

CAMEROUN  
Ministère de l'Environnement

Projet ECOFAC - Composante Cameroun

**I. SURVEY OF PRIMATE POPULATIONS &  
LARGE MAMMAL INVENTORY**

**II. SURVEY OF ELEPHANTS, GORILLAS  
& CHIMPANZEES**

**RESERVE DE FAUNE DU DJA  
CAMEROUN**

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February 1995

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## SUMMARY

Surveys of elephants, gorillas, chimpanzees and diurnal monkeys by line-transects took place during five months of 1994 and January 1995 in the Réserve de Faune du Dja. The Réserve du Dja covers 5,260 km<sup>2</sup> of semi-deciduous lowland tropical forest and is the focus of activities by Ecofac - Composante Cameroun.

Seventeen transects with a combined length of 94.7 km were surveyed twice at intervals of five to seven months for elephant dung, ape nests, and signs of human activity. All indications of duiker, bush pigs, buffalo and large carnivores were also noted. The program DISTANCE was used to produce density estimates of elephant dung and ape nests. The density of elephant dung piles was estimated to be 705.9 per km<sup>2</sup>, and a mean dung decay rate of 0.0158 was calculated using rainfall and temperature data. This represents an elephant density of 0.56 /km<sup>2</sup> (0.33-0.96 /km<sup>2</sup>). Two concentrations of elephants were found: one in the M'pep river basin where the vegetation was dominated by *Raphia* swamps, secondary gaps and old secondary forest with *Haumania* and *Ancistrophyllum* thickets. The other near Ndengué coincided with an extensive *Cyperus-Pandanus* marsh. The average density excluding M'pep and Ndengué was 0.22 /km<sup>2</sup>. It was clear that elephants were not evenly distributed. Although no relationship between elephant densities and human activities was determined, the highest densities recorded were at distances over 25 km from the nearest village. Seasonal effects could not be measured in this short-term study, but we obtained evidence that they occur. An extrapolation from the lowest density stratum suggests a potential elephant population of 1,157 (789-1736) for the Dja Reserve, however, it would be unwise to assume that elephants are present through out the Reserve without further investigation.

The mean group size of chimpanzees was  $2.2 \pm 1.9$  weaned individuals. The density of nest sites was 41.63 per km<sup>2</sup>, indicating a population of 0.79 weaned chimpanzees per km<sup>2</sup> (0.60-1.04 /km<sup>2</sup>). Their distribution seemed to be relatively even.

Mean gorilla group size was  $3.7 \pm 3.1$  weaned individuals and the overall density of nest sites was 36.37 per km<sup>2</sup>. This translates to 1.71 weaned gorillas/km<sup>2</sup> (1.02-2.86 /km<sup>2</sup>). The average density excluding M'pep and Ndengué was 0.47 /km<sup>2</sup>, but even this lower limit may not be appropriate for the entire Reserve. Gorilla distribution was uneven, and many transects were devoid of nests. A similar pattern to that of elephants occurred, with concentrations on transects between 15 and 25 kms from villages around the river M'pep and east of Ndengué. High local densities are generally associated with swamp forests (Blake, 1993; Fay *et al*, 1989), and *Raphia* swamp and seasonally inundated forest with abundant *Uapaca* spp. trees covered large areas of the sectors sampled. Most nest sites were found near Ndengué and half of these were in *Raphia* swamp. Swamps, marshes and seasonally inundated forests provide refuge from hunters in northeastern Gabon (Lahm, 1993), and Blake (1993) explained gorillas use of the Likouala swamps in Congo as a modification of the gorillas' behaviour to avoid areas of human impact.

Censuses for primates by direct observation were carried out on the same transects. These add up to 247.8 km (N = 51), and were supplemented by 110 km of census data from Mekas and 105 km from Ekom. Eight species of diurnal primates were seen: *Miopithecus talapoin*, *Cercopithecus cephus*, *Cercopithecus nictitans*, *Cercopithecus pogonias*, *Cercocebus albigena*, *Cercocebus galeritus*, *Colobus guereza* and *Pan troglodytes*. *Cercopithecus neglectus*, was probably seen once only, and *Gorilla gorilla* not at all. *Cercopithecus mona* and *Cercocebus torquatus* are reputed to occur in the Dja Reserve, but the present study found no evidence to support this.

