people whenever an opportunity arose. It is the largest carnivores (crocodile and lion) and herbivores (elephant and hippopotamus) – species that are difficult and potentially dangerous to deal with - that feature most often in the current DNTF records of conflicts.

The implication of this scenario is that, in many rural areas of Mozambique, all except the largest species of wildlife are already being managed - by the local people for their own benefit. Hence, in the absence of a massive programme of law enforcement, accompanied by an equally large programme to ensure food security for rural people suddenly without access to bush meat, there is probably little immediate scope for government authorities to promote the restoration of wildlife populations within the communal areas.

Nevertheless, where government authorities should be able to promote the conservation of wildlife is in the country's protected areas. The species reintroduction programmes in Limpopo NP show how rapidly wildlife populations can be restored. But many of Mozambique's protected areas are also occupied by people. While this continues to be the case, human-wildlife conflict will occur even inside Mozambique's protected areas (Begg *et al*., 2007).

6.5.2 Conservation of large riverine species: Hippopotamus and Crocodile

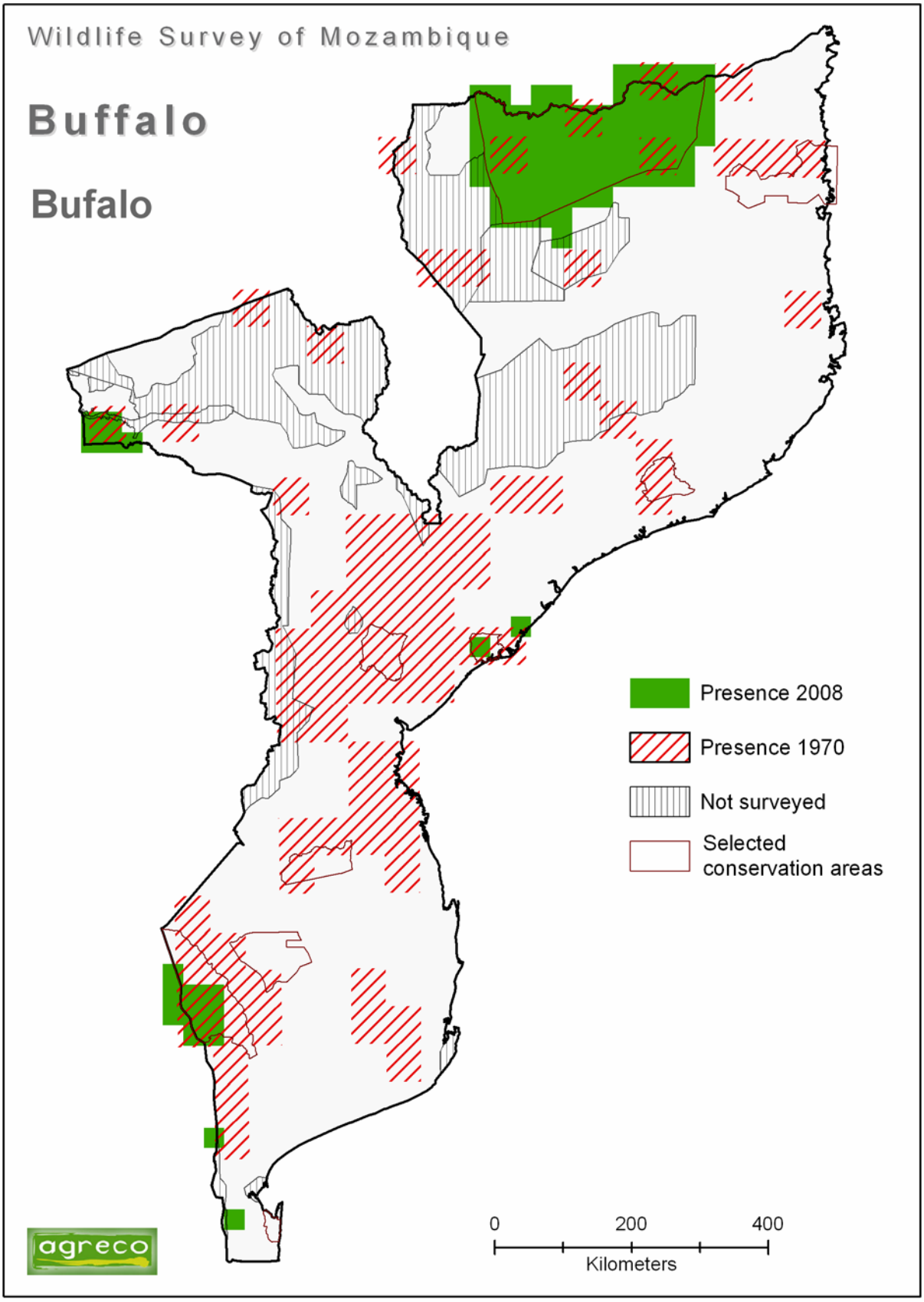
Both the hippopotamus and crocodile live in large rivers or lakes. While the crocodile is largely confined to the close proximity of water (although some individuals will travel some considerable distances overland between water bodies), the hippopotamus comes on to land at night to feed. Both species cause human-wildlife conflicts and consequently both species are unpopular with rural communities and many of these people would like to see these species removed from their district, or at least have their numbers reduced.

The removal of hippos and large crocodiles from areas where they cause conflicts is often recommended (for example, Anderson & Pariela, 2005; Ghiurghi & Pariela, 2007). Reducing the number of these species outside protected areas assumes that viable populations exist in protected areas. This assumption needs to be tested. In fact, many protected areas on Mozambique have major rivers as one of their boundaries (for example, hippos in Zinave NP inhabit the Save River which is the northern boundary of the park; Rovuma river is the northern boundary of Niassa Reserve; the Limpopo and Elefantes Rivers are the eastern and southern boundaries of Limpopo NP; and a river forms the de facto south-eastern boundary of Gorongosa NP. Hence, hippos or crocodiles living in rivers that form the boundaries of protected areas are still likely to cause conflicts with people. Furthermore, Lake Cabora

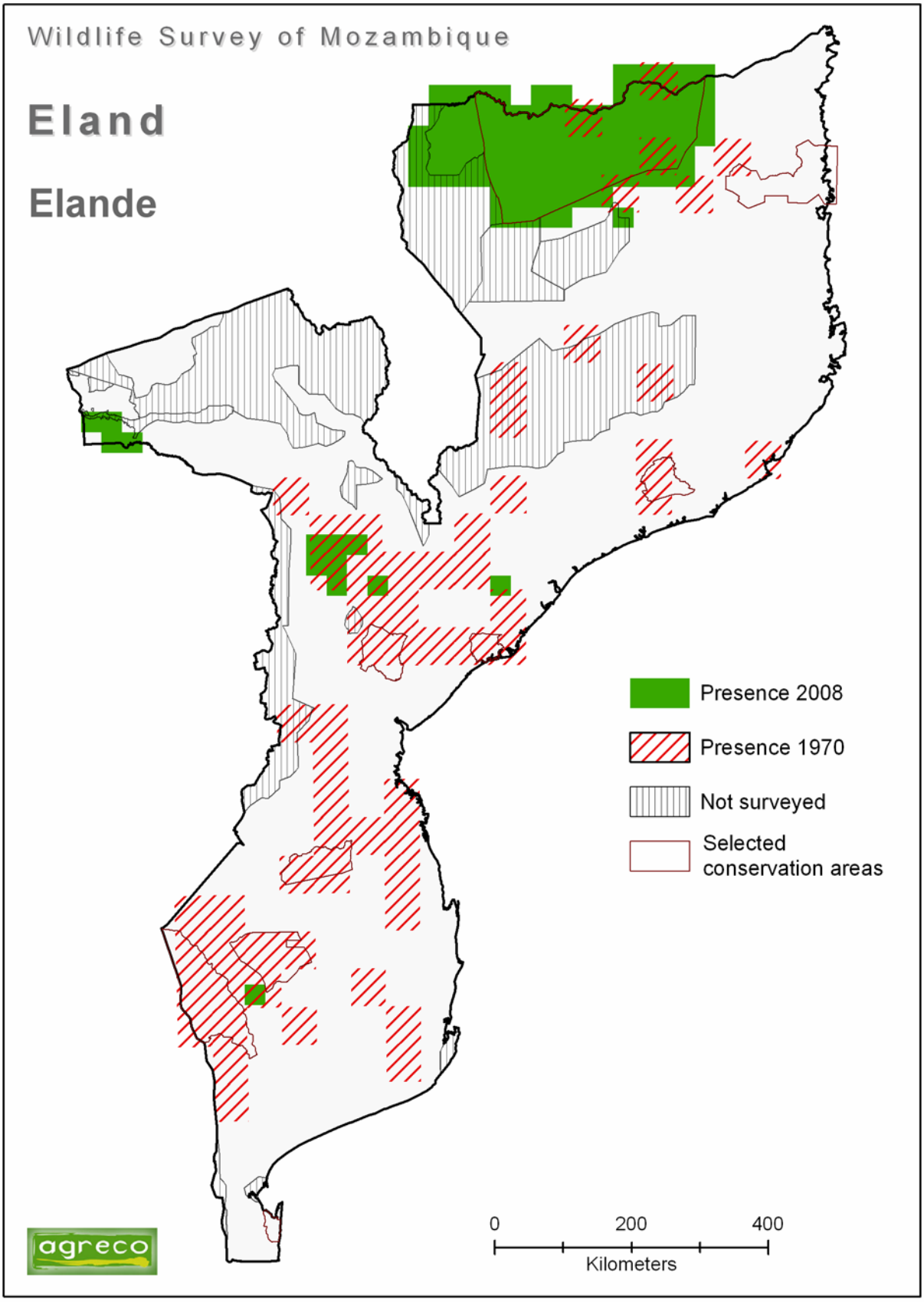
Bassa, which is capable of supporting large numbers of both hippopotamus and crocodile, is outside all of Mozambique's protected areas. In the light of this:

6.5.3 Crocodile conservation

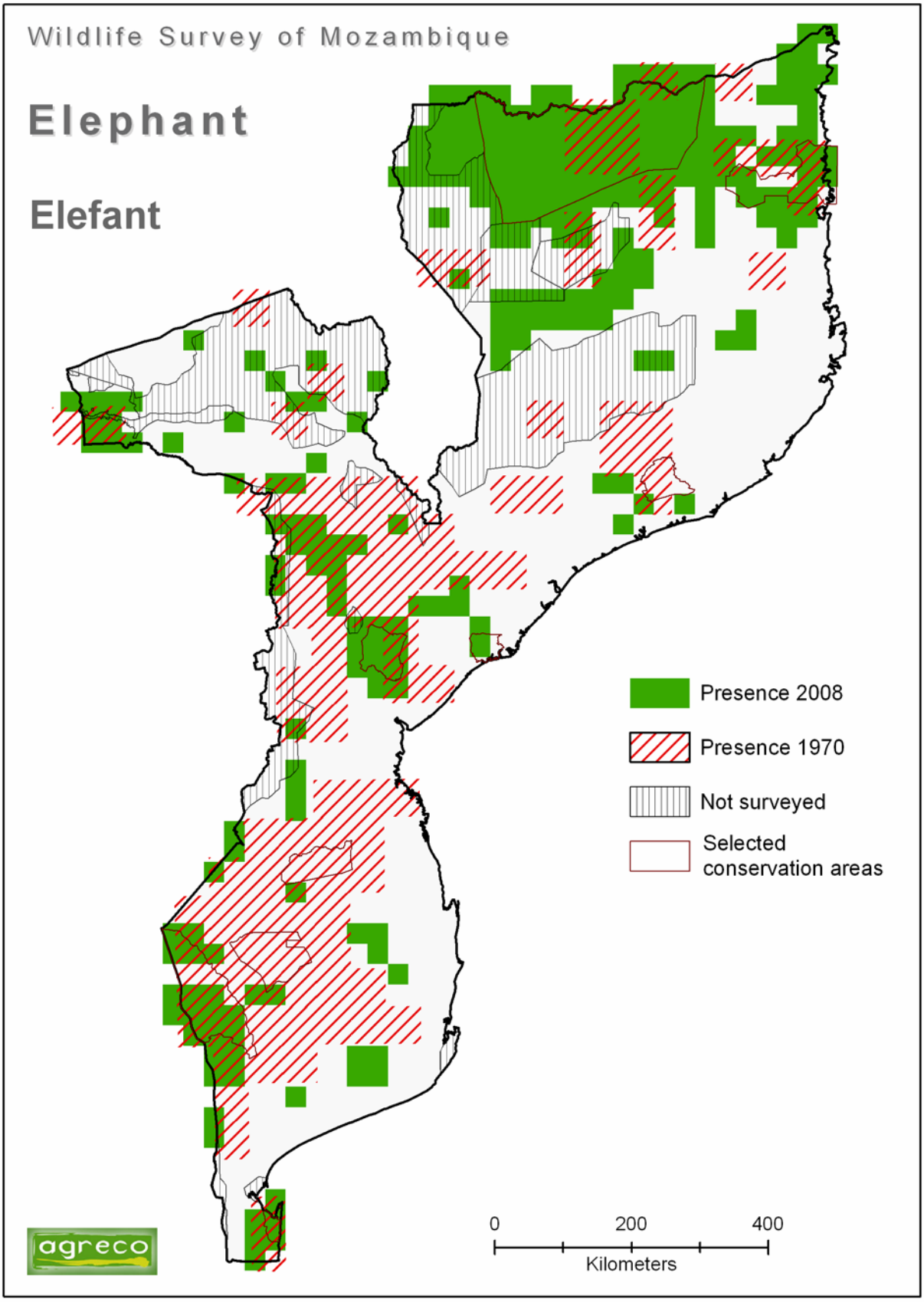
One recommendation for resolving human-crocodile conflict is the removal of large crocodiles from waters in rural areas where they are causing conflict. For example, Ghiurghi & Pariela (2007) suggested the removal of crocodiles longer than approximately 2.5 m. While this is a valid means of dealing with human-crocodile conflict, those implementing it should be aware that it is the large crocodiles that form the breeding population. Hence, the removal of all large crocodiles would probably prevent future recruitment to that population. Thus, the consequences of removing all large crocodiles from a population would, in the long term, be similar to removing all crocodiles.



