# FACTORS AFFECTING ELEPHANT DISTRIBUTION AT GARAMBA NATIONAL PARK AND SURROUNDING RESERVES, ZAIRE, WITH A FOCUS ON HUMAN-ELEPHANT CONFLICT

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## INTRODUCTION

Human pressures on elephants *(Loxodonta africana)* caused by poaching and by conflict for resources, and the modifying effects of elephants on vegetation and on domestic crops, are widespread throughout Africa (Douglas-Hamilton, 1987; Barnes *et al.*, 1991; Barnes & Kapela, 1991; Dudley *et al.*, 1992). They are exacerbated when there is an unequal distribution of the resources across protected area boundaries (Lewis, 1986). We examine here the interplay of these effects, with a focus on human-elephant conflict, in one protected area of Zaire.

The 4,920km$^2$ Garamba National Park in north-eastern Zaïre contains the densest elephant population in the country. The park is surrounded on three sides by reserves in which there is limited human settlement and agriculture, and on the fourth side by the border with southern Sudan, a country currently suffering chronic civil war.

The reserves are significantly more wooded than the open long grass savanna of the park. The elephants have always used both park and reserve habitats in differing degrees depending on contemporary factors (Cornet d'Elzius, 1957), but since the gazetting of the National Park in 1938, they have inevitably concentrated more in the park with its greater protection, increasing to over 22,000 in 1976.

An immediate expression of human-elephant conflict is poaching, which affects both elephant numbers and distribution. Between 1978 and 1983 heavy poaching, particularly in the north, reduced elephant numbers by 80% and compressed the population into the south of the park. Improved protection since 1984 resulted in a marked increase in the elephant population in the south of the park, with continued repression of woody vegetation. The cessation of control shooting and stricter protection in the reserves, linked with a higher diversity of forage availability, have led to a notable increase in elephant movements into the reserves and more reports of crop damage since 1990.

This paper makes a preliminary examination of the background factors and current situation of human-elephant conflict at Garamba, with the help of a Geographic Information System (GIS). Our aim is to present an overview of the situation, as a basis for planning both integrated management and further research.

## HABITAT DESCRIPTION

The Garamba ecosystem falls within the sudanoguinean savanna biome between latitudes 3 and 5°N and longitudes 28 and 30 The soil is of lateritic origin and well drained. Within the park, it is leached with very little humus, which is rapidly converted by fire and termites, in contrast to the higher humus and carbon content of soil outside the park. Towards the north the ground rises to the Zaire-Nile watershed, with gneissic schist and granite outcrops. Altitude varies from 800 to 1060m. Mean annual rainfall over the ten-year period, 1981-1991, was 1,346mm, which is lower than previous records (1940-1949: 1,514mm; 1951-1963: 1,627mm). It falls mainly in one wet season from April to November.

The southern two-thirds of the park is undulating with long grass savanna, dominated by *Loud etia arundinacea* and *Hypparrhenia* species. Flowing water courses and freshwater springs are widely dispersed, some with varying degrees of relict riparian woodland. Towards the north is an increasing gradient of tree/bush savanna and woodland with dense gallery forest.

The park is bordered to the west by the Domaine de Chasse Azande (2,892km$^2$), to the south by D.C. Gangala na Bodio (2,652km$^2$) and to the east by D.C.

Mondo-Missa (1,983km$^2$). The vegetation in these reserves is largely woodland and dense to medium treel bush savanna, dominated by such species as *Combretum collinum* and *Piliostigma thonningii*, with gallery forest or riverine swamp. The human population density averages 0.21km$^2$, although two dense centres of human settlement occur on the borders of the south-eastern and south-western corners of the reserves. Land-use is mainly shifting subsistence agriculture with traditional use of bush meat for protein, and there are areas of open-cast gold mining.

## METHODS

### Aerial survey data

The overall elephant, human and vegetation distribution maps are based on systematic aerial surveys (Norton-Griffiths, 1978; Savidge *et al.*, 1976; Hillman *et al.*, 1983; Smith & Smith, 1993). The elephant population sizes are also based on these and on a comparable series of sample counts, plus one species-specific elephant count in 1989 (Hillman Smith, 1989). Human population distribution has been mapped on the basis of hut counts taken during the 1993 general aerial census. Ground work was undertaken to establish person/hut ratios.