DISTANCE was used to produce density estimates of the four most common species of monkey: *C.cephus*, *C.pogonias*, *C.nictitans* and *C.albigena*. The number of observations of all other species was inadequate for density calculations. Monkeys were common throughout the areas sampled, and attained particularly high numbers in the southeast near Alat, where the maximum density for a single species was recorded (*C.nictitans* 3.71 troops/km<sup>2</sup>) and for four species combined (9.73 troops/kms). Lowest densities were found in the northeast Ndengué (2.22 troops/km<sup>2</sup> of four species combined). These estimates are comparable to densities obtained by several other studies in forests with similar primate species composition. It was notable that near Ndengué, where gorillas occurred in their highest numbers, monkeys were relatively rare, and at Alat and Mekas where there were most monkeys, gorillas and elephants densities were quite low. This suggests an inverse relationship between the abundance of monkeys and that of gorillas and elephants, however, no significant trends were identified at the transect level. The frequency with which polyspecific associations were recorded seemed to be low (46.7 to 72.6 % of observations per species), but this may have been a function of the methodology.

In conclusion, the Réserve de Faune du Dja was shown to harbour important populations of elephants, gorillas, chimpanzees and at least four species of diurnal monkeys. Four other diurnal monkey species were confirmed to occur at overall low densities, but their status remains to be determined. These preliminary results should be viewed with extreme caution, and further longer-term studies are needed to confirm our findings.

## **ACKNOWLEDGEMENTS**

First and foremost, we thank the Chef de Composante, Jean Marc Froment, for sharing his knowledge and enthusiasm, and for his assistance in all aspects of the study. Jean Marc's patience, compassion, and dedication to his work are an inspiration.

Preparation for this mission by the Chef de Composante enabled us to make efficient progress and maximise data collection during the time available. In this context, we also thank Michel Lombardi and François Nkotit for help in the organisation of our sorties. During the surveys, we worked with many guides and porters, but three people in particular deserve mention: Ng Antoine, Bokama Basile and Mekame Moise. Other members of the Ecofac Project personnel at Somalomo provided new perspectives of the challenges in conservation.

Valuable data were contributed to this study by Martin Tchamba, Marc Dethier, Pia Muchaal, Ngandjui Germain, Ngnegueu Paul Robinson, Ken Whitney and Mark Fogiel.

For discussion and companionship during field work, we thank Ken, Mark and the researchers of Projet Calao, Marc, Pauwel De Wachter, Ngandjui, Pia and Bertin Tchikangwa Nkanje. Robinson gets special mention for his ability to maintain team sanity during transect cutting. For advice and moral support during Distance analyses, thanks go to Richard Barnes, Steve Buckland, Atanga Ekobo, Jefferson Hall and Buddy Powell. Lee White gave general advice on methodology. Caroline Tutin and Michel Fernandez of Ecofac Gabon helped towards the standardisation of methods. And for their generous hospitality, we thank the project staff of the Wildlife Conservation Society in Cameroun.

## CONTENTS

Summary

Acknowledgements

1. Introduction

2. Methods

- I. Primate Censuses
- II. Elephants, Gorillas and Chimpanzees
- III. Data Analysis

3. Results

- I. Primate Censuses
- II. Elephants, Gorillas and Chimpanzees
- III. Vegetation

4. Discussion

- I. Primate Censuses
- II. Elephants, Gorillas and Chimpanzees

5. Conclusions & Recommendations

- I. Questions to be addresses in future studies
- II. Conservation priorities.