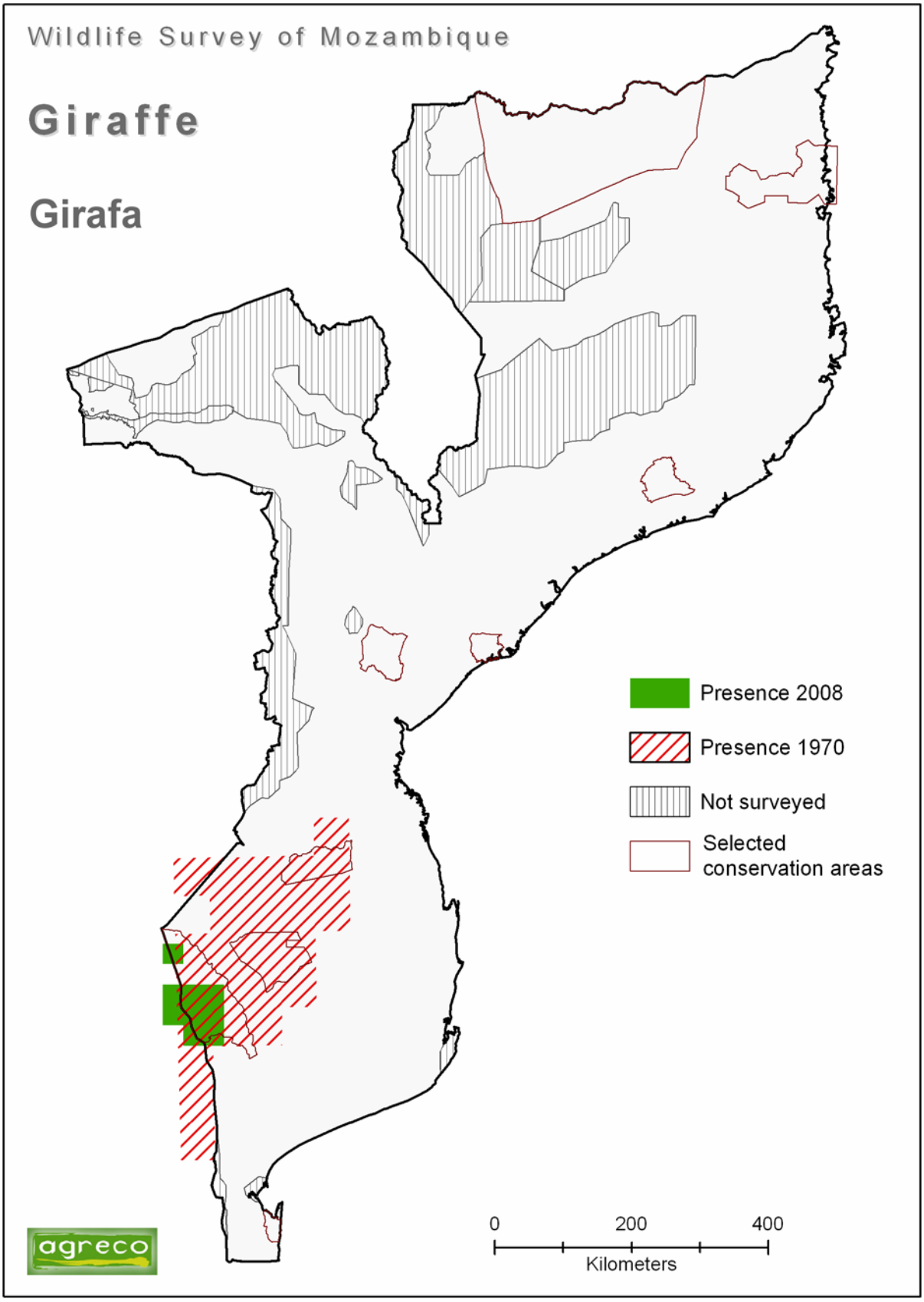
Map 46. Changes in buffalo distribution in Mozambique since the pre-1970s
Grid cells coloured green are those where this species were recorded recently, while the red-striped cells are those where elephants were recorded by Smithers & Lobão Tello (1976) prior to the 1970s.



Map 47. Changes in eland distribution in Mozambique since the pre-1970s
Grid cells coloured green are those where this species were recorded recently, while the red-striped cells are those where elephants were recorded by Smithers & Lobão Tello (1976) prior to the 1970s.

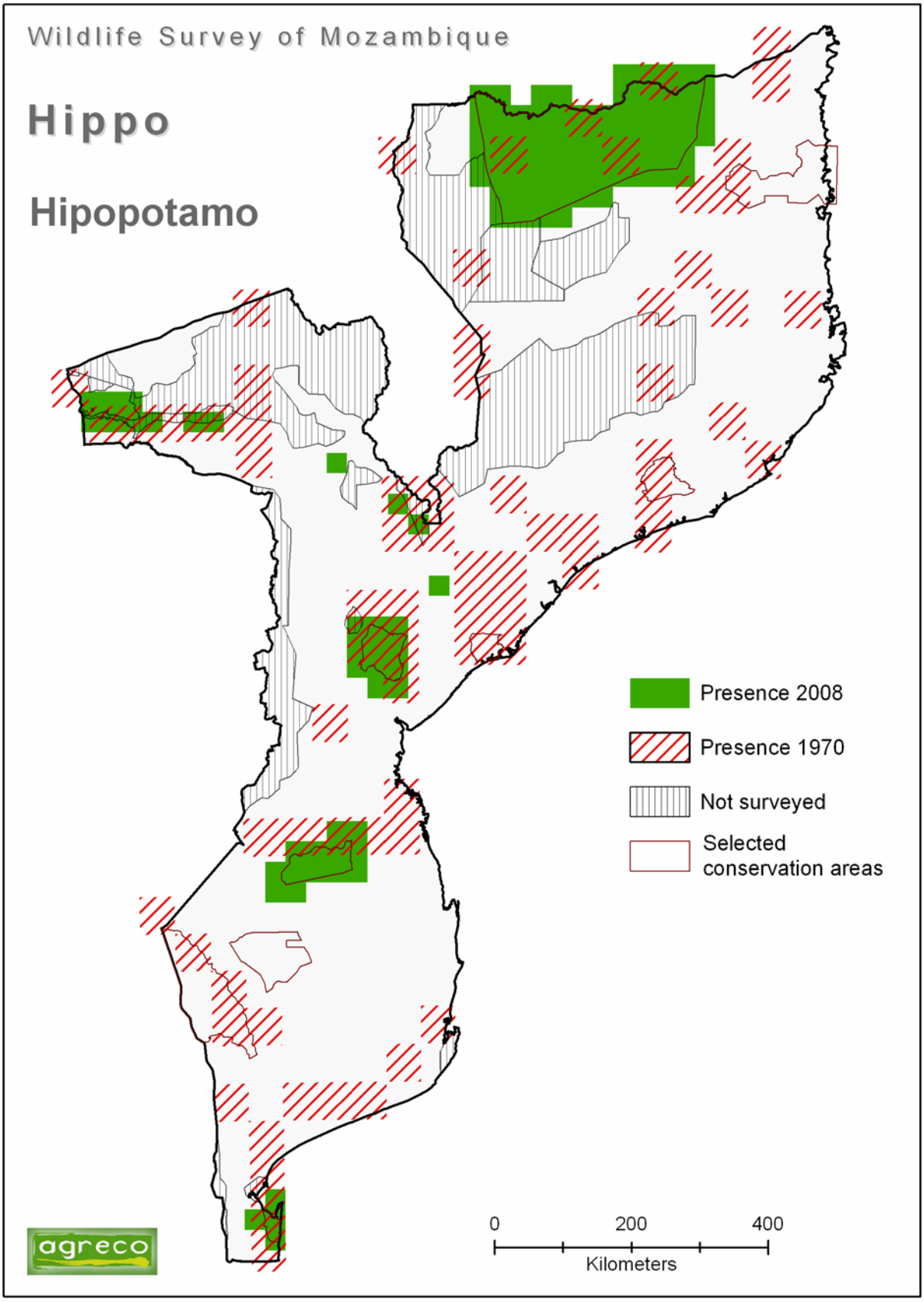


Map 48. Changes in elephant distribution in Mozambique since the pre-1970s
Grid cells coloured green are those where elephants were recorded recently, while the red-striped cells are those where elephants were recorded by Smithers & Lobão Tello (1976) prior to the 1970s.

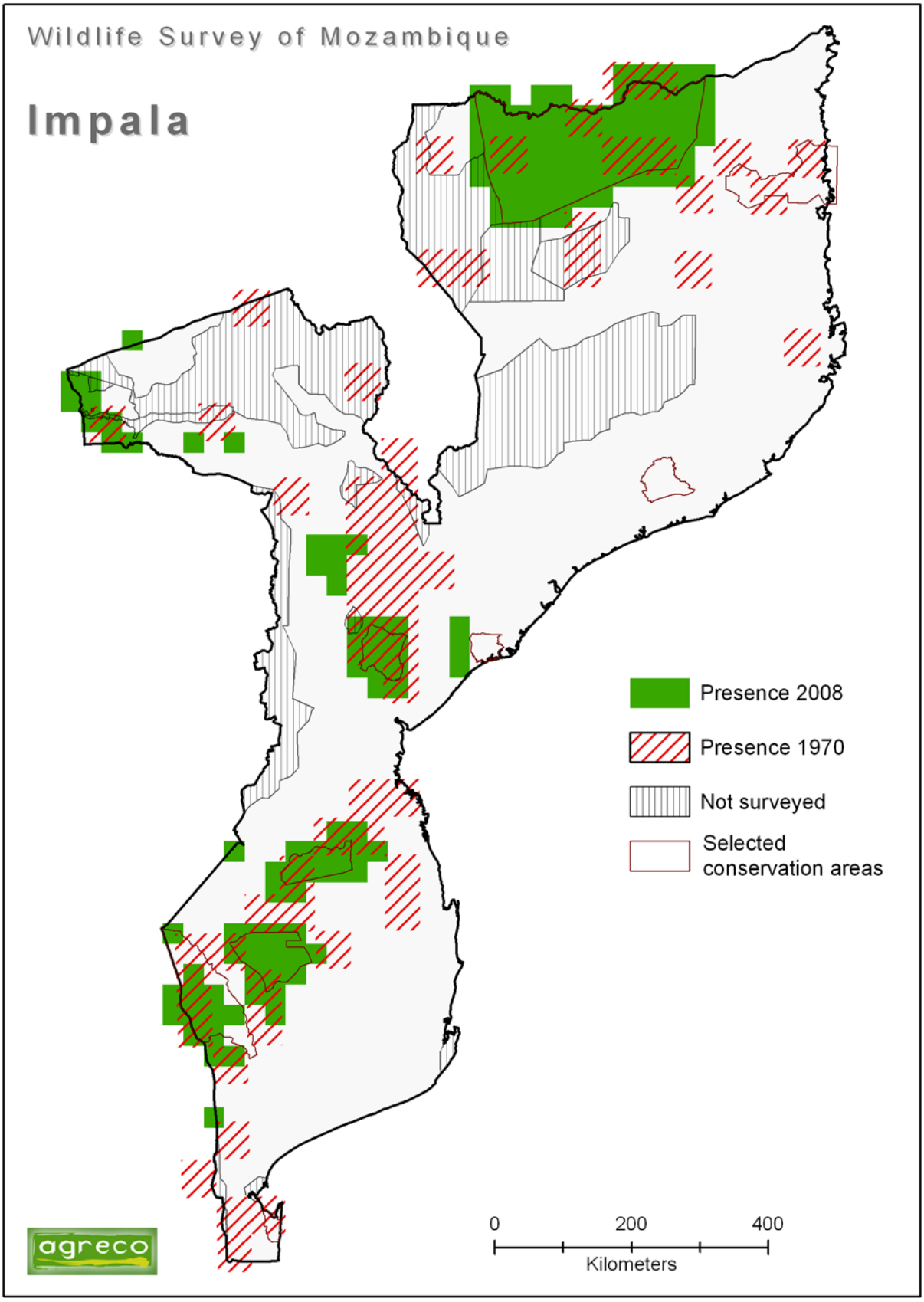


Map 49. Changes in giraffe distribution in Mozambique since the pre-1970s

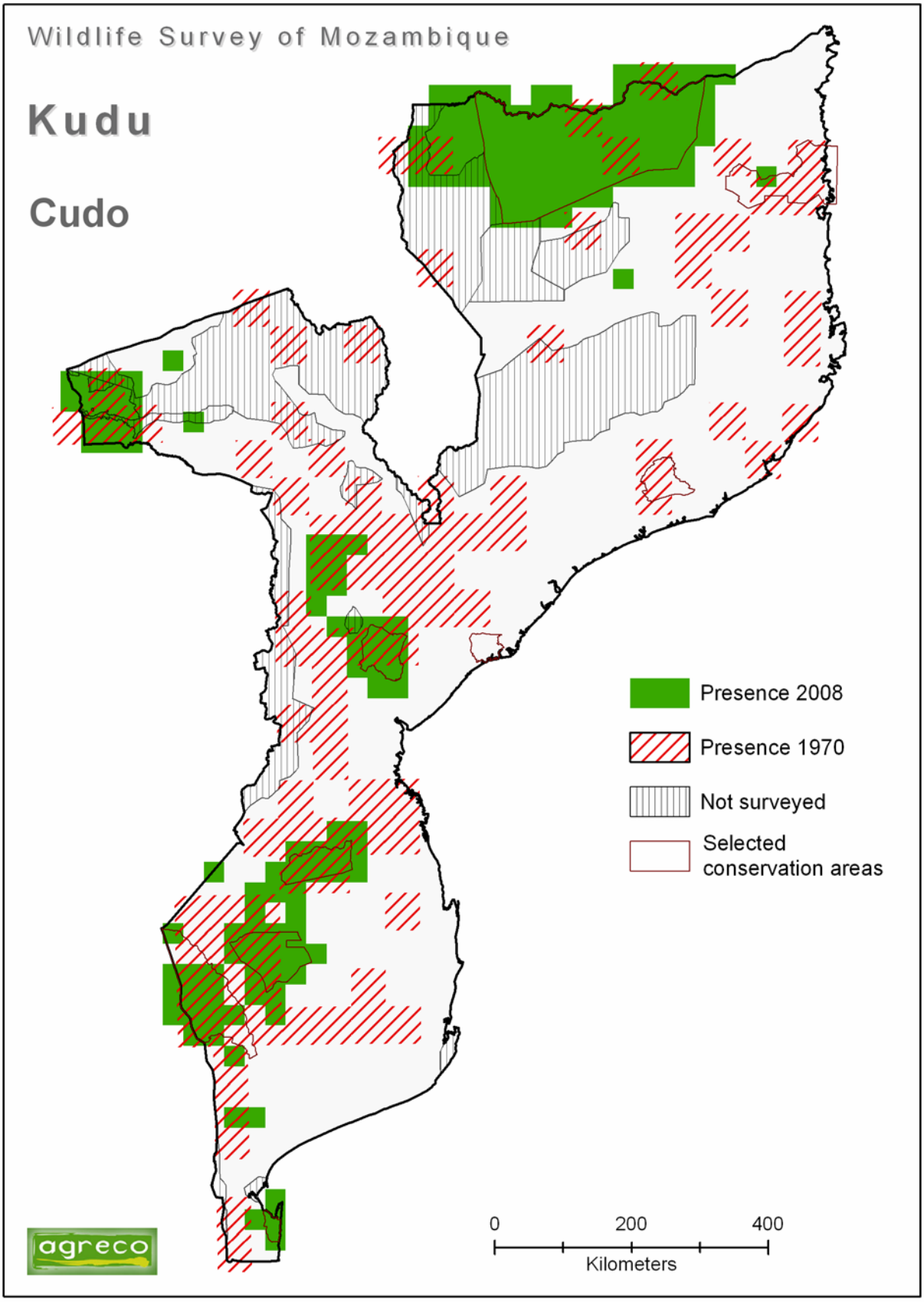
Grid cells coloured green are those where this species was observed during recent aerial surveys, while the red-striped cells are those where the species was recorded by Smithers & Lobão Tello (1976) prior to the 1970s.



Map 50. Changes in hippopotamus distribution in Mozambique since the pre-1970s
Grid cells coloured green are those where this species was observed during recent aerial surveys, while the red-striped cells are those where the species was recorded by Smithers & Lobão Tello (1976) prior to the 1970s.