### Poaching assessment

Elephant numbers from aerial counts and records of ivory recovered by guards are used as indicators of the poaching pressure on elephants. Reports of poaching and anti-poaching activities are made by guards on patrol. Since 1992, however, improved reporting procedures similar to those outlined by Bell (1984), have made it possible to assess the intensity and distribution of poaching on a monthly basis.

### Ground transects

Aerial survey data give elephant distributions only during the day. Many of the elephant movements into the Domaines are known to be at night. Evidence includes observations of elephant movements across the park boundary in the evenings and early mornings, spoor, vegetation damage and crop damage. The more detailed distribution of elephants within the Domaines de Chasse is based on 42 x 5km line transects. They were surveyed during the dry season, from February to April 1994.

The techniques adopted were those of Barnes and Jensen (1987) for estimating elephant densities based on the number of dung piles recorded along the transect, combined with defecation and dung decay rates. The latter rates were calculated from data collected from the domestic elephants in Garamba, while feeding freely in natural habitat. (Hillman, in prep.). The programme of Dawson & Dekker (1992) was used for analysis.

Each transect was classified by vegetation type and sampled for the type and extent of damage caused by elephants. Elephant damage could still be recognised more than six months after it had occurred, but the dung counts only indicated elephant distribution within the preceeding month. Relative abundances of other species were also recorded along the length of each transect, as were all signs of poaching.

### Preliminary study on crop damage

In November 1993, the pre-harvest and harvest period, a short study of crop damage by wildlife was made in the Nagero area in Gangala na Bodio Reserve. Forty-eight interviews were conducted, giving information concerning 68 cultivated fields. The subsistence agriculturalists interviewed around the station of Nagero are all employees of IZCN, living adjacent to the park boundary. They therefore have a vested interest in the wildlife, which provides their livelihood.

Data collected included details of ownership, location and situation (i.e. the number of sides adjacent to other fields as opposed to open bush), crops grown, actual damage to each crop, animal species causing damage, period of damage, frequency of damage, trend and preventative measures used. Direct observations of the fields were also made to verify damage estimates.

Data were collected on the incidence of crop damage in two other areas of the reserves. One area was identified as having high potential conflict, the other as low.

### GIS modelling

The purpose of the GIS modelling was to interpolate sample data to the whole region and to relate elephant distribution to spatial factors. The IDRISI and

ARCINFO systems were used for the modelling exercise.

All data relating to elephant and human distributions were taken from sample surveys. Confidence interval for the sampled data were determined according to Jolly's Method 2 (Norton-Griffiths, 1978), in the case of the aerial count data.

Information on the distribution of elephants, elephant damage and human settlement was extrapolated using GIS interpolations, whereby values for unsampled areas were calculated from the six nearest sampled points using a distance weighting factor of 2 (i.e. a sampled point at distance x will have twice the influence on a point to be calculated as a sampled point at distance 2x). The statistical accuracy of this model is being researched and it was felt that the results should be treated with some caution. Elephant use of the reserve was mapped on the basis of elephant damage to vegetation. This variable was chosen as being representative of a long-term distribution of elephants, covering more than one season, rather than the short-term distribution based on dung data.

It was hypothesised that the distribution of elephants in the reserves would be explained by proximity to the areas of highest (core) elephant density within the park, and also by the distance from centres of human settlement in the reserves (Michelmore *et al.*, 1990).

Areas of extensive elephant damage to natural vegetation, and areas of high human population densities, were modelled using a GIS overlay, as areas with a high potential for elephant crop-raiding. These areas were defined using two sets of parameters:

i. The population density and natural vegetation damage as found at Nagero (1,820 trees/km$^2$) in order to locate areas of high crop-raiding intensity. This figure was based on the results of the sample study of crop damage around the Nagero station.

ii. The parameters in i. were arbitrarily lowered to a population density of >5/km$^2$ and a natural tree damage level of >1 ,000/km$^2$, to identify areas of potential conflict at a lower level.

## Satellite radio tracking

Between April 26th and December 21st 1992, locations of an adult female elephant were tracked using a Platform Transmitter Terminal mounted on a collar and transmitting to a NOAA satellite. The collar, constructed by Telonics Inc. was the property of the Wildlife Conservation Society (WCS/NYZS), which carried out the study, and was attached by Dr William Karesh, Field Veterinarian International. Eighty-one locations were received, of which 74 were useable, based on the Argos Centre's classification of accuracy.