## *ANNEXES*

Annex 1. L. White (1994) Bomassa Workshop Methods. Document prepared for WCS

Annex 2. GPS data

Annex 3. Census data collection sheet with explanations

Annex 4. Trail data collection sheet with explanations

Annex 5. Vernacular names of large mammals

Annex 6. Elephant dung decay rates

Annex 7. Raw data: primate census

Annex 8. Raw data: nests, dung & trail

Annex 9. Raw data: nests & dung off transect (prospection)

Annex 10. Raw data: primates (behind transect cutters)

Annex 11. Raw data: primates (off transect)

Annex 12. Summary of DISTANCE output for monkeys

Annex 13. Summary of DISTANCE output for elephants, gorillas and chimpanzees

## *TABLES*

Table 1: Number of kilometres censused

Table 2: Encounter rates

Table 3: Monkey densities

Table 4: Polyspecific groupings

Table 5: Gorilla nest types

Table 6: Comparative monkey densities

### *FIGURES*

Figure 1: Map of the Dja Reserve, indicating locations of transects

Fig 2: rainfall

Figure 3: Map of transect locations in Djolimpoum and Malele sectors

Figure 4: Map of transect locations near Ndengué

Figure 5: Map of transect locations near Alat

Fig 6: Frequency of monkey observations

Fig 7: Frequency of monkey vocalisations

Fig 8: Monkey densities per sector

Fig 9: Distribution of elephant dung

Fig 10: Gorilla nest

Fig 11: Gorilla nest

Fig 12: Distribution of gorilla nests

Fig 13: Distribution of chimpanzee nests

Fig 14: Distribution of snares

Fig 15: Distribution of duiker trail

Fig 16: Distribution of bushpig and buffalo trail

Fig 17: Cyerus-Pandanus swamp

Fig 18: Rattan

Fig 19: River Mpam

Fig 20: Elephant footprints

Fig 21: Chimpanzee

## 1. INTRODUCTION

### Objectives

Ia. To inventory small diurnal primates (cercopithecines, mangabeys and colobines) and to obtain indices of relative abundance for each species.

Ib. To estimate the densities of diurnal monkeys.

II. To estimate the density of large mammal populations, in particular those of elephants, gorillas and chimpanzees, and to describe their distribution in the Dja Reserve.

Surveys of elephants, gorilla, chimpanzees and diurnal monkeys were carried out as part of the Ecofac-Composante Cameroun programme during the months of May, June, July, August and December 1994 and January 1995. The data in this report were collected by Liz Williamson, Leonard Usongo, Martin Tchamba and Ngnegueu Paul Robinson. Additional data were contributed by Marc Dethier, Pia Muchaal, Ngandjui Germain, Ken Whitney and Mark Fogiel.

Our mission benefited from the experience and knowledge accumulated by other researchers associated with the Ecofac project, and from the contacts they made with the local population (Dethier & De Wachter at Ekom-Ndengué; Debroux at Djomedjoh-Alat). In this respect we gained a significant logistical advantage which enabled the team to begin work rapidly. For the most part, we chose to work in sectors of the forest where botanical transects are already in place, one of these (Djolimpoum transect) served as a baseline from which a series of perpendicular transects were cut.

The Réserve de Faune du Dja is poorly known. Gartlan (1989) noted that no systematic inventories had taken place in the Dja Reserve. Gartlan and Struhsaker (1972) presented preliminary information on the primate fauna of the Dja, but quantitative studies of large mammals began only recently with the implantation of the Projet Ecofac (e.g. Samba, 1994). At least 10 species of diurnal primates: *Miopithecus talapoin*, *Cercopithecus cephus*, *Cercopithecus nictitans*, *Cercopithecus pogonias*, *Cercopithecus neglectus*, *Cercocebus albigena*, *Cercocebus galeritus*, *Colobus guereza*, *Pan troglodytes troglodytes* and *Gorilla gorilla gorilla* were already known to occur in the Dja Reserve (Gartlan, 1989).

## 2. METHODS

In the Terms of Reference for these surveys, the Ecofac Scientific Committee recommends the application of the line-transect census methods developed by Tutin & Fernandez (1983, gorillas and chimpanzees) and Whitesides *et al* (1988, primates). The literature on techniques for sampling the abundance of animal populations using line-transects is ample. Methods for large mammals in tropical

forests are described in articles by the authors mentioned above and by Barnes *et al* (1987, 1991, 1993), whilst the theory of line transecting is discussed, critically evaluated, and presented with models and survey designs by Buckland *et al* (1993). To avoid reiteration of these methods, a document prepared by Lee White is included as Annex 1 of this report, which describes the stages of a survey from cutting transects to analysing data.