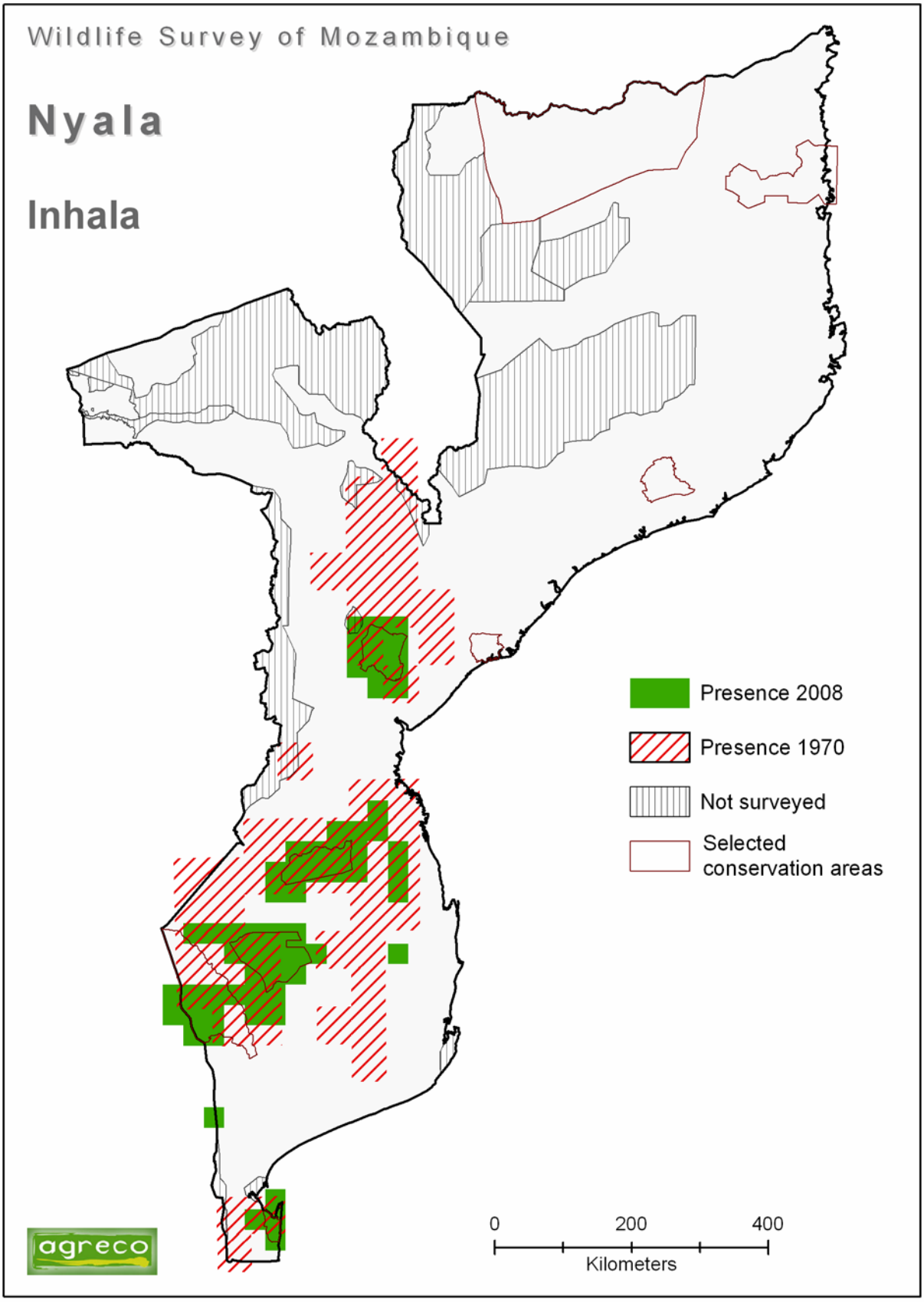


Map 51. Changes in impala distribution in Mozambique since the pre-1970s
Grid cells coloured green are those where this species was observed during recent aerial surveys, while the red-striped cells are those where the species was recorded by Smithers & Lobão Tello (1976) prior to the 1970s.



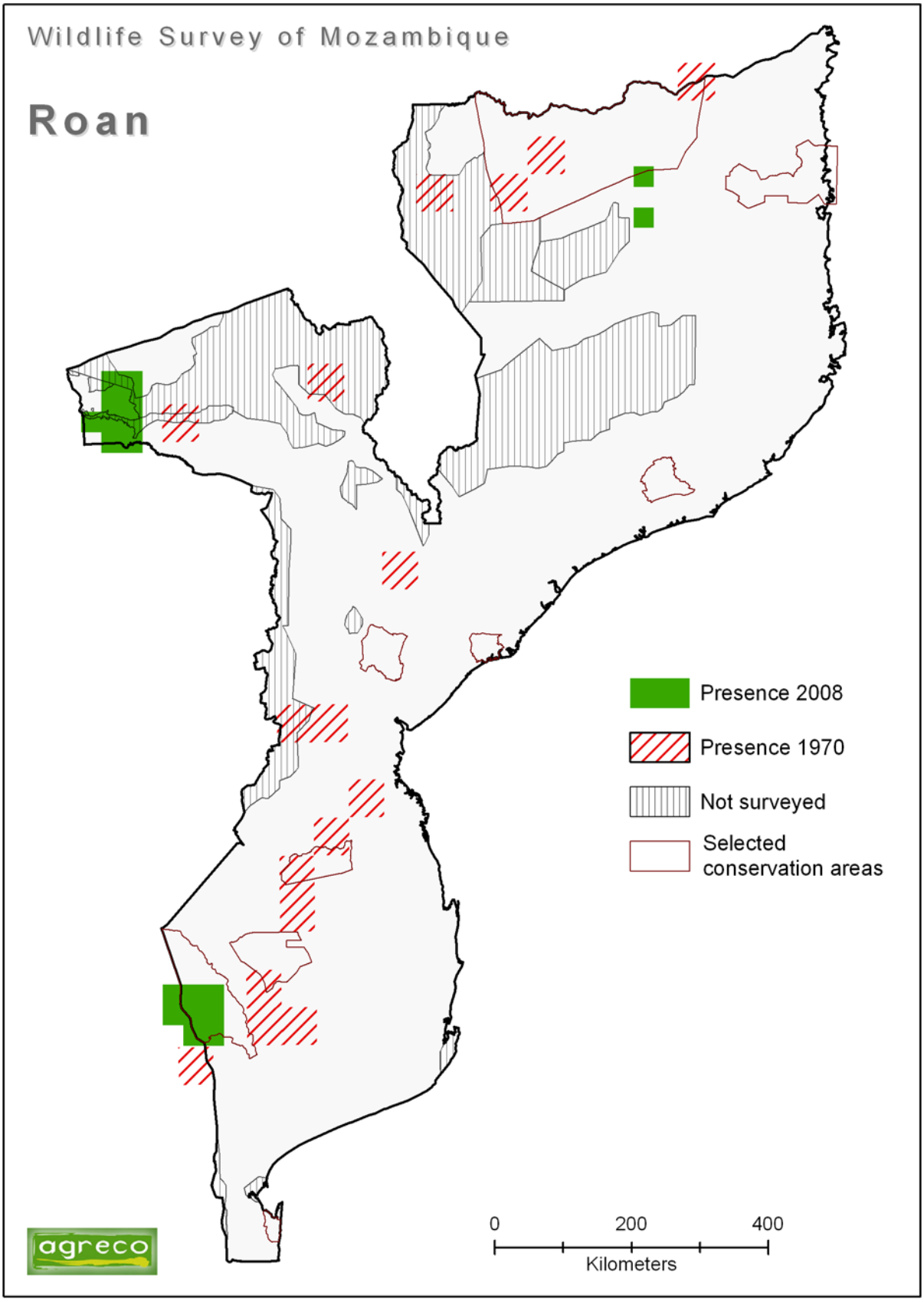
Map 52. Changes in kudu distribution in Mozambique since the pre-1970s

Grid cells coloured green are those where this species was observed during recent aerial surveys, while the red-striped cells are those where the species was recorded by Smithers & Lobão Tello (1976) prior to the 1970s.



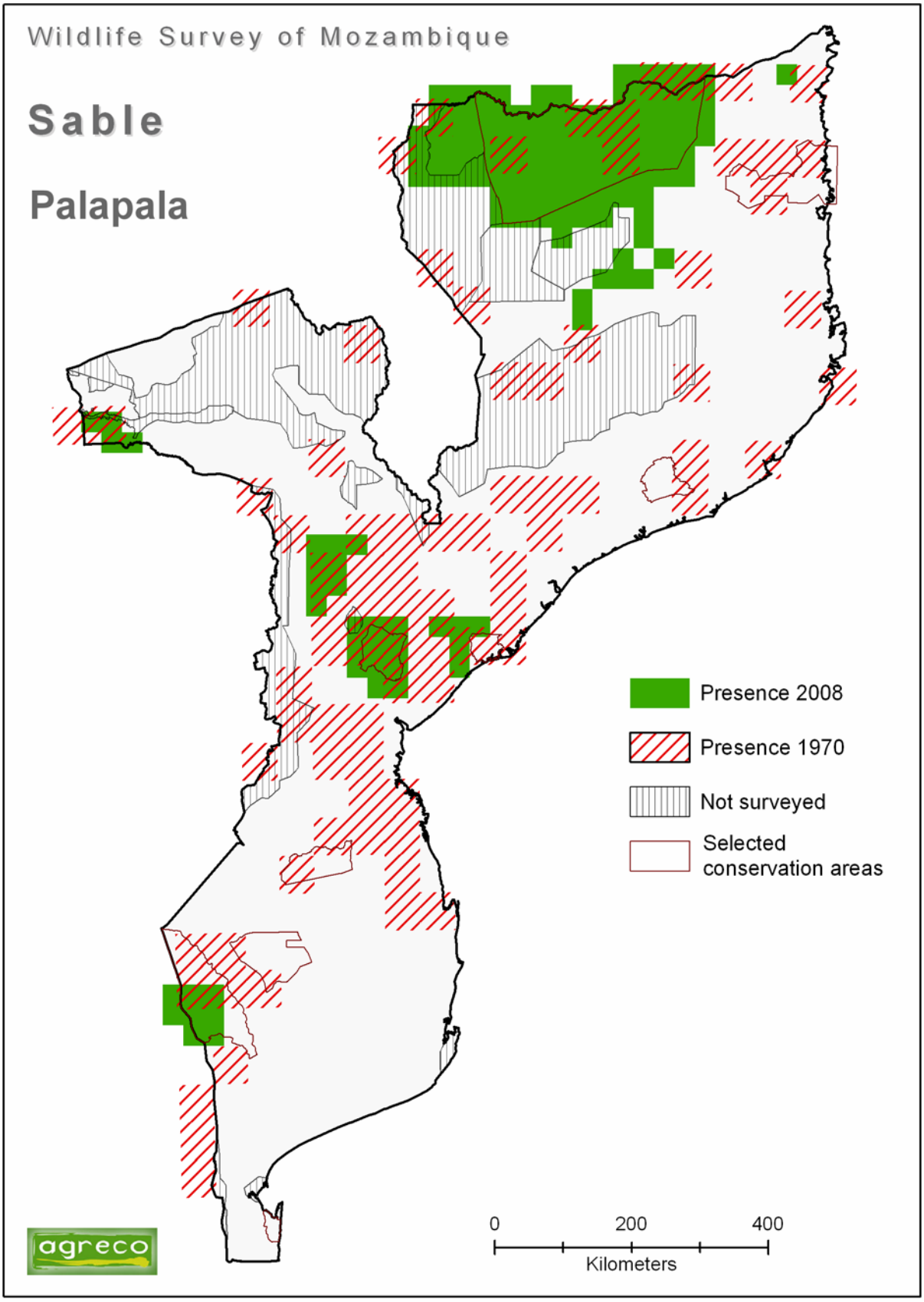
Map 53. Changes in nyala distribution in Mozambique since the pre-1970s

Grid cells coloured green are those where this species was observed during recent aerial surveys, while the red-striped cells are those where the species was recorded by Smithers & Lobão Tello (1976) prior to the 1970s.



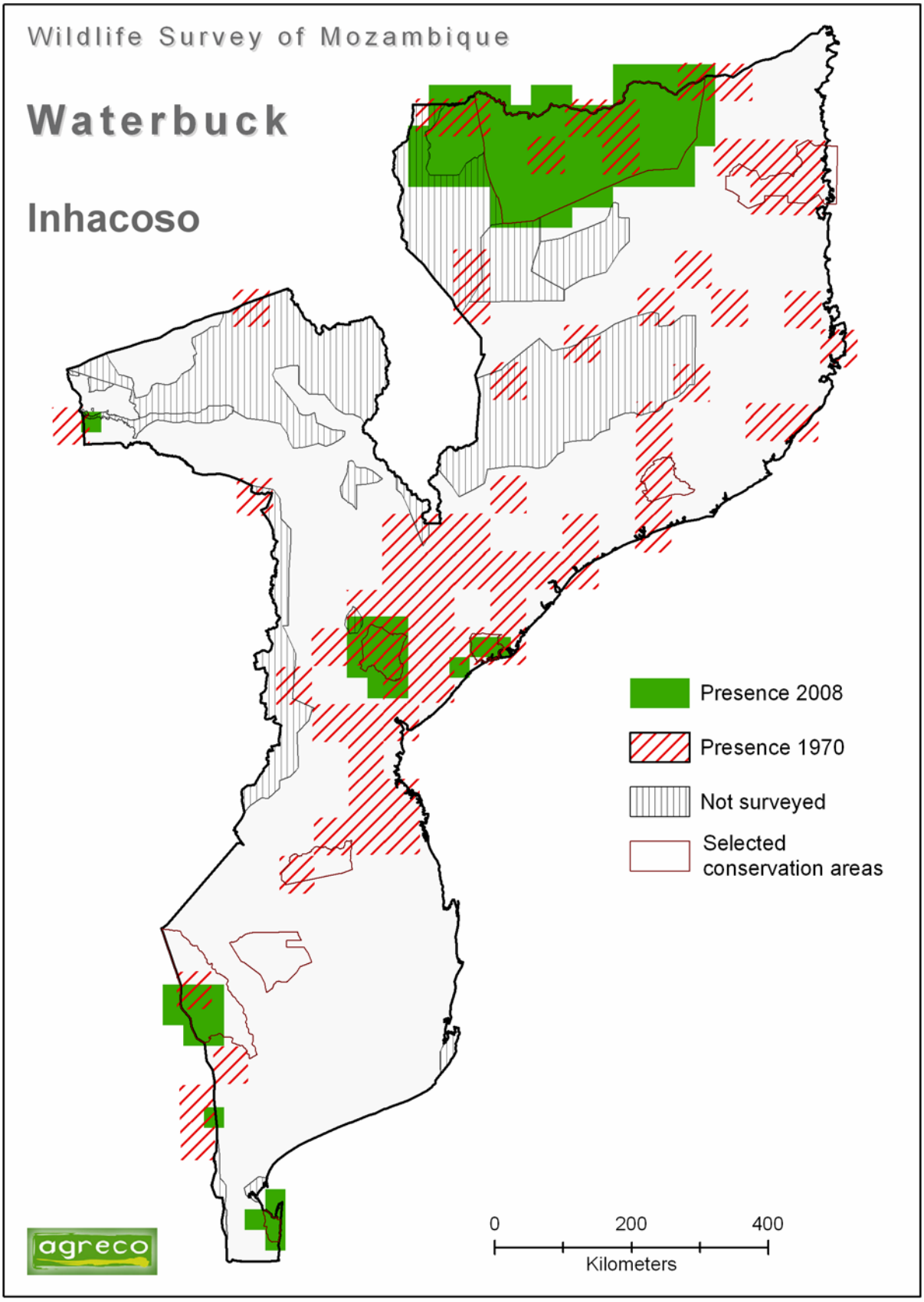
Map 54. Changes in roan distribution in Mozambique since the pre-1970s

Grid cells coloured green are those where this species was observed during recent aerial surveys, while the red-striped cells are those where the species was recorded by Smithers & Lobão Tello (1976) prior to the 1970s.