# RESULTS

## Distribution of elephants and poaching in the park

Figure 1 gives the elephant population estimates from successive counts, showing decrease at the time of heavy poaching, a time lag and then a recovery under protection.

In 1976 the elephant population was 22,670 ± 11,790 (Savidge *etal.*, 1976) and the elephants were distributed throughout the park (Figure 2a) at an overall density of 4.6/km$^2$. By 1983 the elephant population in the park was estimated at 7,742 ± 3,690 (Hillman *et al.*, 1983). The densities plotted in Figure 2b are lower overall and show a compression into the south of the park, at a density of 3.6 /km$^2$, compared with an overall density for the park of 1 .6/km$^2$. Figure 2c shows the distribution of elephants in the park in 1993.

According to local park staff, heavy poaching began in 1978. It continued at an average annual rate of 2,154 elephants per year throughout 1983 and half of 1984. It was widespread, but heavier in the north. The dead to live ratio of elephants overall in the park in 1983 was 1:8 compared with 1:28 in the south. The focus of

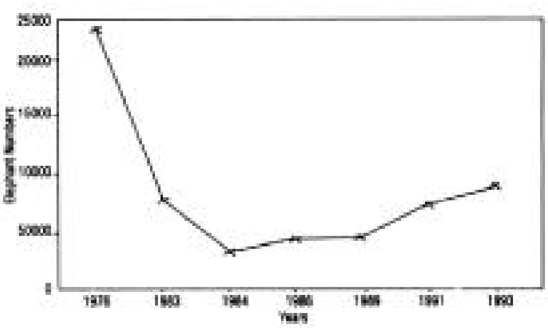

*Figure 1. Number of elephants in Garamba National Park as estimated from aerial surveys from 1976 to 1993.*