Nonetheless, certain issues concerning data collection should be stressed here. The first critical point with current census techniques, is that the strip-width is not predetermined: all animals or objects seen should be recorded irrespective of their distance from the centre line of the transect. “Effective strip widths” are estimated *post hoc* by analysing perpendicular distance from the transect to the animal or object sighted, and “detection functions” determined (*i.e.* the probability of detecting an object that is at distance  $y$  from the random line). This differs from earlier surveys where a strip of a fixed width was searched (*e.g.* Barnes & Jensen, 1987). However, an important assumption of the DISTANCE model is that all objects of interest which lie on or above the centre line are detected with certainty (Buckland *et al*, 1993). Thus the sampling probability at zero perpendicular distance equals one (100%). Violation of this assumption would lead to underestimation of density, and render the model inapplicable. Because of the importance of detection of all objects on the line, and because of the reduced importance of “outliers” at relatively large distances from the transect line, most effort can be put into searching near to the centre line of the transect. Trail on the line should not be missed whilst searching for distant nests or troops of monkeys.

Perpendicular or sighting distances should be recorded accurately. Animals or objects which overlap the centre line should not automatically be recorded as having zero perpendicular distance, but efforts made to locate the centre of the dung pile or nest and to record even a few centimetres. The precision of all measurements, from length of a transect to observer-to-animal distances, is critical if population densities are to be estimated with confidence. For this reason, a hip-chain was used to record all transect lengths (model Topochaix). During our first passage on a transect, distances were marked with forestry ribbon, so that on subsequent passes it was not necessary to use topofil thread. A pedometer is acceptable only for repeat censuses of an already measured route (model used DigiWalker E).

### **Location of transects**

Ideally, transects 5 km long would be placed throughout the reserve, however, due to the large size of the Dja Reserve, 5,260 km<sup>2</sup>, and the short duration of our study, the number of transects established was limited. Since extrapolation will be made from a relatively small sample, sampling of the habitat needs to be random, and sampling of animal populations must be random (Buckland *et al*, 1993). Transects were stratified according to distance from the nearest village, as recommended by Barnes and Jensen (1987), and orientated to lie to across the drainage pattern with the intention of sampling a representative proportion of all vegetation types. Transect lines should be straight, and should not follow animal paths in the forest, as this will introduce a major bias in the data.

To locate the start point of a transect, the route walked was measured with Topofil, and direction recorded (using a Silva Ranger Type 15 compass). Topographic features such as rivers and streams were noted, which helped to determine locations on a map. GPS information was collected whenever possible with a Trimble Navigation Ensign XL GPS.

## **Description of the Vegetation**

The Dja Reserve covers 5,260 km<sup>2</sup> of low altitude tropical forest, classified as “forêt semi-décidue congolaise” by Letouzey (1963). As all transects were cut, forest type was noted, and the presence of certain tree species recorded together with the relative abundance of herbs belonging to the Zingiberaceae and Marantaceae families which are known to be important food sources for great apes (*e.g.* Williamson *et al*, 1990; Tutin *et al*, 1991).

## **I. Primate Censuses**

First, it should be stressed that censuses of primates were not carried out on the same day as cutting of a transect, and at least two days lapsed between censuses on the same transect (*c.f.* Whitesides *et al*, 1988). Primates encountered during cutting were recorded, but such data serve only to confirm the presence or absence of monkey species (raw data are to be found in Annex 10). Similarly, records of primates seen from paths provide qualitative but not quantitative information about species presence and distribution (Annex 11).

Direction of travel could not be controlled as with one exception, it was not possible to access the end of the transect and carry out a census in the reverse direction. Although rotation is recommended, analyses of direction of travel by Whitesides *et al* (1988) and White (1992) have not revealed any significant differences in the data.

During censusing of the 34.2 km Djolimpoum botanical transect, censuses were not limited to 5 km, but were of variable length as recording continued through out the day. One means of increasing sample size is to sample at all times of day and any decrease in activity will be compensated for by the increased length of transects sampled (Chapman *et al*, 1988). Barnes and Jensen (1987) noted the importance of minimising dead time, and of achieving a balance between statistical requirements and logistical constraints.