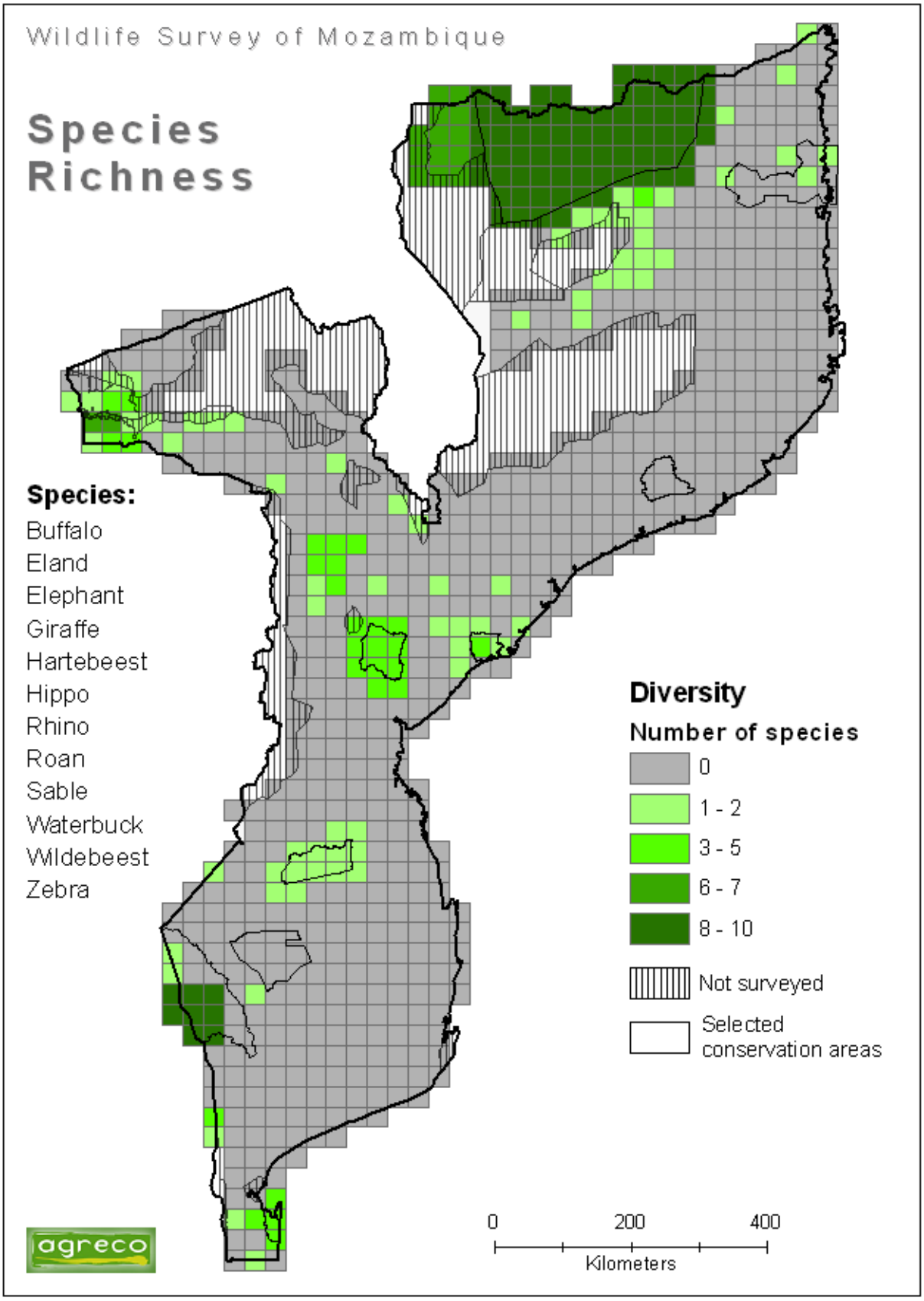


Map 55. Changes in sable distribution in Mozambique since the pre-1970s

Grid cells coloured green are those where this species was observed during recent aerial surveys, while the red-striped cells are those where the species was recorded by Smithers & Lobão Tello (1976) prior to the 1970s.

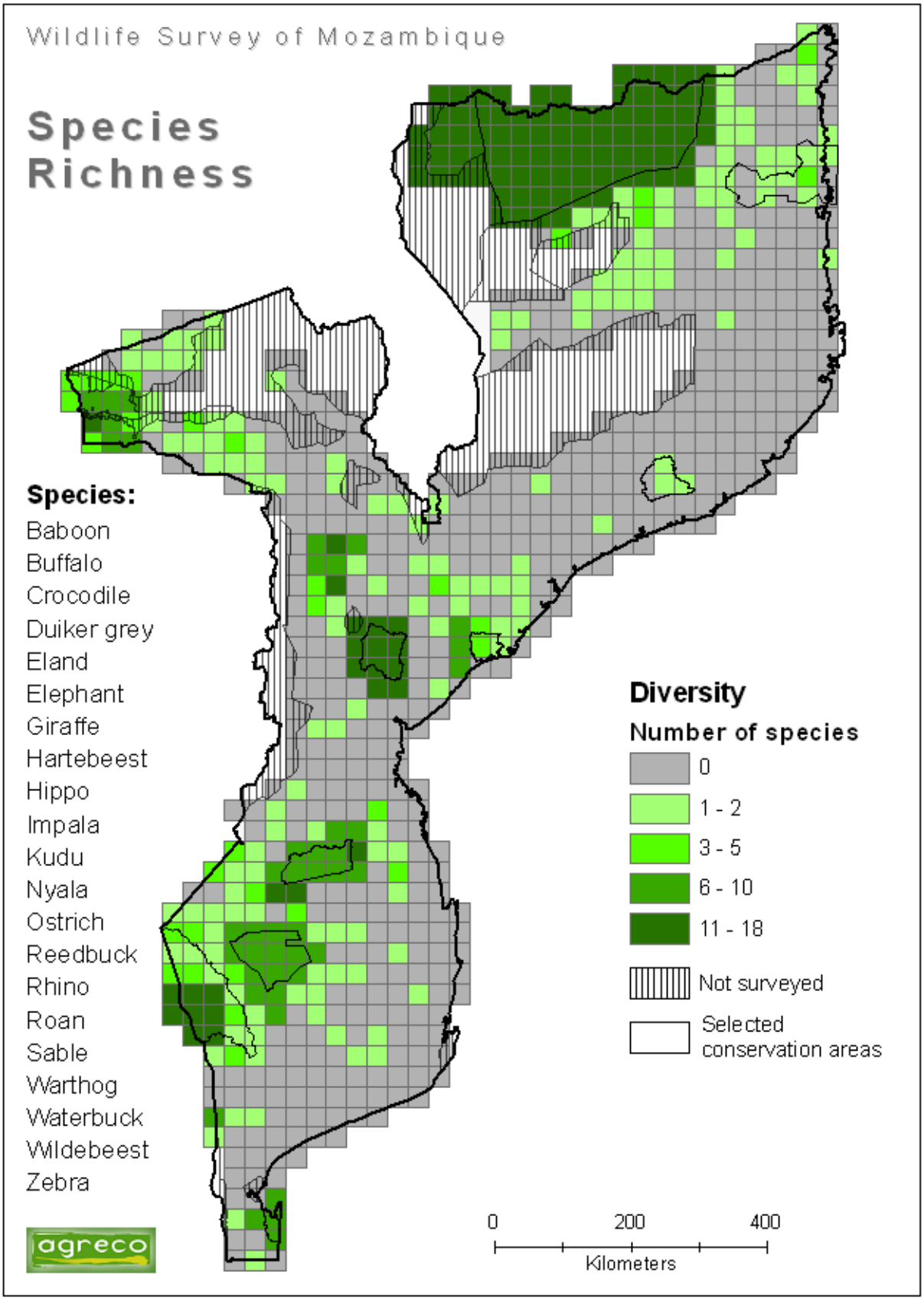


Map 56. Changes in waterbuck distribution in Mozambique since the pre-1970s
Grid cells coloured green are those where this species was observed during recent aerial surveys, while the red-striped cells are those where the species was recorded by Smithers & Lobão Tello (1976) prior to the 1970s.



Map 57. Species richness of largest species of wildlife in Mozambique

Each map square is coloured to indicate the number of the largest wildlife species (listed on left) that were seen in that square during the 2008 aerial survey and during earlier surveys of some conservation areas.



Map 58. Species richness of wildlife species across Mozambique

Each map square is coloured to indicate the number of wildlife species (listed on left) seen in that square during the 2008 aerial survey and during earlier surveys of conservation areas.

7 Conclusions and Recommendations

7.1.1 Status of Wildlife

The density distribution maps and the species-specific statements about the past and current distribution of wildlife in Mozambique reveal several common themes:

- most wildlife species now have a much more restricted distribution in Mozambique than they did 40+ years ago;
- many species occur at relatively high density in conservation areas and at low density (if at all) outside protected areas;
- a significant proportion of the national populations of many of the larger species of wildlife is in Niassa Reserve and its adjacent hunting areas (the Niassa survey area contained more than 40 % of the estimated national populations of buffalo, eland, elephant, hartebeest, sable, warthog, wildebeest and zebra); and
- the Limpopo NP is a relatively new national park, where many species of wildlife have been reintroduced and which contains almost the entire Mozambican population of some wildlife species, for example giraffe and white rhinoceros.

7.1.2 Human-crocodile conflict

This study has revealed that:

- crocodiles killed more people each year in Mozambique than did all the other species of wildlife combined;
- attacks on people by crocodiles occurred in more districts of Mozambique (46 districts) than did attacks by any other wildlife species; and
- the number of people killed annually by crocodiles has increased during the past decade.

Crocodiles attack people and domestic livestock in order to eat them. Large mammals are a significant component of the diet of large crocodiles, and crocodiles view humans as just another species of large mammal that can be eaten.

Unlike the other large species causing conflicts (elephant, hippopotamus and lion), crocodiles are largely confined to water. Hence, the places where there is a likelihood of people being attacked are more predictable for crocodiles than for other conflict species. But although crocodiles can grow longer than 5 m, such large crocodiles can easily hide underwater. Thus, people may approach a river or lake without realising that a large and potentially dangerous animal is hidden close by.

While the DNTF records note the numbers of people killed by wildlife, the circumstances of their death (for example, the activity in which the people were engaged immediately prior to be attacked) are not included. Knowing the circumstances in which people are killed by wildlife is a prerequisite to proposing actions that might reduce the number of deaths.

A retrospective study of human-carnivore conflicts in Niassa Reserve found that, of 51 people killed by crocodiles: 55 % were fishing with nets or traps immediately prior to their death; 4 % were fishing with rod and line; 19 % were bathing; 14 % were wading across rivers; 4 % were swimming; 2 % were collecting water; and 2 % fell out of a canoe (Begg *et al*., 2007). Begg *et al*. (2007) reported that, owing to the danger that crocodiles posed to people and the damage that they caused to fishing nets, the residents of Niassa Reserve opportunistically killed crocodiles and destroyed their nests.

Protective barriers or wells adjacent to a river allow people to collect water or bathe without exposing themselves to crocodile attack. But the above figures from Niassa Reserve suggest that just 21 % of the people killed by crocodiles (those bathing or collecting water) might have been saved if wells or protective barriers had been used. Many people that died in the reserve were attacked whilst in the water, fishing. Presumably they wanted fish as food for themselves and their family, or for sale. Presumably also, these people knew that they were

risking a crocodile attack (although they may have underestimated the risk), but took the risk because alternative foods or livelihoods were lacking. In other words, these people were killed by crocodiles because they were too poor to feed their family in a manner that did not expose them to the risk of being killed by a crocodile. This provides an example of one of the links between human-wildlife conflict and poverty.

Anderson & Pariela (2005) recommended that crocodiles should be removed from waters that no longer contain enough natural food to sustain viable populations of adult crocodiles.

- It is recommended that a national conservation strategy for crocodile should consider:
    1. the long term consequences for conservation of the species in Mozambique, of removing large crocodiles from populations in communal areas; and
    2. the scope for the conservation of viable populations of this species in rivers or lakes well inside protected areas, instead of only along the borders of protected areas.

7.1.3 Human-elephant conflict

This study has revealed that:

- elephants killed or injured fewer people each year in Mozambique than did crocodiles, with elephants being responsible for 15 % of human deaths and 7 % of injuries caused by wildlife;
- attacks on people by elephants were concentrated largely in parts of northern Mozambique;
- crop-raiding by elephants was more widespread (reported in 46 districts) than were elephant attacks on people (22 districts);
- elephants raided crops more frequently during March-October than during other months of the year;
- elephants were killed in response to conflicts more frequently during March-October (the period when crops ripen and are harvested) than during other months of the year;
- the number of elephants killed in response to conflicts was greater than for any other species of wildlife, with elephants forming 31 % of problem animals killed; and
- the number of elephants killed annually in response to conflicts increased during the last decade.

Elsewhere in Africa, there has been extensive research into human-elephant conflicts (e.g. Barnes *et al*., 2005; Boafo *et al*., 2004; Chiyo *et al*., 2005; Hoare & Du Toit, 1999; Hoare, 2000, 2001; O'Connell-Rodwell *et al*., 2000; Oppong *et al*., 2008; Osborn, 2004; Osborn & Parker, 2002, 2006; Sam *et al*., 2005; Sitati & Walpole, 2006; Sitati *et al*., 2003, 2005). Despite this, dealing with problem elephants and their effects on people is one of the most difficult problems facing wildlife managers (Hoare, 2001).

Anderson & Pariela (2005) noted that there were a relatively high number of wounded elephants in Mozambique as a result of poaching and community hunters with inappropriate weapons. Wounded elephants are likely to become rogue animals, thereby increasing the likelihood of people being attacked by elephants. Anderson & Pariela (2005) recommended that land use plans should be developed for districts where elephant are a problem. They suggested that these plans consider the possibility of creating areas where elephants can be sustainably managed to provide benefits for the local communities without competing with people for the same resources. The plans should also consider areas where there may have to be no elephants.