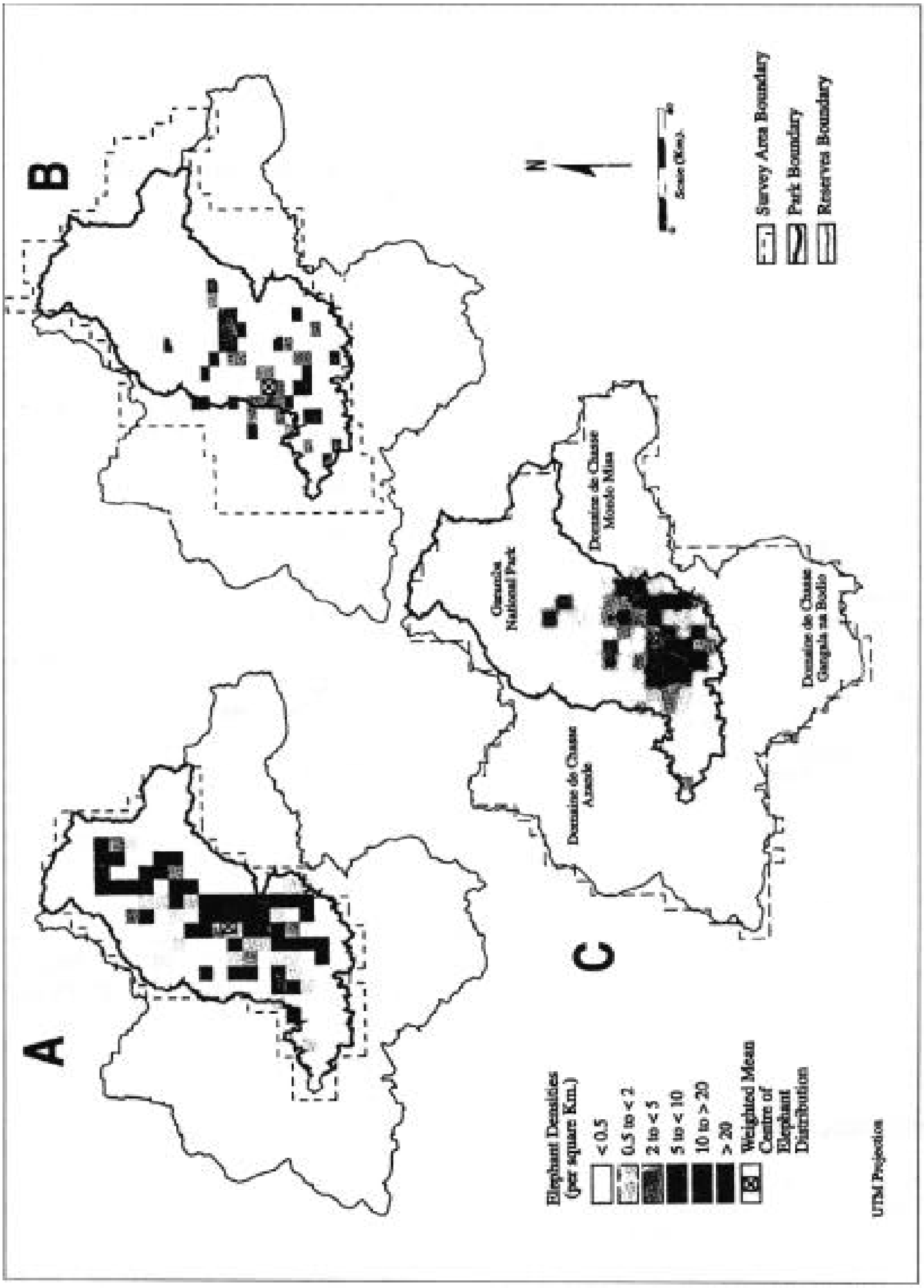


*Figure 2. Elephant density per square kilometre in Garamba National Park in A) 1976; B) 1983; and C) 1993.*

poaching in the north is due to a combination of isolation and distance from the park headquarters, and to the proximity with Sudan, where automatic arms are readily available.

From the end of 1984, the co-operative support of an aid project working with IZCN was able to bring the poaching largely under control. Elephant poaching virtually stopped. Dead to live ratios of elephants changed from 1:8 in 1983, to 1:23 in 1984; and 1:86 in 1986 to 1:576 in 1991. No dead elephants were seen in 1993.

Despite the control of elephant poaching during the period from 1984 to 1992, there continued to be limited poaching for meat, but primarily buffalo *(Synceros caffer brachyceros)*, in the north of the park and this continued to have a deterrent effect on the redistribution of elephants northwards.

## Effects on vegetation

Figure 3 shows tree cover in the park and reserves, mapped from the 1993 aerial census. It illustrates the contrast between high tree density in the reserves and very low density in the park. There is a significant negative correlation ($p<0.1$) between the distribution of bush and the day-time distribution of elephants, as mapped from the 1993 aerial sample count. The contrast between the higher density of woody vegetation in the reserves and the low density in the south of the park would appear not only to be causally related to elephant distribution, but to be one of the major factors which attracts elephants out of the park at night.

## Elephant distribution in the reserves

Figure 4 plots the distribution of elephant use of the reserves as indicated by the interpolated map of vegetation damage. It shows three main areas of high density use by elephants. Three core areas of more than 20 elephants/km$^2$ can be identified in the 1993 distribution (Figure 2c). It is known from direct observation that these, particularly the easternmost one, represent areas where elephants congregate when they return to the park in the morning, and from whence they move out into the reserves at night. The three areas of high density use outside the park correspond with the three core retreat areas inside. The southeastern area of 10 to 20 elephants/km$^2$ in the park corresponds to an area of long unburnt grass favoured by elephants.

Results from the satellite tracking in 1992 (Koontz, 1993) also support the fact that these same areas of the reserves are attractive to elephants. There appear to be frequent movements within a core area within the park and infrequent movements out to the reserves and back.

## Human-elephant conflict: crop damage

Of the 48 interviews conducted, 85.4% claimed damage to crops by wildlife. In a few cases, 100% of the annual crop was lost. In ranked order, elephants were found to be causing the most damage. Hippos *(Hippopotamus amphibius)* were second. While hippo damage was limited to within 2km of the river, which forms the park boundary, and had even caused 47% of the growers to move their fields in the last year, elephant damage occurred throughout the study area, which extended 4km from the river.

Manioc was the main staple crop grown until the past three to four years, but growers reported that with the increasing elephant population there has been a significant increase in damage to manioc, which as well as being favoured by elephants, is more difficult to protect since it grows all year round. Many growers have therefore been forced to change their main crops to rice and millet. Only 24 (50%) of the growers interviewed are currently growing any manioc at all, and of these, five of the manioc fields sustained 100% damage. Millet, although not favoured, is now grown by 83% of the farmers interviewed.