For most of December we were able to carry out daily censuses. Occasionally the distance between transects exceeded that which we could travel after a census, so the subsequent census got underway later in the day after completing the journey.

During censuses, the team consisted of one or two researchers, accompanied by a local guide. The data

collection sheet used together with explanatory notes on how it should be completed were adapted from those prepared by the Ecofac project in Gabon (see Annex 3). All monkeys seen within 50 m of another monkey were considered to form part of a troop; conversely animals seen more than 50 m from a troop were recorded as solitary (*c.f.* Whitesides *et al.*, 1988). Because of the critical importance of accurate recording of perpendicular distances, a Topofil was used to measure many sightings distances to monkeys.

## **II. Elephants, Gorillas and Chimpanzees**

Collecting data on all animal signs is compatible with cutting of transects and is in fact preferable, as animals may begin to use transect lines as paths. This change in animal movements would increase the density of trail close to the centre line. The team consisted of one or two researchers, accompanied by a local guide, plus two to four transect cutters and a compass bearer. The data collection sheet and accompanying information were also adapted from the Ecofac-Gabon format (see Annex 4). The presence and distribution of all large mammal signs, such as nests, dung, feeding trail and foot prints were noted, together with human signs, including snares, machete cuts, hunting or fishing camps, paths and footprints. Each transect was sampled twice, at intervals of between five and seven months.

Besides all indications of elephants, gorillas and chimpanzees, we noted those of duiker, bush pigs, buffalo and large carnivores. Footprints were recorded with the intention of converting them into indices of abundance, as has been done successfully for terrestrial mammals elsewhere (e.g. Prins & Reitsma, 1989; Wilkie & Finn, 1990). Footprints were attributed to a particular animal species by the guide, using local names for animal species, which are listed in Annex 5.

Signs were classified by age, but since elephant dung may remain visible for almost a year and tree nests for many months, precise ages are difficult to estimate. The categories “fresh”, “recent” “old” and “very old” refer to: <7 days (F), > 1 week and < 1 month (R), 1 to 3 months (V), or more than 3 months (TV). These ages do not apply to duiker dung, which ages rapidly and has a mean duration of 4.3 days (White, 1994a) and for which the time scale was reduced to 14 days.

In the case of nests, particular effort is required to search for all nests present at any individual nest site. Once a nest has been detected, observers must leave the centre line to carry out a thorough search and record all nests whether or not they are visible from the transect centre line. Perpendicular distances to the centre of each nest site were calculated from the perpendicular distances measured to each nest (*N.B.* this differs from analyses of nest density, as in Tutin and Fernandez, 1983).

## **III. Data Analysis**

The program DISTANCE was chosen for data analysis because of its superior performance in producing density estimates. It is currently the most robust program developed, which is also readily available and

being applied on an ever widening scale. To meet statistical requirements, the number of observations should reach at least 60 to 80 per species, although a sample size of 40 may be adequate for some purposes (Buckland *et al*, 1993).

a) Monkeys: Density calculations incorporate the mean spread of a troop of monkeys and mean troop size. We used distances compiled by White (1994a). Half of the mean troop spread was added to each perpendicular distance recorded before analysis by DISTANCE (*C.cephus*: 15 m, *C.pogonias*: 30 m, *C.nictitans*: 30 m, *C.albigena*: 50 m). DISTANCE produces estimates of the number of troops of monkeys per km<sup>2</sup>.

b) Elephants: To calculate the density of elephants (E) from the dung piles density (Y) as produced by DISTANCE, we used the formula:

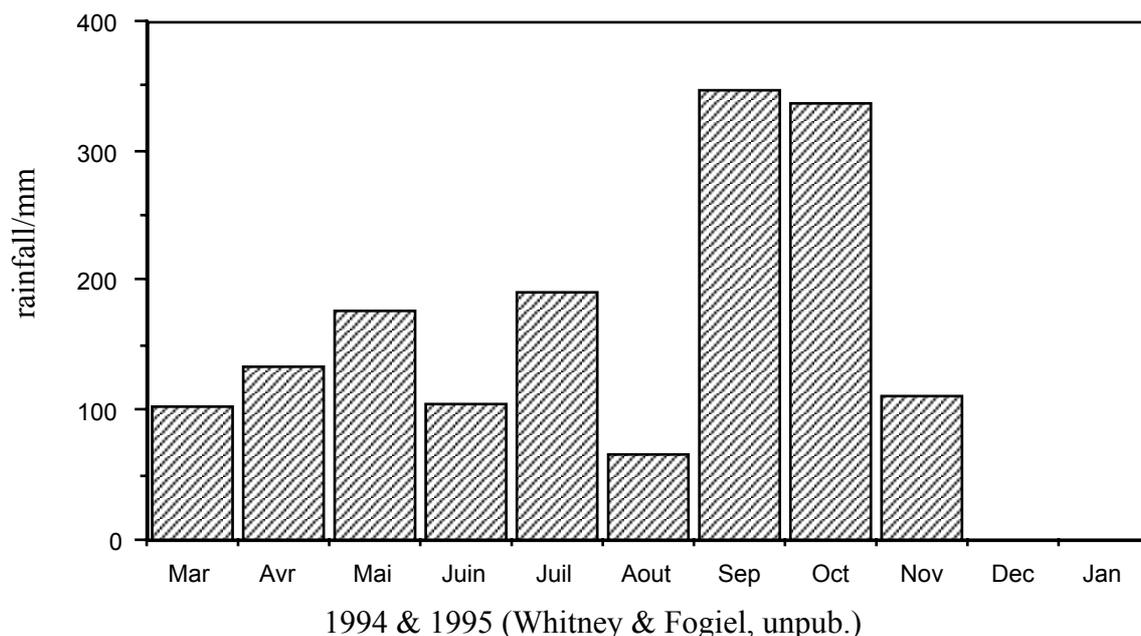
$$E = (Y \times V) / D \quad (\text{Barnes } et \text{ al}, 1995a)$$

Several estimates of defaecation rate (D) by forest elephants have been published (*e.g.* Merz, 1986); following Richard Barnes' recommendation, that used here is 20 dung piles per day per elephant (Tchamba, 1992).

Dung decay rate (V) varies with many factors, including diet, but climate is a major determinant of the time that dung piles remain visible (White, in press). The best correlation found is with rainfall and temperature in the month of data collection and explains 81% of the variation in elephant dung decay (Barnes *et al*, 1994). Decay rates were calculated with the following equation:

$$V = (-96.498 + (0.063 \times \text{monthly rainfall}) + (4.667 \times \text{mean monthly temperature})) / 1000$$

Fig. 2: Rainfall at Bouamir, Reserve de Faune du Dja



Rainfall at Bouamir in the Dja Reserve during the period of these surveys is shown in Figure 2. The mean monthly maximum temperature recorded was 26.0 °C, while mean monthly minimum temperature was 18.4 °C. (unpublished data from Whitney & Fogiel, Projet Calao). Decay rates for each month of data collection range from 0.026 in December (dry season) to 0.285 in September (beginning of the rainy season) (Annex 6).

c) Gorillas and chimpanzees: Densities of gorillas (G) and chimpanzees (C) are calculated from nest site densities (N) output by DISTANCE using the formula:

$$G \text{ or } C = (N \times \text{mean group size}) / \text{mean duration of nest sites}$$

The mean duration of chimpanzee nests in northeastern Gabon was found to be 113.5 days (Tutin & Fernandez, 1983) and this figure will be applied to our data. Mean longevity of gorilla nest sites varies with the types of nests constructed, but we have applied the 78 day mean from studies at Lopé (Tutin *et al*, in press). To make accurate counts of group size, nests sites need to be located within four days of apes having slept there, as some gorillas in CAR and Gabon sleep in “bare ground nests” without vegetative construction (Remis, 1994; Tutin *et al*, in press). Mean group sizes in the Dja will be calculated from the number of nests at fresh nest sites only, including some sites found away from transects.