7.1.4 Human-lion conflict

This study has revealed that:

- lions attacked people in relatively few districts of Mozambique (6 districts);

- lions killed or injured fewer people each year in Mozambique than did crocodiles, with lions being responsible for 12 % of human deaths and 24 % of injuries caused by wildlife;
- although, in terms of their attacks on people, lions were less of a problem than crocodiles, this was true only at the national level;
- in the districts where lion attacks on people were recorded, there were an average of 7.3 attacks per district over 27 months, which was twice the number of attacks by crocodiles (average of 3.7 attacks on people per district);
- lions attacked people more frequently during March-August than during other months of the year;
- the number of people killed by lions apparently increased during the last decade;
- lions were the major predator of domestic livestock, being responsible for killing 81 % of the cattle and 62 % of the goats recorded killed, as well as killing some sheep, chickens and domestic dogs; and
- the killing of domestic animals by lions was a more widespread conflict (reported in 12 districts) than lion attacks on people.

Begg *et al*. (2007) noted that 11 people were killed and 17 injured by lions in Niassa Reserve during the six years preceding their study. Anderson & Pariela (2005) suggested that human-lion conflicts should be managed by killing lions outside conservation areas or coutadas, and that in areas where conflicts are numerous, pre-emptive management of lions in adjoining conservation areas should be considered. In districts where the killing of domestic livestock is a much more serious conflict than attacks on people, improvements in animal husbandry can reduce the likelihood of conflict (Ogada *et al*., 2003).

7.1.5 Human-hippopotamus conflict

This study has revealed that:

- hippos attacked people in relatively few districts of Mozambique (8 districts);
- hippos were responsible for 6 % of human deaths and 12 % of injuries caused by wildlife;
- crop-raiding by hippos was a more widespread conflict (reported in 28 districts) than hippo attacks on people;
- crop-raiding by hippos occurred throughout the year;
- people living in the vicinity of large rivers or lakes regarded human-crocodile conflicts as a more serious problem than human-hippo conflicts; and
- the number of hippos killed annually in response to conflicts increased three-fold during the last decade.

Anderson & Pariela (2005) recommended land use planning to determine where hippos could be conserved outside conservation areas and where hippos were incompatible with the needs of people and therefore should be removed. They recommended also the construction of barriers to exclude hippo from crops (a strong barrier approximately 60 cm above the ground will exclude hippos, which are unable to leap and can step over only low items). Sisal hedges are an alternative barrier.

- It is recommended that a national conservation strategy for the hippopotamus should consider the scope for the conservation of viable populations of this species in rivers or lakes well inside protected areas, instead of only along the borders of protected areas.

7.1.6 Human-buffalo conflict

This study has revealed that:

- reported human-buffalo conflicts were concentrated in districts that included Limpopo NP, or were adjacent to Limpopo NP or South Africa's Kruger NP; and

- at the national level, the buffalo appeared to be a minor conflict species, being responsible for the death of one person (0.5 % of people killed by wildlife) and injuries to seven people (9 % of recorded injuries). Eleven buffaloes were killed (4 % of large animals killed in response to conflicts), with three of them apparently killed in response to crop damage.

Although the DNTF records suggested that the buffalo was a minor conflict species, it has the potential to cause conflicts that would not be noted in the DNTF records. This is because buffalo and domestic cattle often share diseases, for example, foot and mouth disease, corridor disease, brucellosis and bovine tuberculosis. Anderson & Pariela (2005) reported that 228 cattle died during January to October 2005 near Limpopo NP from corridor disease (transmitted by ticks) that was contracted from buffalo. The number that died can be compared with the 139 cattle reported killed by lions or crocodiles throughout Mozambique during the 27 months covered by the DNTF records. Anderson & Pariela (2005) encouraged the development of a policy that ensured that cattle and buffalo in southern Mozambique were geographically separated from one another.

7.1.7 Human-hyaena conflict

This study has revealed that:

- reported human-hyaena conflicts were in districts adjacent to Zimbabwe's Gonarezhou NP, or South Africa's Kruger NP; and
- at the national level, the spotted hyaena was a minor conflict species, with no reports of people killed or injured by hyaenas during the 27 months of records, and hyaenas being responsible for killing two cattle (1 % of cattle reported killed by wild animals) and 12 goats (9 % of goats reported killed). No hyaenas were reported killed in response to conflicts.

Nevertheless, Begg *et al*. (2007) reported that nine people were injured and four killed by spotted hyaenas in Niassa Reserve during the last 14 years and Anderson & Pariela (2005) noted that 'hyaena problems' were reported from the north-west of Niassa province. Anderson & Pariela (2005) and Begg *et al*. (2007) noted that hyaena conflicts were often not geographically widespread and that problems might be caused by a single clan of hyaenas. The removal of a problem clan might be sufficient to mitigate human-hyaena conflict.

7.1.8 Human-leopard conflict

This study has revealed that:

- the leopard was a minor conflict species, with no reports of people or domestic livestock being killed or injured by leopards during the 27 months of DNTF records. But one leopard was killed in response to a conflict.

The idea that the leopard is a relatively minor conflict species is supported by the report of Begg *et al*. (2007), which noted that two people were injured (and none killed) by leopards in Niassa Reserve during recent years.

7.1.9 Human-wildlife conflict with other species

This report has concentrated on human-wildlife conflicts generated by large species of wildlife. In part, this reflects the terms of reference of the project. But even when local people were asked about the seriousness of conflicts generated by different species (or groups) of wildlife, they regarded the most serious conflicts as those generated by the large species. Bushpigs, baboons, monkeys and birds sometimes damaged crops, but perhaps these conflicts were regarded as less serious because the local people were able to deal with them without the risk that they would be killed by the animals causing the conflict.

7.1.10 Human-wildlife conflict generally

This study has revealed that:

- conflicts are common in the districts that border South Africa's Kruger NP and Zimbabwe's Gonarezhou NP;
- local people throughout Mozambique believed that they received no benefits from the wildlife in their district, except occasionally when they received meat from animals shot in response to human-wildlife conflicts, or when they obtained small species in the form of bush meat;
- not surprisingly, local people believed that the elimination of problem species, or at least a reduction in their numbers, was the most appropriate way of dealing with human-wildlife conflicts;
- local people believed that human-wildlife conflicts were becoming more frequent; and
- the available data also suggested that conflicts generally have increased during the past decade (although the completeness of the dataset is uncertain).

If large animals in Mozambique are to survive outside conservation areas, then probably the benefits to the local people of living with wildlife must exceed:

- the costs of living with wildlife; *and*
- the benefits of living without wildlife.

Human-wildlife conflict represents the cost to local people of living with wildlife and so reducing the incidence of conflicts reduces these costs. But it is important to note that even if all conflicts in a district were eliminated (without exterminating the wildlife), this simply removes the costs to the local people of living with wildlife – it does not provide them with any benefits from living with wildlife.

After much study of human-elephant conflict across Africa, the IUCN SSC African Elephant Specialist Group (Undated) concluded that the key to successful mitigation of conflict lay in enabling and empowering local people to take greater responsibility for the management of conflict problems. In the longer term, the focus must shift towards what the AfESG described as the 'root causes' of conflict such as poor land use planning and the lack of benefits from wildlife for those who bear most of the costs of living with it. Mozambique's national elephant management strategy (DNFFB, 1999) also emphasized the need to develop and implement land use plans.

After analysis of three studies of human-wildlife conflict, WWF (2008) also concluded that improved land use planning and its strict implementation can reduce conflict, by ensuring both humans and animals have the space they need, ensuring that key areas for wildlife (such as core habitats and corridors) are secured and by ensuring that land uses likely to generate human-wildlife conflict are kept far from, or buffered from, wildlife habitats.

Providing local people with significant benefits from living alongside large and potentially dangerous wildlife is not easy. But often it is assumed that the first step is to permit local communities to manage directly their own natural resources and to benefit financially from this management. In a few areas of Africa, where the density, variety and visibility of large mammals are all high, non-consumptive tourism, including ecotourism, may provide significant financial returns. But in much of Africa, including many communal lands, the density and visibility of wildlife are low. In these areas, significant financial returns from wildlife are possible only from consumptive utilization, such as safari hunting. Trophy hunting by foreigners – especially of elephant, but also of buffalo, lion and leopard - is the form of consumptive utilization that provides the greatest financial returns. But if these benefits are to offset the costs to the local people of living with wildlife, then the bulk of the financial benefits must go to the individuals who actually incur the costs of living alongside the wildlife. Currently, local communities receive only 20 % of revenues from the sale of hunting licences and Anderson & Pariela (2005) recommended that this percentage should be increased.

7.1.11 Human-wildlife conflict: more information needed

The considerable research by the IUCN SSC AfESG on human-elephant conflict has emphasised the importance of extensive information gathering about conflicts as a prelude to attempts to mitigate or eliminate them. The DNTF records of human-wildlife conflicts provided general information on *what* occurred, *when* (to the nearest month) and *where* (to the nearest district) the conflict occurred. But they provide no information on *how* the conflict happened (for example, what a deceased was doing immediately prior to the conflict that resulted in their death) or *why* (for example, why the deceased was doing that). Obviously, without knowing the circumstances in which a person was killed by an animal, it is difficult to propose a means of preventing such conflicts.

8 References

Anderson, J.L. & Pariela, F. 2005. *Strategies to mitigate human-wildlife conflict in Moçambique*. Direcção Nacional de Florestas e Fauna Bravia. Maputo.

Barnes, R.F.W., Hema, E.M., Nandjui, A., Manford, M., Dubiure, U.F., Danquah, E. & Boafo, Y. 2005. Risk of crop raiding elephants around the Kakum Conservation Area, Ghana. *Pachyderm* **39**,19–25.

Begg, C., Begg, K. & Muemedi, O. 2007. *Preliminary data on human - carnivore conflict in Niassa National Reserve, Mozambique, particularly fatalities due to lion, spotted hyaena and crocodile*. Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa Moçambique.

Blanc, J.J., Barnes, R.F.W., Craig, G.C., Dublin, H.T., Thouless, C.R., Douglas-Hamilton, I. & Hart, J.A. 2007. *African elephant status report 2007: an update from the African elephant database*. Occasional paper series of the IUCN SSC, no. 33. IUCN/SSC African Elephant Specialist Group, IUCN. Gland, Switzerland.

Boafo, Y., Dubiure, U.F., Danquah, E., Manford, M., Nandjui, A., Hema, E.M., Barnes, R.F.W. & Bailey, B. 2004. Long-term management of crop raiding by elephants around Kakum Conservation Area in southern Ghana. *Pachyderm* **37**, 68–72.

Chardonnet, P. *et al*. 2008. *Conservation status of the lion (*Panthera leo*) in Mozambique. Phase 1: Preliminary survey*. Draft report submitted to IGF partners. IGF Foundation, DNAC/MITUR & CAMPFIRE Association.

Chiyo, P.I., Cochrane, P.E., Naughton, L. & Basuta, G.I. 2005. Temporal patterns of crop raiding by elephants: a response to changes in forage quality or crop availability? *African Journal of Ecology* **43**, 48–55.

Conybeare, A. 2005. *Aerial survey of wildlife on Coutada 9, Macossa District, Manica Province, Mozambique*. Unpublished report.

Craig, G.C. 2006. *Aerial survey of wildlife in the Niassa Reserve and surrounds, October 2006.* Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa. Maputo.

De Boer, W.F. & Ntumi, C.P. 2001. Elephant crop damage and electric fence construction in the Maputo Elephant Reserve, Mozambique. *Pachyderm* **30**, 57–64.

De Boer, W.F., Ntumi C.P., Correia A.U. & Mafuca, J.M. 2000. Diet and distribution of elephant in: the Maputo Elephant Reserve, Mozambique. *African Journal of Ecology* **38**, 188–201.

Direcção Nacional de Florestas e Fauna Bravia. 1999. *National strategy for the management of elephants in Mozambique*. Ministerio da Agricultura e Desenvolvimento Rural. Maputo.

Douglas-Hamilton I. & Burrill, A. 1991. Using elephant carcass ratios to determine population trends. In: *African Wildlife: Research and Management.* Eds Kayanja, F.I.B. & Edroma, E.L. pp. 98-105. International Council of Scientific Unions, Paris.

Dunham, K.M. 2004a. *Aerial survey of large herbivores in Gorongosa National Park, Mozambique: 2004.* Carr Foundation. USA.

Dunham, K.M. 2004b. *Aerial survey of elephants and other large herbivores in the Zambezi Heartland (Zimbabwe, Mozambique and Zambia): 2003*. African Wildlife Foundation. Kariba, Zimbabwe.

Dunham, K.M. 2008. Detection of anthropogenic mortality in elephant *Loxodonta africana* populations: a long-term case study from the Sebungwe region of Zimbabwe. *Oryx* **42**, 36-48.

Fergusson, R.A. & Pentolfe, N.W. 2007. *Preliminary aerial survey of crocodile populations in Zambeze Valley and Manica Province, Mozambique 2007*. Crocodile Conservation & Consulting (Pty) Ltd.

Fusai, A & Carpaneto, G.M. 2006. Subsistence hunting and conservation issues in the game reserve of Gile, Mozambique. *Biodiversity & Conservation* **15**, 2477–2495.

Garnier, J., Dunham, K.M., Robertson, E.F. & Murphree, M. 1999. *An ecological and sociological survey in Cabo Delgado province, northern Mozambique. Survey report and recommendations for the conservation of terrestrial and marine resources and for community involvement*. Cabo Delgado Biodiversity & Tourism Project. Paris.

Ghiurghi, A. & Pariela, F. 2007. *Wildlife Survey in Machaze. An assessment of the medium and large wildlife of the northern sector of the Machaze district (Manica province, Mozambique) and recommendations for its managements*. *Final report*. Direcção Nacional de Terras e Florestas, Departamento de Inventario de Recursos Naturais. Maputo.

Hoare, R.E. 2000. African elephants and humans in conflict: the outlook for coexistence. Oryx **34**, 34–38.

Hoare, R.E. 2001. *A decision support system for managing human-elephant conflict situations in Africa*. IUCN/SSC African Elephant Specialist Group. Nairobi.

Hoare, R.E. & Du Toit, J.T. 1999. Coexistence between people and elephants in African savannas. *Conservation Biology* **13**, 633–639.

Hofer, H. & Mpanduji, D.G. 2004. *Distribution and movements of elephants and other wildlife in the Selous-Niassa Wildlife Corridor, Tanzania*. Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ), Eschborn.

IUCN/SSC African Elephant Specialist Group. (Undated). *Evolution of the Human Elephant Conflict Working Group and synthesis of key lessons learnt*. Downloaded from http://www.iucn.org/afesg.

Jackson, T. & Erasmus, D.G. 2005. *Assessment of seasonal home-range use by elephants across southern Africa's seven elephant clusters*. Conservation Ecology Research Unit, University of Pretoria, Pretoria.

Jolly, G.M. 1969. Sampling methods for aerial censuses of wildlife populations. *East African Agriculture & Forestry Journal* **34**, 46-49.

Matthews, W.S. & Nemane, M. 2006. *Aerial survey report for Maputo Special Reserve*. Unpublished report.

Mpanduji, D.G. & Ngomello, K.A.S. 2007. *Elephant movements and home range determinations using GPS/ARGOS satellites and GIS programme: Implication to conservation in southern Tanzania*. Paper presented at 6th TAWIRI Annual Scientific Conference, Arusha International Conference Centre, Arusha Tanzania. 3-6 December 2007.