The growers have found that unless they stay at their fields to protect them every night in the pre-harvest period, they risk losing all their crops. Damage prevention methods include staying in the field, keeping a fire burning, drumming on a metal surface and chasing the animals. Pilipili *(Capsicum)* seeds are often burned in the fires to give the smoke an extra deterrent effect.

Field verifications were carried out in May 1993 of one location identified as being susceptible to a high level of elephant crop-raiding and of one area where no damage was expected. At the first location, of the 24 family units studied, 96% had experienced crop-raiding within the previous week. This is comparable to the results obtained at Nagero. At the second site, no crop damage by elephants was reported at all.

Peak damage periods by elephants are May-June during the mango season and September-November, the pre-harvest and harvest period. Major movements of elephants out of the park at night have also been noted

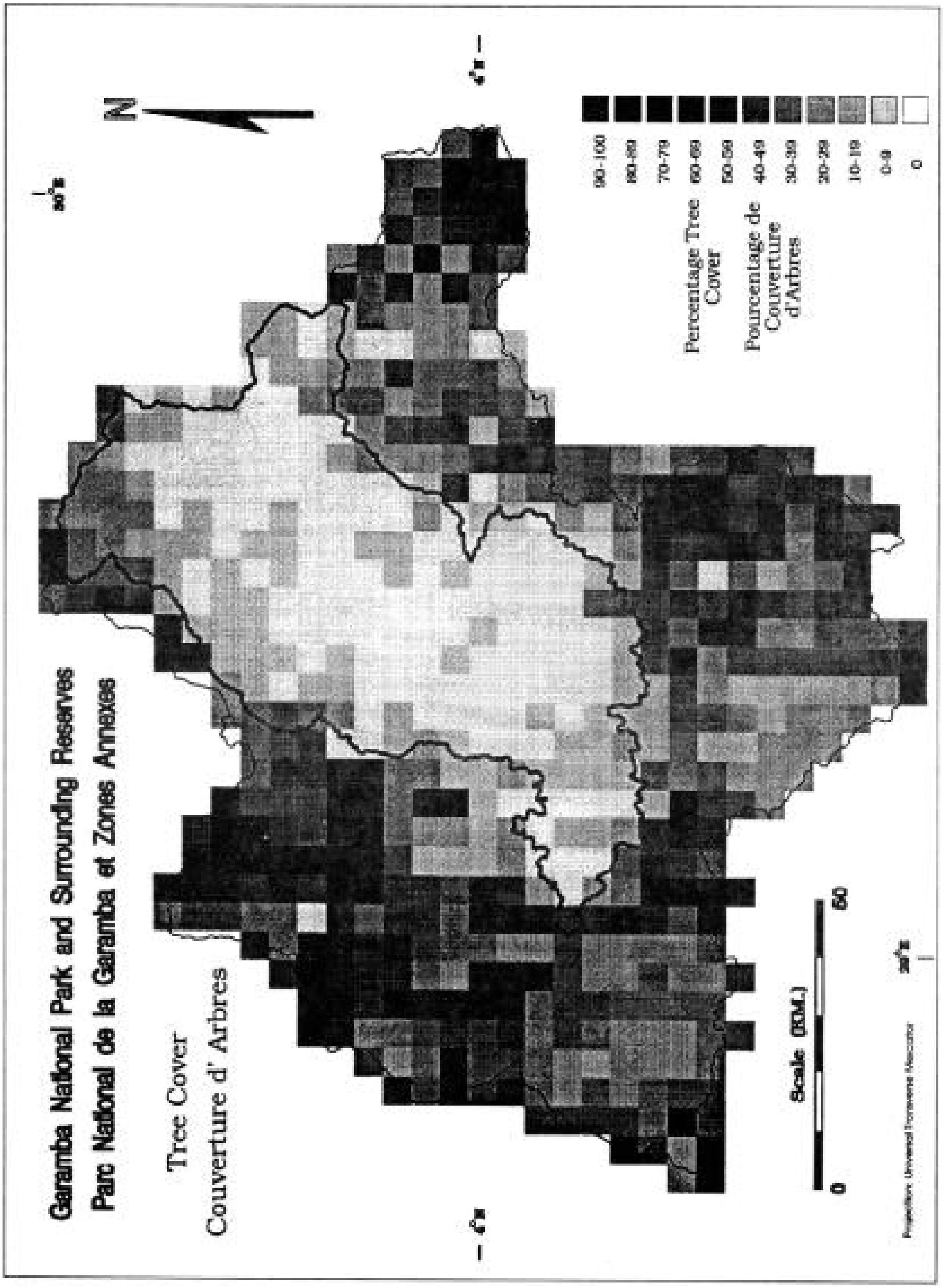


*Figure 3 Percentage tree cover in Garamba National Park and surrounding reserves.*

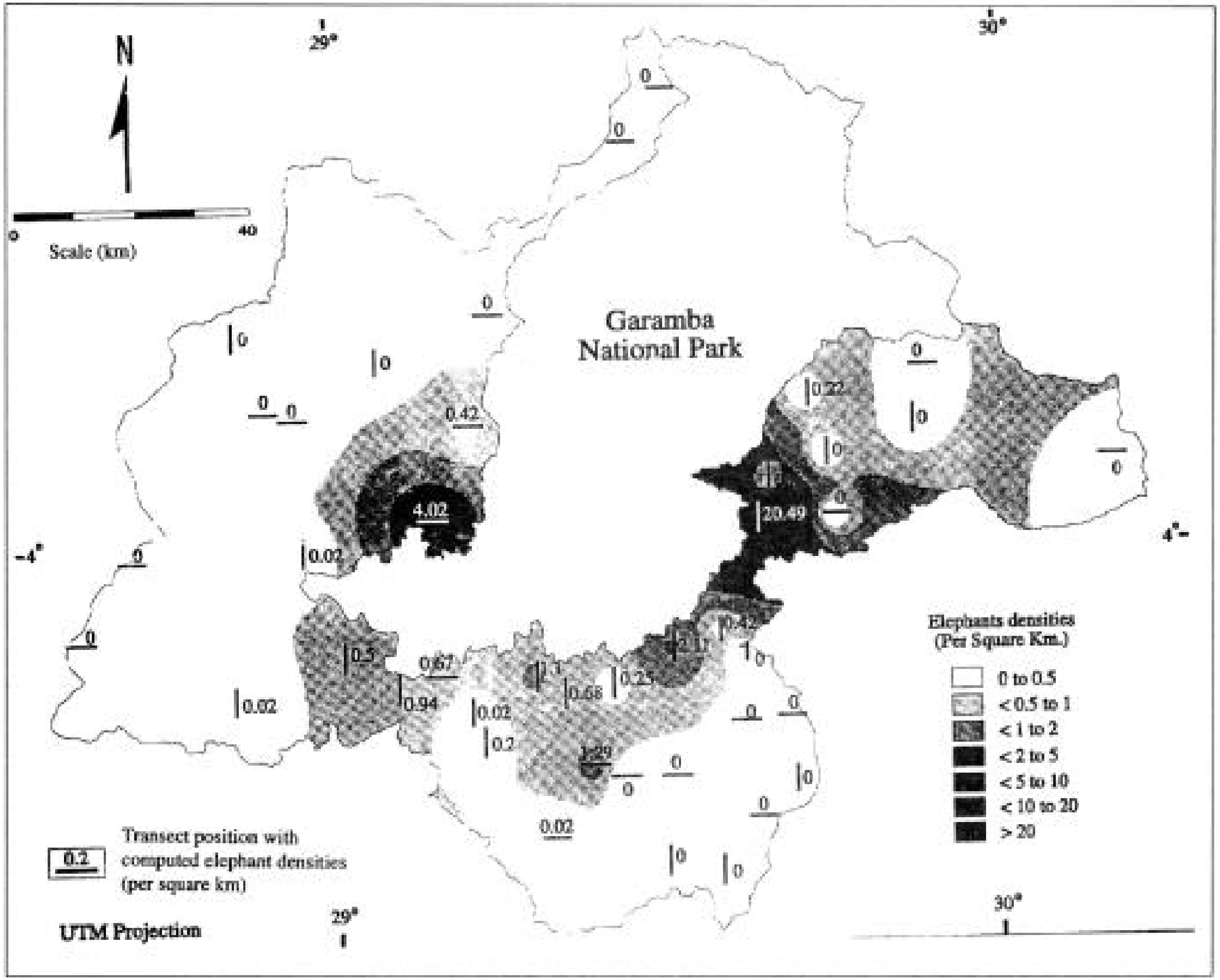


Figure 4. Elephant density per square kilometre in the reserves which surround Garamba National Park.

during the dry season, when the trees in the reserves are coming into new leaf, but virtually no crops are being grown.