Norton-Griffiths, M. 1978. *Counting Animals*. Second edition. African Wildlife Leadership Foundation. Nairobi.

Ntumi, C.P., van Aarde, R.J., Fairall, N. & De Boer, W.F. 2005. Use of space and habitat by elephants (*Loxodonta africana*) in the Maputo Elephant Reserve, Mozambique. *South African Journal of Wildlife Research* **35**, 139–146.

O'Connell-Rodwell, C.E., Rodwell, T., Rice, M. & Hart, L.A. 2000. Living with the modern conservation paradigm: can agricultural communities co-exist with elephants? A five-year case study in East Caprivi, Namibia. *Biological Conservation* **93**, 381–391.

Ogada, M., Woodroffe, R.B., Oguge, N.N. & Frank, L.G. 2003. Limiting depredation by African carnivores: the role of livestock husbandry. *Conservation Biology* **17**, 1521-1530

Oppong, S.K., Danquah, E. & Sam, M.K. 2008. An update on crop raiding by elephants at Bia Conservation Area, Ghana from 2004 to 2006. *Pachyderm* **44**, 59-64.

Osborn, F.V. 2004. Seasonal variation of feeding patterns and food selection by crop-raiding elephants in Zimbabwe. *African Journal of Ecology* **42**, 322–327.

Osborn, F.V. & Parker, G.E. 2002. Community-based methods to reduce crop loss to elephants: experiments in the communal lands of Zimbabwe. *Pachyderm* **33**, 32–38.

Osborn, F.V. 1998. *Elephant/human conflict around Maputo Elephant Reserve*, *Mozambique*. Department of Zoology, University of Cambridge.

Parker, G.E. & Osborn, F.V. 2006. Investigating the potential for chilli to reduce human-wildlife conflict in Zimbabwe. *Oryx* **40**, 343–346.

Sam, M.K., Danquah, E., Oppong, S.K. & Ashie, E.A. 2005. Nature and extent of human-elephant conflict in Bia Conservation Area, Ghana. *Pachyderm* **38**, 49–58.

Sitati, N.W. & Walpole, M.J. 2006. Assessing farm-based measures for mitigating human-elephant conflict in Transmara District, Kenya. *Oryx* **40**, 279-286.

Sitati, N.W., Walpole, M.J. & Leader-Williams, N. 2005. Factors affecting susceptibility of farms to crop raiding by African elephants: using a predictive model to mitigate conflict. *Journal of Applied Ecology* **42**, 1175–1182.

Sitati, N.W., Walpole, M.J., Smith, R.J. & Leader-Williams, N. 2003. Predicting spatial aspects of human-elephant conflict. *Journal of Applied Ecology* **40**, 667–677.

Smithers, R.H.N. & Lobão Tello, J.L.P. 1976. *Check list and atlas of the mammals of Moçambique*. Museum Memoir no. 8. Salisbury.

Stalmans, M. 2004. *Parque Nacional de Banhine. Wildlife census*. International Conservation Services.

Stalmans, M. 2007a. *Parque Nacional de Banhine, Moçambique. Wildlife survey*. International Conservation Services.

Stalmans, M. 2007b. *Parque Nacional de* Zinave*, Moçambique. Wildlife survey*. International Conservation Services.

Whyte, I.J. & Swanepoel, W. 2006. *An aerial census of the Shingwedzi basin area of the Parque Nacional do Limpopo (Limpopo National Park) in Mozambique. 16th–21st October 2006*. Scientific Report 02 / 2006, South African National Parks.

WWF. 2008. *Common Ground. Solutions for reducing the human, economic and conservation costs of human wildlife conflict*. Species Programme, WWF International. Gland, Switzerland.

Zambezi Society & Mid Zambezi Elephant Project. 2000. *Elephant research and management in Muzarabani district and the mid-Zambezi Valley*. Zambezi Society & Mid Zambezi Elephant Project, Harare.

9 Recommendations for Further Studies

Wildlife Survey and Human-Wildlife Conflicts study and monitoring in Mozambique: a Proposal for the year 2009

Based on the activities and results of the 2008 wildlife survey in Mozambique, the following activities are proposed for 2009.

9.1 Aerial Survey

9.1.1 Objectives

1. To carry out aerial surveys in the large strata not surveyed during 2008; and
2. To re-survey more intensively some of the areas surveyed during 2008 where there appeared to be significant wildlife populations.

9.1.2 Justification

The larger mountainous strata were scheduled to be surveyed with block counts during 2008, but for logistical reasons they were not surveyed. The four largest mountainous strata (three in northern Mozambique and one in Tete province, north-eastwards of Lake Cabora Bassa) total approximately 16 % of Mozambique's surface area. Hence, surveying these areas will fill the major gaps in coverage remaining after the 2008 survey.

Re-surveying (during 2009) some areas covered during 2008 will allow the results of the 2008 and 2009 surveys to be combined to provide more precise (and possibly more accurate) estimates of animal numbers and distribution in these areas.

9.1.3 Areas proposed for wildlife survey during 2009

Five areas of high-diversity were identified in Mozambique using the maps derived from the 2008 survey. Three of these areas consist largely of conservation areas where the wildlife has been, or is likely to be, surveyed. It is proposed that the other two high-diversity areas – northern Mozambique excluding Niassa Reserve and the Chipanje area, and western Tete province – are resurveyed during 2009, in order both to fill in gaps in the existing survey coverage and to provide additional information on the species and densities of wildlife in these two high-diversity areas (see Map 59 below).

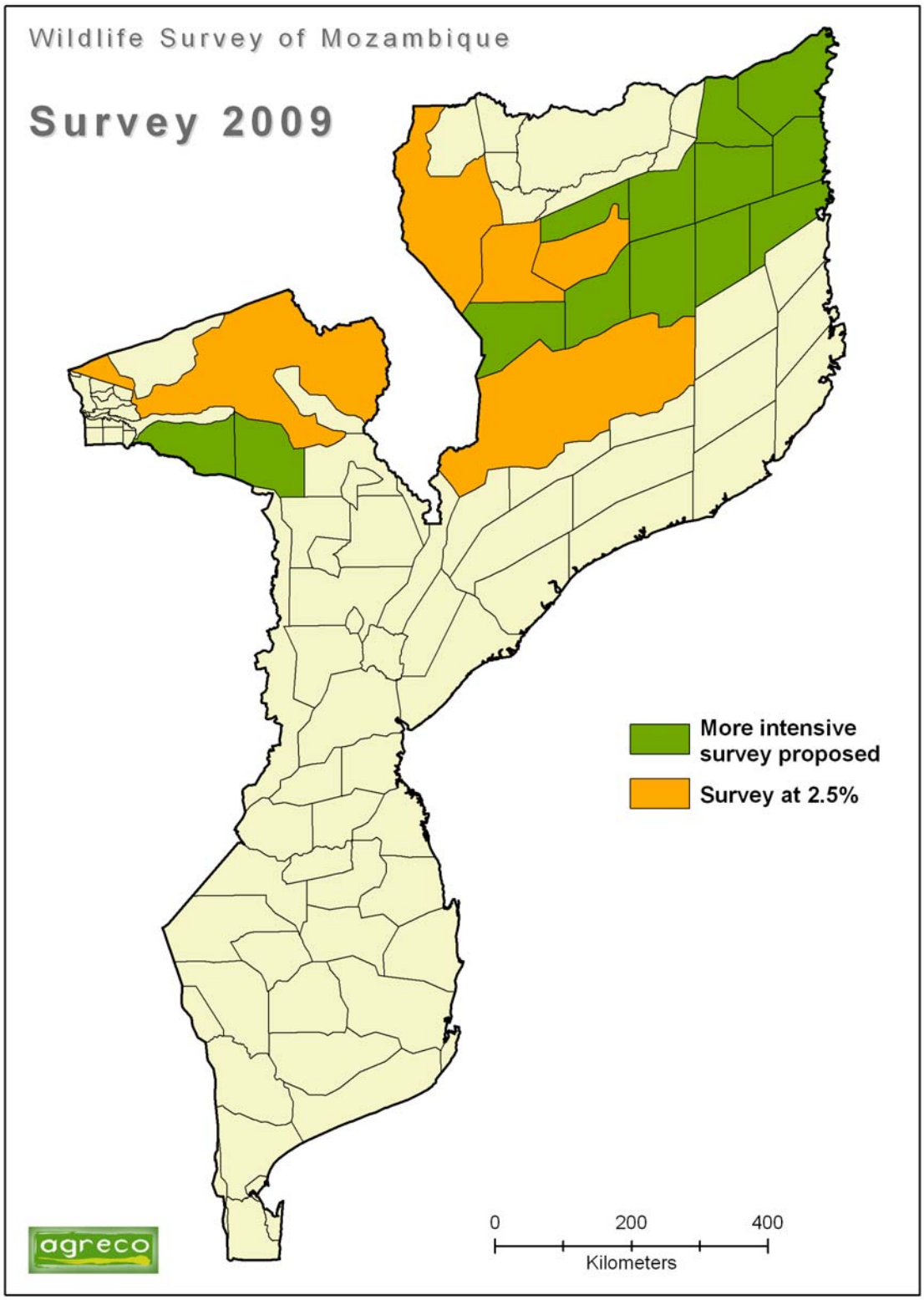
9.1.4 Methods

9.1.4.1 Block counts

Four large mountainous areas scheduled for block counts will be re-examined using digital elevation models and satellite images to confirm that the terrain is unsuitable for transect surveys and thus that these areas must be surveyed with block counts, if they are to be surveyed at all. Satellite images will also be used to check the extent of human habitation and cultivation, because it is questionable if the expensive of wildlife surveys is justifiable in areas where human settlement, or cultivation, or both are extensive.

The areas to be surveyed with block counts will be divided into 30x30 km grid squares (the same grid squares that were used for density distribution mapping in this report) and in each of these squares, one of the thirty-six smaller, 5x5 km blocks within the square will be randomly selected and surveyed for wildlife. In this way, the sample intensity will be similar to

the transect survey (that is, 2-3 %). By this procedure, it will be possible to use the data both to produce population estimates and variances, and to map the distribution of the different wildlife species. If sufficient funds were available, it would be possible to increase sampling intensity by sampling two 5x5 km squares in each 30x30 km grid square.



Map 59. The areas proposed for wildlife survey during 2009. Within the strata indicated for intensive survey (in green in the map) selected areas will be surveyed at 7-8% intensity.

Block sample counts are necessary in mountainous areas, because the sampling units (blocks) can be searched as convenient for flying the terrain – in other words, it is not necessary to fly in straight lines and flying height does not have to be kept constant. Many types of aircraft will suffice for block counts, but slower flying aircraft (for example, the two-seater SuperCub) are preferable. Blocks will be flown at 70 miles per hour (115 km per hour) or less. An aircraft can fly slower if its load is reduced, for example by flying with just the pilot and one recorder/observer (even in a four-seater aircraft) and without the fuel tanks being filled to capacity.

Blocks will be covered by flying on flight lines spaced at about 500 metres. Lines may be curved and orientated as required by the terrain. Flying height above the ground will be at the discretion of the crew and take into consideration the optimal height for sighting animals as well as safety. Each block will be located by flying to the virtual block as displayed on a GPS receiver and then searched by flying lines within the block which are traced on the GPS display by the track log function. These track logs will be visually kept about 500 metres apart and the tracks displayed in real time will be used to ensure complete coverage. Whether an observation is in or out of the block will be determined by reference to the GPS receiver (and if all sightings are recorded with location during the survey, whether sightings were in the block can be determined after the survey).

9.1.4.2 Transect surveys

Areas where significant wildlife populations were found during the 2008 survey will be partially resurveyed during 2009, using similar methods as used during 2008. Selected areas of those strata will be surveyed at 7-8% sampling intensity. If the sampling intensity is the same during 2009 as during 2008 (due to funds availability), then the 2009 transects will be spaced halfway between the 2008 transects.

9.1.5 Logistics

Three mountainous strata in northern Mozambique and one north-eastwards of Lake Cabora Bassa will be surveyed with block counts, if re-examination suggests that they (or more likely, parts of them) cannot be surveyed with transects, but that they might contain reasonable numbers of wildlife. The 2008 survey revealed that there were major wildlife populations in northern Mozambique, northwards of Nampula. Thus, it is proposed that northern Mozambique - excluding the Niassa and Chipanje-Chetu survey areas (Craig, 2006) - is surveyed during 2009 (Map 59). A relatively small area that also appeared to justify being re-surveyed was the area south of Lake Cabora Bassa, between the Lake and the Mozambique/Zimbabwe border, excluding the Magoe survey area.

The four strata provisionally scheduled to be surveyed with block counts total 130646 km^2. And the areas where transect surveys are recommended during 2009 total another 131654 km^2. Thus the total area recommended for survey during 2009 is 262300 km^2.

It will be important that the block counts are flown early during the dry season, before the strong winds that occur during the mid and late dry season make the flying in mountainous areas very hazardous.

For both the block counts and the transect surveys, survey design and planning must start early during 2009 so that there is plenty of time to acquire and position aircraft fuel before the surveys start. The small number of locations where aircraft fuel was available (and then only sometimes) was a major constraint for the 2008 survey.

9.1.6 Personnel and equipment

The block counts will require a small aircraft such as SuperCub with an experienced survey pilot and one observer/recorder. The transect surveys will require a 4 or 6 seater aircraft (e.g. Cessna 185 or Cessna 206) with an experienced survey pilot, one recorder and two experienced survey observers.

Both aircraft will need the support of a ground crew (consisting of a vehicle with driver and assistant) to move and position aircraft fuel before and during the surveys.

9.1.7 References

Craig, G.C. Undated. *Aerial survey standards for the MIKE programme*. CITES MIKE Programme, Nairobi.

Craig, G.C. 2006. *Aerial survey of wildlife in the Niassa Reserve and surrounds, October 2006.* Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa, Maputo.

9.2 Crocodile and Hippopotamus Surveys

9.2.1 Objectives

1. To conduct dedicated aerial surveys to count hippos and large crocodiles along all major rivers and water bodies in Mozambique; and
2. To conduct night-time boat surveys of crocodiles of all sizes along the Zambezi River in Mozambique.

These will lead to precise estimation of crocodile and hippo numbers in Mozambique as well as in each district, and detailed mapping of their distribution.

9.2.2 Justification

Crocodiles kill more people each year in Mozambique than do all the other species of wildlife combined. Although hippos cause relatively few deaths, they frequently raid crops. Furthermore, hippos can be counted at little extra cost during aerial surveys designed to count large crocodiles.

9.2.3 Methods

Two methods will be used to complete this survey:

1. aerial surveys for hippos and large crocodiles along major rivers; and
2. boat surveys for crocodiles of all sizes just along the Zambezi river.

9.2.3.1 Counts of hippopotamus and large crocodiles

Hippos and large crocodiles in the major rivers and large water bodies of Mozambique will be counted during dedicated aerial surveys. These surveys will be total counts of the hippos and large crocodiles along the selected rivers or shorelines.

For crocodiles, the time of the year when an aerial survey is undertaken is important. Ideally, the count should take place at a time when the water level in the river or lake is low and when the ambient temperature encourages crocodiles to haul out of the water to bask in the sun for several hours of the day. Typically these two periods do not coincide, but there are several months – from July to September - when conditions are suitable.

The survey will be conducted in a small, two-seater, high wing, single engine aircraft. The pilot should have experience in survey flying, i.e. at slow speeds (100 km per hour) and low level (300 feet above ground level). Ideally, the observer/recorder should have prior experience of aerial surveys along rivers and the variability between counts along different rivers can be reduced by using the same team for all counts.

The aircraft will be flown so as to maximise the visibility of the shoreline for the observer. The survey height will be approximately 300 ft above ground level and the speed will be approximately 100 km per hour. The aircraft height and velocity are not critical for survey purposes and will be determined by the requirements for maximising safety and visibility.

The survey will be conducted at the time of day (morning) that maximises the probability that most large crocodiles and hippos are basking, and thus most visible.

Along narrow stretches of river, the aircraft will be flown along the centre of the river channel and the numbers of crocodiles and hippos seen on both banks recorded simultaneously. Along wide sections of river, then the aircraft will need to make several flights between the two banks in order to cover the entire width of the river.

All large crocodiles, hippos and boats will be counted and recorded. The number of boats in any section of river will provide a simple index of human activity in the habitat of crocodiles

and hippos. Large groups of hippos will be circled to provide adequate time for the individuals to be counted. The location, date and time of each sighting of crocodiles, hippos and boats will be recorded using the waypoint facility of a GPS receiver, and the track of the aircraft will be recorded using the track log facility of a GPS. The waypoints and track log will be downloaded from the GPS to a laptop computer immediately after each flight.

A data sheet will be used to record the aircraft type, identity of the crew, times of takeoff and landing, etc.

9.2.3.2 Boat survey of crocodiles

Aerial surveys to count crocodiles are limited to counting large crocodiles (i.e., those approximately 2 m or more in length), because smaller crocodiles are easily missed by aerial observers. Estimation of the number of smaller crocodiles is best undertaken using night-time surveys with boats, using powerful spotlights to detect the red/orange reflections of crocodiles' eyes up to 200 m away (Hutton & Woolhouse, 1989). The methods outlined here follow those used for boat surveys of crocodiles elsewhere on the Zambezi River and in parts of Lake Cabora Bassa (Fergusson, 2006). Ideally, boat surveys for crocodiles will take place at the end of the dry season (October-November), when the water level is at its lowest and when the temperature is high.

During the boat survey, a shallow-draft boat with a 20-30 horsepower engine will be occupied by a team consisting of a boat driver, an observer and a recorder. At least one crew member will be trained and competent in conducting repairs to lights and other equipment.

The shallow draft of the boat is important if the boat is to be operated efficiently in the shallow sections of river that crocodiles often inhabit. If the boat's draft is not shallow, it may be necessary to haul the boat in shallow water, which will expose the crew to risk of attack by crocodiles. Equipping the boats with punting poles will reduce the need for hauling, but will be no substitute for a shallow-draft boat.

The observer will be responsible for operating a strong (500000–1000000 candlepower) spotlight powered by a large 12 volt vehicle battery to search for and observe crocodiles. The observer, when holding the spotlight immediately below his/her eye level, will be able to see the red reflection of the beam off the tapetum of the eye of any crocodile that is above the water level. He/she will then hold the beam on this reflection while the boat driver slowly manoeuvres the boat towards this point. Provided the crocodile remains above water long enough to allow a close approach, its size will be estimated from the size of the head or body. Ideally, each crocodile will be approached close enough to allow it to be assigned to one of five size categories (Fergusson, 2006):

- category 1 – crocodiles of total length (TL) <0.5 m, including all animals in their first year;
- category 2 - larger juveniles of TL >0.5 m and <1 m;
- category 3 - sub-adults of TL >1 m and <2.5 m;
- category 4 - adults of TL >2.5 m; and
- category 5 - 'eyes only' (a crocodile was detected by eye-shine, but its size could not be determined).

Distant sightings and those which would entail lengthy delays will be recorded as 'eyes only'.

The recorder will be responsible for: recording the size category of each crocodile seen; using the waypoint facility of a GPS receiver to record the time and location of each crocodile sighting; and using the track log facility of the GPS to record the start and end points and times of each survey section and to record the track of the boat during the survey. A standard data sheet will be used to record the count information and the survey conditions (air temperature, wind strength and direction, moon phase, vegetation and bank type). The waypoints and track log will be downloaded from the GPS to a laptop computer immediately after each survey.

The driver will be responsible for the navigation of the boat – often in complete darkness with just the occasional assistance from the spotlight and sometimes in a swift current. The driver will need to have the experience and judgement to determine which of many river channels will both allow passage of the boat and place it close enough to observed crocodiles to allow accurate determination of their size.

The boat will be steered along the shoreline of the lake or river and the red reflections of the spotlight from each crocodile's eyes will be recorded. It will be easier and more fuel efficient for boats to operate downstream, going with the river's current. Surveys will start after sunset once full darkness had occurred and will continue until the survey section is completed, or until first light. Ideally, the boat surveys for crocodiles will be conducted during periods when there is no moonlight, because this will enable a closer approach to the crocodiles for size classification.

Not all crocodiles in the survey area will be visible during the brief period when the spotlight beam passes over them: some will be under water and others may be concealed by waves, or vegetation fringing the shore. Correction factors for these effects are difficult to derive without extensive studies, but work by Hutton & Woolhouse (1989) suggests that, even under good survey conditions, only two-thirds of a population of large crocodiles will be seen during spotlight surveys.

9.2.3.3 Logistics

To survey adequately a wide river, such as the Zambezi River, two boats should work simultaneously, one near the northern bank and one near the southern bank. During boat surveys of crocodiles along the Zambezi River in Zimbabwe (Fergusson, 2006), the boat crews were able to cover less than 9 km of river per hour. The costs of boat surveys will include boat hire, boat fuel, spotlights, batteries, punting poles, life vests and GPS receivers. Adequate facilities must be available for charging or changing batteries during the survey: each boat must be provided with a fully-charged battery every night. Experience has shown that even when surveys are conducted during a warm period of the year, boat crews may become cold and fatigued by consecutive nights of survey: warm and waterproof clothing and adequate provision for sleeping during the day are essential. The provision of food, drink and bedding on a boat will provide for greater comfort and allow the crew to return to their base in daylight.

The boat survey to count crocodiles will be conducted along the length of the Zambezi River in Mozambique, from the Cabora Bassa dam wall to the Zambezi delta, a linear distance of approximately 600 km.

Hippos and large crocodiles along the Zambezi River and other major rivers in Mozambique will be counted during dedicated aerial surveys. The 2008 survey suggested that the shores of Lake Cabora Bassa should be a priority area for hippo counts during 2009.

Inspection of the maps of human-crocodile conflicts suggests that most conflicts occurred in the districts that border the Zambezi, Save, Limpopo, Elefantes, the lower Rovuma, Lurio and Pungwe Rivers, or that border or include Lakes Cabora Bassa, Niassa, Massingir, Corrumane and Pequenos Libombos. These rivers and lakes should be the priority areas for aerial surveys of crocodiles.

To complete the Crocodile-hippo aerial survey an estimated 150 flight hours will be necessary.

To complete the Zambesi River boat survey 75 hours of actual night observation per river bank will be necessary. Working with 2 boats simultaneously (each boat with 3-4 people on) the activity can be completed in about 3 weeks.

9.2.4 References

Fergusson, R.A. 2006. *Populations of Nile crocodile (*Crocodylus niloticus*) and hippopotamus (*Hippopotamus amphibius*) in the Zambezi Heartland*. African Wildlife Foundation, Kariba, Zimbabwe.

Hutton J.M. & Woolhouse M.E.J. 1989. Mark-recapture to assess factors affecting the proportion of a Nile crocodile population seen during spotlight counts at Ngezi, Zimbabwe, and the use of spotlight counts to monitor crocodile abundance. *Journal of Applied Ecology* **26**, 381-395.

9.3 Lion and Spotted Hyena Survey in Mozambique for Wild Carnivore Management and Mitigation of Conflicts with People

9.3.1 Objective

To carry out a lion and spotted hyena survey in Mozambique with the objective of proposing management options and measures to mitigate conflicts with these species.

9.3.2 Study justification

The lion is a powerful symbol of Africa. In some areas of Mozambique, the lion is a major predator of domestic livestock, leading to serious conflicts with local people. The preliminary results of the 2008 wildlife survey state that lions are also potentially dangerous and still take livestock and human lives with troubling frequency in some areas. Yet the lion is not only a source of personal and economic damage, but also of economic and personal benefits, as a primary attraction for tourists and one of Africa's "Big Five" trophy animals.

Recent surveys have indicated a suspected decline of 30-50 % in the African lion population, with current estimates ranging from 23,000 to 39,000. The lion is classified as Vulnerable on the IUCN Red List of Threatened Species for this reason.

The situation of the lion drew international attention at the October 2004 CITES COP 13 (13th Conference of the Parties to CITES). A proposal to transfer the lion to Appendix I and restrict trade in lion trophies sparked extensive debate among Africa Range States, and highlighted the need to achieve pan-African consensus on the way forward for the lion conservation. Range States agreed that a series of regional lion conservation workshops should be held.

The Eastern and Southern African Lion Conservation Workshop was organised by IUCN in January 2006, in South Africa. It followed a similar regional workshop for lions in West and Central Africa held in Cameroon, in October 2005. The lion specialists working in the region identified threats to the lion in Eastern and Southern Africa and formulated a regional strategy with the goal to secure and, where possible, restore sustainable lion populations throughout their present and potential range within Eastern and Southern Africa.

In Mozambique, in order to begin the improvement of this regional strategy, with assistance from Fauna and Flora International, the Society for the Management and Development of Niassa Reserve (SGDRN) is trying to ensure the monitoring and the effective conservation management of lions, their habitats and wild prey (objective number 1 of the strategy). Furthermore, a national Large Carnivore Action Plan is under preparation.

To improve the formulation of this important Action Plan and to tackle at a national scale the problem of human-predator conflicts, AGRECO propose the following study on lion and spotted hyena density and distribution. The collected data, shared with similar information produced for national protected areas, will allow the implementation of the IUCN lion strategy actions and long-term monitoring of the species, and will help in proposing a mitigation plan for conflicts with large carnivores.

9.3.3 Methods

Conventional census techniques for large mammals which use distance sampling such as line and point transects described in Buckland *et al.* (1993) cannot be used with large carnivores (Mills *et al.,* 2001). These methods rely upon the observer being able both to sight the animal and to estimate its distance to the track line or the selected point. This is impractical for nocturnal and/or low-density animals such as the large carnivores' species.

As recommended by IUCN and the African Lion Working Group and in order to determine with sufficient accuracy the density and distribution of lions and hyenas, AGRECO will combine various counts' methods: playback recording, random searches, tracking and interviews to the local people. The same methods have already been successfully implemented by AGRECO G.E.I.E. in West and Central Africa (ECOPAS and ECOFAC projects) between 2003 and 2008 (Savini, 2003; Di Silvestre, 2004 and 2008).

9.3.3.1 Playback recordings

The technique involving broadcasting of animal vocalizations recorded ("call-in" method) has been widely used in the past to count lions and hyenas (Kruuk, 1972, 1985, Smuts *et al*., 1977; Whateley & Brooks, 1978; Mills, 1985; Mills *et al*., 2001). The presence of one of the two species does not appear to prevent the other species responding (Mills *et al*., 2001). The sounds used included the bleating of an antelope calf, spotted hyenas mobbing lions, an inter-clan fight between spotted hyenas and hyenas competing on a kill. At each station calling is conducted twice for about 5 minutes with 15 minutes between calls. If spotted hyenas or lions are heard in the vicinity, but did not appear, the tape is played a third time. The animals are observed with a spotlight.

9.3.3.2 Interviews

Information about lions and hyena abundance and distribution will be collected during interviews with the local people. Many studies, that compared the results of long-term field research on rare carnivores with the data obtained with questionnaires, have demonstrated the high reliability of this method (Creel and Creel, 1995; Gros *et al*., 1996).

Furthermore, Participatory Rapid Appraisal (PRA) surveys will be undertaken in the different study areas in order to assess the socio-economic importance of the wildlife predatory activities on livestock and the local knowledge of predators. Depending on the results of the PRA surveys and the population assessment, a range of methods aiming at minimizing the negative impact of lions on human populations and livestock will be identified.

9.3.3.3 Random observations

The search techniques used to locate lions and hyenas during the day will be: random searching, tracking, and study of the presence and behaviour of vultures. All water points will be patrolled. All footprints found will be examined and measured to determine the species, the age class and the number of individuals. The GPS position will be taken at each observation.

9.3.4 Logistics

The study will be executed in large sample areas, which will be chosen according to the results of the 2008 survey and according to the results of the IGF/MITUR preliminary lion survey (*Conservation status of the lion (*Panthera leo*) in Mozambique – Phase I: Preliminary survey, 2008*). The effort will be focused on the districts with the highest intensity of human-carnivore conflicts and in areas of high densities of wildlife (i.e. potential prey for lions and hyenas). Ideally, the largest possible number of districts will be included in the study, distributed between 4 or 5 larger focus-areas.

An area of approximately 78.5 km^2 can be covered every night for this survey (playback radius effectiveness = 2.5 km), totalling 1177.5 km^2 per month if we assume 15 nights of field work in a month. The sample areas will be chosen according to the results of the 2008 survey and considering the limited road network in rural areas.

Two or more teams will work simultaneously in order to cover the sample areas during the 6-month dry season (approx. May-October 2009). Each team will be formed of at least one driver, one researcher and one local person (villager, staff of the district directorate of agriculture services, etc.).

9.3.5 Personnel and equipment

The following personnel will execute the study for an estimated period of 4 months: one international scientific coordinator, two principal researchers, two local support personnel and two drivers.

The equipment will include: two 4WD vehicles, two 12 volt amplifiers, horn speakers, spotlights, two desktops and GPS.

9.3.6 References

Creel, S. & Creel, N.M. 1995. Status of African Wild Dogs in the Selous Game Reserve and Mikumi National Park. *IUCN/CSG Canid News* **3**, 34-35.

Di Silvestre, I. 2004. *Distribution et abundance des grands carnivores dans les zones cynégétiques du Parc Régional du W*. Programme ECOPAS, rapport de mission.

Di Silvestre, I. 2008. *Coordination des activités de suivi et dénombrement des grands carnivores du Complexe WAP (W-Arly-Pendjari).* Rapport final de mission pour le Programme ECOPAS.

Gros P.M., Kelly M. & Caro, T.M. 1996. Estimating carnivores densities for conservation purposes: indirect methods compared to baseline demographic data. *Oikos* **77**, 197-206.

Kruuk, H. 1972. *The Spotted Hyena.* University of Chicago Press, Chicago.

Kruuk, H. 1985. Hyaena Survey of Kruger National Park: August-October 1984. *IUCN Hyaena Specialist Group Newsletter No. 2, 1985.*

Mills, M.G.L. 1985. Hyaena survey of Kruger National Park. August-October 1984. *IUCN SSC Hyaena Specialist Group Newsletter* **2**, 15-25.

Mills, M.G.L., Juritz, J.M. & Zucchini, W. 2001. Estimating the size of spotted hyaena *(Crocuta crocuta)* populations through playback recordings allowing for non-response. *Animal Conservation* **4**, 335-343.