Attitudes and conflicts were assessed as part of a facilitated workshop held for management planning purposes in October 1993. Of 34 problems raised, human-animal conflict was ranked second in importance. The primary problem was inadequate salaries, which also has a direct bearing on conflict, since in the current economic climate of Zaïre, the staff cannot live on their salaries alone and rely on growing their food for subsistence.

## Results of the GIS modelling exercise

The ground survey of huts revealed a ratio of 1.92 persons per hut, on which the final interpolation was based.

The relationship between natural vegetation damage by elephants and proximity to the core area of elephant density within the park was positively significant at the 0.01 level. Proximity to human settlement showed a strong negative correlation (0.01 level) against the distribution of vegetation damage.

Figure 5 identifies areas of high human-elephant conflict. In case A the level of tree damage was set at ≥1,820 trees/$kin^2$, which is the level of damage found around the station of Nagero. In case B a lower level of damage (≥1,000 trees/$kin^2$) was used as a more sensitive indicator. The heavy shading represents areas with a high incidence of crop-raiding and which therefore require follow-up work to establish the extent of the problem to the people.

## DISCUSSION

The interpolated mapping, together with data on elephants and poaching, shows how the current situation has developed over the last few years. Broadly speaking, the distribution of elephants has been primarily affected by poaching. Although it is probable that the park area has been more open than surrounding areas for a long time, elephants have concentrated there in its relative safety since the establishment of the park. There has also been a history of hot fires, particularly in the south. These two major factors are associated with a continued loss of mature trees and a repression of tree regeneration in the park. According to longterm observation (Verschuren, J. and Cornet d'Elzius, C., pers. comm.) woody vegetation has, over the same period, increased outside the park. Concomitant with these factors has been the increase in coarse grass grazers, notably the buffalo - which may further reduce the proportion of palatable grasses - and an apparent reduction in browsers, such as the giraffe *(Giraffa camelopardalis congoensis)*. This change is reinforced by the development of a contrasting nutrient status of the soil inside and outside the park.

The contrast in habitats inside and outside the park, and the availability of woody vegetation with its higher protein content outside the park, was therefore hypothesised to be a major factor attracting the elephants out of the park at night. This was supported by the observed elephant damage, particularly fresh damage, to natural vegetation around the boundary of the southern part of the park, where the elephants are concentrated. The strong positive correlation between elephant vegetation damage and distance from the elephant population core in the south of the park, together with the absence of this type of elephant distribution during the day, demonstrates how damage is largely caused by night-time elephant movements and limited by the distance which can be covered in a night. This is supported by many observations of elephants crossing the river boundary of the park at dusk and early in the morning, and by crop-raiding being largely limited to the night. The apparent increase in this type of movement in recent years coincides with better protection due to stronger law enforcement in both the reserves and the park.

There is evidence that some elephants are more or less resident in the reserves, but their distribution in the reserves is mainly affected by proximity to the core population in the south of the park and distance from humans. It is known from direct observation that considerable elephant movement out of the park occurs in the dry season, despite the absence of crops. The strong negative correlation of elephant distribution with that of humans indicates that elephants are largely avoiding areas of human settlement. Crop-raiding for specific resources in the dry season is therefore not a primary attractant. The main periods of crop-raiding are associated with the time when mangos are ripe, from April to June, and later in the wet season when crops are close to harvesting. However, in the dry season much of the grass in the park is either long and dry, or burnt, and the trees outside the park are coming into new leaf. Further work will examine this aspect of seasonal elephant use of the reserves and the effect of different vegetation zones and favoured tree species on the distribution of elephants.

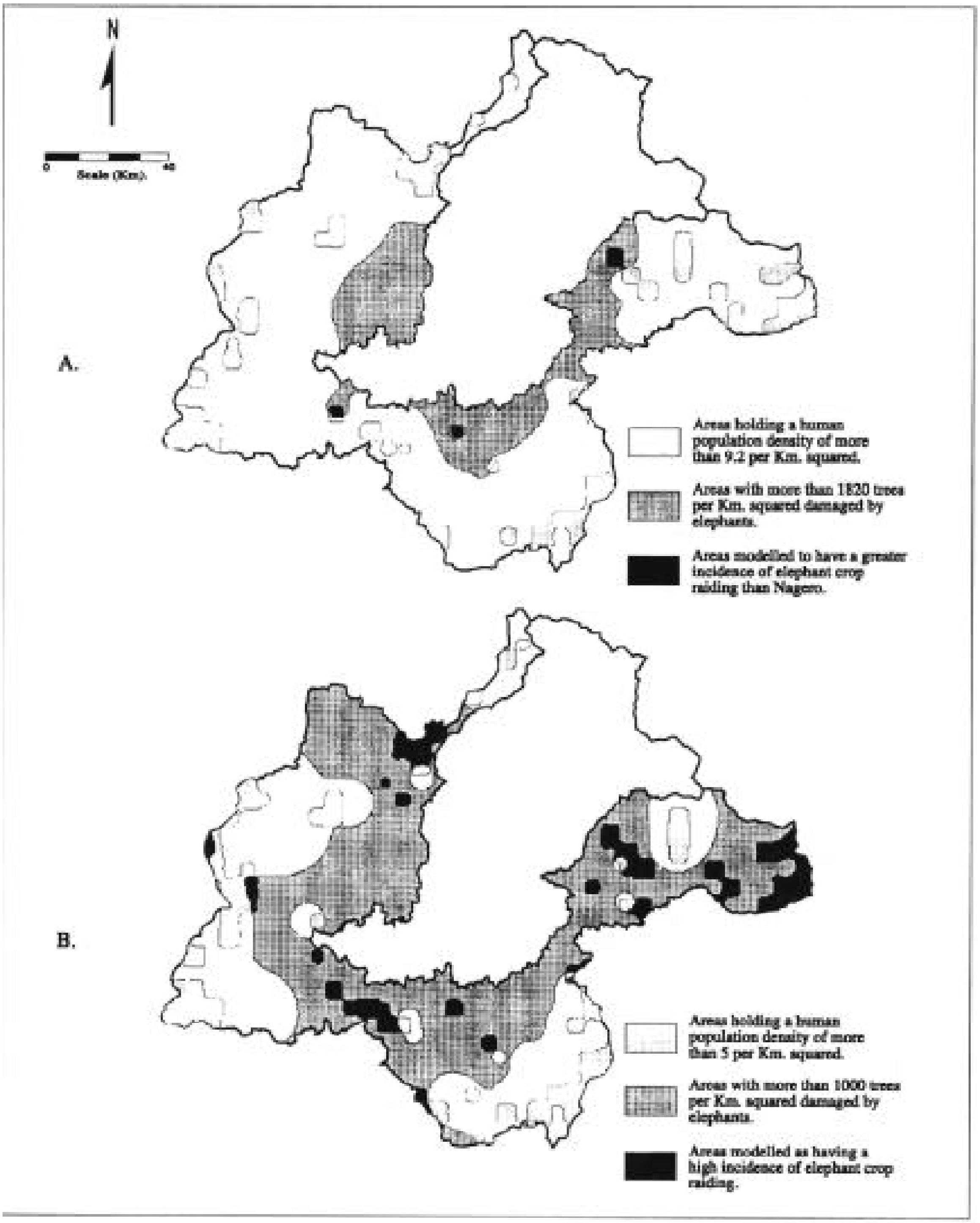


*Figure 5. The results of GIS modelling to predict areas in the reserves with a high incidence of crop-raiding. A) shows those areas expected to have a greater incidence of crop-raiding by elephants than Nagero. B) shows those areas with a high/eve/of crop damage using a human population density of .>5/km$^2$ and more than 1,000 trees/km$^2$.*

The crop damage study indicated that elephants are threatening the livelihood of certain human communities, particularly those living close to the park boundary. However, the modelling exercise which predicted areas of potential human-elephant conflict illustrated how limited these areas are. Although elephant distribution is associated more with the distribution of natural vegetation in the dry season than with crops, the impact of crop damage is nevertheless recognised as an important problem by the people who are affected.

The above information is being used to contribute to the preparation of a zoned management plan for the park and reserves. It is not possible, given the current financial and manpower resources, to protect the reserves by conventional forces. In principle it may be possible to make the reserves more safely available through schemes which identify the most important areas for elephants and other wild species and which involve local human communities.

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