Savini, S. 2003. *Analyse de l'état de la population du lion (*Panthera leo*) et de la hyène tachetée* (Crocuta crocuta*) dans la zone d'intervention du Projet ECOFAC/ZCV (R.C.A.).* Rapport final de mission de recherche-développement moyenne durée.

Smuts, G.L., Whyte, I.J. & Dearlowe, T.W. 1977. A mass capture technique for lions. *E. Afr. Wildl. J.* **15**, 81-87.

Whateley, A. & Brooks, P.M. 1978. Numbers and movement of spotted hyaenas in Hluhluwe Game Reserve*. Lammergeyer* **26**, 44-52.

*9.4 Leopard (*Panthera pardus*) Survey in Mozambique for Wild Carnivore Management and Mitigation of Conflicts with People*

9.4.1 Study justification

The status of the leopard (*Panthera pardus*) in Africa has been a matter of debate since 1973 when the species was first listed under CITES Appendix I. Several attempts have since been made to determine the leopard's status in Sub-Saharan Africa, most of which have relied heavily on interviews and questionnaires.

Martin & de Meulenaer (1988) carried out interviews on a continental scale, but also developed a leopard population model that used linear regression techniques to link leopard densities with annual rainfall and predict numbers of leopards throughout their range in Africa. To date, their study is the only quantitative attempt to estimate leopard numbers across the continent.

The leopard's broad geographic distribution over Africa and much of Asia offers little reason for concern for the survival of the species. In contrast to other endangered large carnivores in Africa, such as the cheetah (*Acinonyx jubatus*) and wild dog (*Lycaon pictus*), leopards exhibit marked adaptability to different habitat and prey conditions, and have been recorded to alter their behaviour when in close proximity to humans (Bailey, 1993).

In eastern and southern Africa, leopards are not infrequently sighted near or within urban or highly-cultivated areas (Hamilton, 1986; see references in Nowell & Jackson, 1996), thereby giving further ammunition to their reputation as a resilient species. On the other hand, ecological knowledge and information on the conservation status of leopards is poor in many parts of their range.

In Mozambique, leopards have never been systematically surveyed, in spite of their potentially vital ecological role as large mammalian predators. The preliminary results of the 2008 wildlife survey state that leopards are also potentially dangerous for livestock and human lives, especially in some areas. Finally, the leopard is also a source of economic benefits as it is one of the primary attractions of trophy hunting safaris.

9.4.2 Methods

Because leopards are rarely seen and are difficult to survey using the most common techniques for assessing relative abundances of mammals, baseline knowledge of leopard ecology and relations with human presence in Mozambique remain largely unknown.

This survey will be executed in large sample areas, which will be chosen according to the results of the 2008 wildlife survey and census. The effort will be focused on the districts with human-leopard conflicts and in areas where leopard presence has been documented, or is believed to be potentially high due to large numbers of natural prey.

As affirmed by Henschel and Ray (2003), ascertaining the presence/absence, the abundance and the distribution of leopards requires relatively few resources; but attempting to estimate the density of this secretive species will need a more complex survey, using the capture-recapture approach.

AGRECO will combine two methods in order to asses the abundance and distribution of leopards: presence/absence surveys and interviews to the local people.

The 2008 wildlife census results, along with other available data on ungulate distribution and density, will allow an estimation of leopard prey density that can be used to obtain a guesstimate of the number of leopards. This will be done by comparing our data on presence/absence to the home range size/prey density ratio found in the literature.

9.4.2.1 Presence-absence ad hoc surveys

The easiest and least expensive way to go about this is to walk along game trails or roads throughout the area, and search for leopard sign, such as tracks or faeces. Areas for survey will be selected according to the results of 2008 wildlife census.

Normally, scats and scrapes in particular should be in evidence on a regular basis if leopards occur, as they are usually left in prominent spots as territorial markers for other leopards.

It is important to note that although these are known as presence/absence surveys, they are actually surveys of detection versus non-detection, as absence may actually indicate failure to detect even when leopards are present. Therefore, while absence can never be verified for certain, the presence of leopards in a given area becomes relatively unlikely if no evidence is encountered during several weeks of fieldwork.

9.4.2.2 Interviews

Information about leopard abundance and distribution will be collected during interviews with the local people. Many studies that compared the results of field long-time research on rare carnivores with the data obtained from questionnaires, have demonstrated the high reliability of this method (Creel and Creel, 1995; Gros *et al*., 1996).

Furthermore, Participatory Rapid Appraisal (PRA) surveys will be undertaken in the different study areas in order to assess the socio-economic importance of wildlife predation on livestock, and the local knowledge of predators.

Depending on the results of the PRA surveys and the population assessment, a range of methods aiming at minimizing the negative impact of leopards on human populations and livestock will be identified.

9.4.3 Logistics

The sample areas will be chosen according to the results of the 2008 survey. The effort will be focused on the districts with the highest intensity of human- carnivores' conflicts and in areas of documented leopard presence. Ideally, the largest number possible of districts will be included in the study areas, distributed between 4 or 5 larger focus-areas.

The research teams will be the same as for the lion and hyaena survey: two teams each formed by at least one driver, one researcher and one local person (villager, staff of the district directorate of agriculture services, etc.) will work simultaneously on the survey of all wild carnivores. This will work in order to cover the sample areas during the 6-month dry season (approx. May-October 2009).

9.4.4 References

Bailey, T.N. 1993. *The African Leopard: Ecology and Behaviour of a Solitary Felid*. Columbia University Press, New York.

Creel S. & Creel N. M., 1995. Status of African Wild Dogs in the Selous Game Reserve and Mikumi National Park. *31 IUCN/CSG Canid News* **3**, 34-35.

Di Silvestre, I., 2008. *Coordination des activités de suivi et dénombrement des grands carnivores du Complexe WAP (W-Arly-Pendjari).* Rapport final de mission pour le Programme ECOPAS.

Grassman, L.I. Jr. 1999. Ecology and behaviour of the Indochinese leopard in Kaeng Krachan National Park, Thailand. *Natural History Bulletin of Siam Society* **47**, 77-93.

Grigione, M.M., Burman, P., Bleich, V.C. & Pierce, B.M. 1999. Identifying individual mountain lions *(Felis concolor)* by their tracks: refinement of an innovative technique. *Biological Conservation* **88**, 25-32.

Gros P.M., Kelly M. & Caro, T. M. 1996. Estimating carnivores densities for conservation purposes: indirect methods compared to baseline demographic data. *Oikos* **77**, 197-206.

Henschel, P. & Ray, J., 2003. *Leopards in African Rainforests: Survey and Monitoring techniques*. Wildlife Conservation Society, Global Carnivore Program.

Karanth, K.U. 1995. Estimating tiger *(Panthera tigris)* populations from camera-trap data using capture-recapture models. *Biological Conservation* **71**, 333-338.

Karanth, K.U. & Nichols, J.D. 2002. *Monitoring Tigers and their Prey: a Manual for Researchers, Managers, and Conservationists in Tropical Asia*. Centre for Wildlife Studies, Bangalore, India.

Lewison, R., Fitzhugh, E.L. & Galentine, S.P. 2001. Validation of rigorous track classification technique: Identifying individual mountain lions. *Biological Conservation* **99**, 131-321.

Martin, R.B. & de Meulenaer, T. 1988. *Survey of the status of the leopard (*Panthera pardus*) in sub-Saharan Africa*. CITES Secretariat, Lausanne.

Miller, C.M. 2001: *Measurements of jaguar tracks: a promising means to identify individuals. Track Collection Protocols*. Wildlife Conservation Society, Bronx New York.

Nowell, K, Jackson, P. 1996. *Wild cats: Status Survey and Conservation Action Plan*. IUCN, Gland, Switzerland.

Smallwood, K.S. & Fitzhugh, E.L. 1993. A rigorous technique for identifying individual mountain lions *(Felis concolor)* by their tracks. *Biological Conservation* **65**, 51-59.

White, G.C., Anderson, D.R., Burnham, K.P., Otis, D.L. 1982. *Capture-Recapture and Removal Methods for Sampling Closed Populations*. Los Alamos National Laboratory, LA 8787-NERP, Los Alamos.

9.5 Feasibility of Land Use Planning as a Means to Reduce Human-Wildlife Conflict

9.5.1 Objective

To undertake a study of the feasibility of preparing a land use plan for one district in Mozambique when land use planning is intended as a means of mitigating and preventing human-wildlife conflict; and to identify and cost the technical expertise, methods, time and other resources needed to prepare such a plan.

9.5.2 Study justification

Unresolved human-wildlife conflict creates negative attitudes towards both the Government and proposed new wildlife-related developments (Anderson & Pariela, 2005). Hence, there is an urgent need to reduce levels of human-wildlife conflict to ensure that where people live with wildlife, the benefits from that wildlife more than compensate for the costs that are incurred. Unfortunately, land use plans are rarely implemented in Africa, but are still of value as a guideline for development (Osborn & Parker, 2002).

Land use planning can mitigate human-wildlife conflict, especially human-elephant conflict (Begg *et al*., 2007; Hoare, 2001; O'Connell-Rodwell *et al*., 2000; Parker *et al*., 2007; WWF, 2008). The planning should determine the optimum development of the district and incorporate wildlife conservation and sustainable utilization where it is economically viable and will benefit the local communities. Planning should consider the creation of areas where elephants can be sustainably managed to provide benefits for the local people and where they do not compete with people for the same resources, and it should consider areas where there may have to be no elephants.

Land use planning and land use change are larger scale methods aimed at creating space for people and wildlife to live together (WWF, 2005). Land use change refers specifically to the management options that change farmers' attitudes to wildlife. The most successful way to do this is by giving farmers a high degree of control over the wildlife, as well as allowing them to derive the potentially significant benefits that can be earned from wildlife management. Land use planning and changes in land use are key elements of community-based natural resource management programmes.

The preparation of a land use plan for a district is likely to be a very time-consuming process. For example, collection of detailed information on conflicts in the district is a prerequisite to land use planning. Conflict data collection is likely to require the training of a local team of reliable and hard-working enumerators, who would report to a local supervisor. The supervisor would be responsible for regularly visiting the enumerators, checking their reports and ensuring that their reports were of the required quality. Once the enumerators were fully trained and had proven their expertise at data collection, their reports could contribute to a database of conflicts for that district. Only after reliable and detailed data have been collected for at least one year would a researcher be able to analyse the data to determine seasonal trends, for example in the extent of crop-raiding, the crops that are targeted and the location of raided fields.

Preparation of a land use plan will also require information, including spatial data, on the current land use within the district (in other words, information on how the local people are distributed and how they are currently using the district's natural resources) and an inventory of the natural resources within the district (in other words, the resources that are potentially available to the local people). The inventory will include information on, for example, water, soils, vegetation, wildlife and domestic animals. Furthermore, no land use plan is likely to work unless it is prepared with the co-operation and consent of the local people. Their concerns and needs, hopes and desires must also be determined and taken account of in the preparation of the plan. Clearly, the preparation of a land use plan for a district is not

simply a few months of work, but seems likely to take several years and involve a team of researchers of various disciplines, including wildlife, sociology, agriculture, economics and geographic information systems.

Preparation of a land use plan for a district is also likely to require inputs from a range of departments of the provincial government, including, for example agriculture and health. And national government departments are also likely to be involved because, for example, if the eventual land use plan called for the elimination of a problem species from part of a district, it is unlikely that this decision can be made and executed without the involvement of officials from national government.

The purpose of this study would be to determine the feasibility of preparing a land use plan to mitigate and prevent human-wildlife conflict: including identifying a suitable district; determining what information including spatial data are already available to be used in the planning process; what new information would need to be collected; the expertise and personnel needed both to collect that information and prepare the plan; and compiling a timetable for the entire process.

9.5.3 Methods

2008 survey results and DNTF records of human-wildlife conflicts can be used to prepare a shortlist of districts that might benefit from land use planning. Districts that suffer a high incidence of crop-raiding by elephants, or hippos, or both, seem most likely to be able to benefit – at least in terms of reducing conflict – from a plan.

As an example, results from this project suggest that a possible candidate area for this activity could be the surroundings of the Gilé Reserve, where conflicts with elephants and hippos are frequently reported. Isolated elephant populations, such as the one of the Gile area, are in principle easier to manage and the presence of a nearby protected area could be taken as an example of how to deal with human-wildlife conflicts in communal lands near parks and reserves elsewhere in Mozambique.

Land use planning will have a strong spatial component and so most, if not all, information used in the planning process must be georeferenced and included in a geographic information system (GIS). Hence, the information layers that would be needed must first be identified and then potential sources of that information should be determined and their suitability for use in the planning process checked. For example, not only must the information be available, but it must be at an appropriate spatial scale and accuracy, and it must be up-to-date.

When information that will be needed is not currently available, the appropriate methods, resources and expertise for collecting the new information in an efficient, timely and cost-effective manner must be identified and its cost determined.

Finally, a timetable for the preparation of a land use plan will be compiled, identifying all the expertise and inputs required, their sequence, and the cost and duration of each input.

9.5.4 Logistics

The study would be undertaken by an international and a national researcher both with experience in land use planning. He/she must also have expertise in GIS, or be supported by a separate GIS expert.

Estimated duration of the activity is 2 months.

9.5.5 References

Anderson, J.L. & Pariela, F. 2005. *Strategies to mitigate human-wildlife conflict in Moçambique*. DNFFB, Maputo.

Begg, C., Begg, K. & Muemedi, O. 2007. *Preliminary data on human - carnivore conflict in Niassa National Reserve, Mozambique, particularly fatalities due to lion, spotted hyaena and crocodile*. Sociedade para a Gestão e Desenvolvimento da Reserva do Niassa Moçambique.

Hoare, R.E. 2001. *A decision support system for managing human-elephant conflict situations in Africa*. IUCN/SSC African Elephant Specialist Group, Nairobi.

O'Connell-Rodwell, C.E, Rodwell, T., Rice, M. & Hart, L.A. 2000: Living with the modern conservation paradigm: can agricultural communities co-exist with elephants? A five-year case study in east Caprivi, Namibia. *Biological Conservation* **93**, 381-391.

Osborn, F.V. & Parker, G.E. 2002. *Living with elephants II; a manual*. Mid Zambezi Elephant Project, Harare.

Parker G.E., Osborn, F.V., Hoare R.E. & Niskanen, L.S. (eds.) 2007. *Human-elephant conflict mitigation: a training course for community-based approaches in Africa. Participant's Manual*. Elephant Pepper Development Trust, Livingstone, Zambia & IUCN/SSC African Elephant Specialist Group, Nairobi.

WWF. 2005*. Human wildlife conflict manual*. WWF SARPO, Harare.

WWF. 2008. *Common Ground. Solutions for reducing the human, economic and conservation costs of human wildlife conflict*. Species Programme, WWF International. Gland, Switzerland.

9.6 Publication of Wildlife Survey and Human-Wildlife Conflicts study

To publish the results of the 2008 and 2009 wildlife surveys, producing and distributing paper copies and CDs of the final report and large cartographic outputs and creating a dedicated website (with WebGIS application for spatial data) to publish the 2008-2009 wildlife survey methods, results, maps and recommendations.

Furthermore, a public workshop, to which national authorities, wildlife experts and managers and the media will be invited, will be organised in Maputo to present the project's results for the two years.