*N.B.* The 95% confidence limits produced by DISTANCE take into account the variances of detection and encounter rates, but the estimates of animal density will not include confidence limits, since the variance of some variables incorporated into calculations is unknown. Also the process of adjusting perpendicular distances of monkeys sighting invalidates the confidence limits given by DISTANCE. All

data sets were truncated during analysis, once the likelihood of an object being seen (the detection probability) dropped below 0.15.

### 3. RESULTS

During the first four months of the surveys, activities concentrated on the establishment of 17 transects totalling 94.7 km. (5 x 5 km Djolimpoum; 5 x 5 km Malele; 1 x 15.4, 1 x 3.6, 1 x 5.7 km Ndengué; 4 x 5 km Alat), see Figure 1 and Table 1.

Table 1: Number of kilometres of transects surveyed for animal sightings and trail

<u>Sector</u>	<u>Month</u>	<u>Trail</u>	<u>Sightings</u>
Djolimpoum	May	21.5 (+34.2)	69.6
Malele	Jun	25.0	25.0
Ndengué	Jul	24.7	0 (Tchamba)
Alat	Aug	20.0	2.5 (Usongo)
Djolimpoum	Dec	23.1	59.0
Malele	Dec	23.0	30.3
Ndengué	Dec	23.6	23.6
Alat	Jan	20.0 (+3.8)	23.8
Djomedjoh	Jan	(9.0)	14.0
Mekas	Jul-Nov	20.0 †	110.0 † (Muchaal, Ngandjui)
Ekom	Jul-Oct	<u>25.0</u> †	<u>105.0</u> † (Dethier)
TOTALS		225.9 (+ 47)	462.8

† subsets of data

Ndengué and Alat are a little difficult to place within a stratification of increasing distance from villages, however, preliminary analyses of the data by transect revealed trends which did not fit simply within the stratification intended. This led to a *post hoc* definition of strata which differs for each species, as detailed below. Two of the transects near to Alat crossed each other. This was not planned, so data were examined for any possible duplicate observations in the region of the overlap; there were none, and the data have been retained. The approximate locations of all transects and nearest villages in the Dja Reserve as a whole are shown in Figure 1 on a small scale map. Transects cut at Djolimpoum, Malele, Ndengué and Alat are positioned on larger scale maps in Figures 3, 4 and 5. GPS references are attached in Annex 2. GPS data are sparse for the transects close to Alat due to adverse meteorological conditions in January 1995. The reference numbers given to each transect can be found in Annex 8 (codes). Note that during collection of trail data during the second mission, a new number was given to each transect, however, data were lumped in most analyses. Also transects longer than 5 km were given separate numbers for each 5 km segment to allow interpretation of strata, but are treated as a one sample in most analyses.

#### **I: Primate Censuses**

The number of censuses carried out for this mission was 51, mostly during the month of December.

These add up to 247.8 kilometres of census, and were supplemented by 110 km from Mekas and 105 kms from Ekom, totalling 462.8 kms (see Table 1). (*N.B.*Data from Mekas and Ekom are not included in Annex 7). In the raw data appended, observer-to-animal distances and sighting angles have been converted to perpendicular distances. In all cases where animals were seen, perpendicular distance is given. Values in the column “observer to animal” refer to the distance estimated if animals were heard but not seen. Times for the start and finish of censuses are given as decimal values to facilitate calculations of speed of travel.

Efforts were made to begin censuses between 6.00 hrs and 7.00 hrs, although several previous studies found no evidence of sighting frequency varying with time of day (Thomas, 1991; White, 1992; Whitesides *et al*, 1988), and density estimates are not systematically affected by sampling during periods of inactivity (Chapman *et al*, 1988). Excluding censuses which were started in the afternoon (N = 2), the mean time at which censuses began was 7.30 hr. (R = 6.00-11.50 hr.), ending on average at 12.54 hr. (R = 9.30-17.20 hr.).

An optimum speed of 1.0 to 1.5 km/hr. is recommended for the censusing of monkeys. If travel is too slowly in relation to the animals, observers could encounter the same troop of monkeys more than once. The average speed with which we carried out censuses was 0.95 km/hr. (R = 0.51-1.48 km/hr.) since trail data were usually collected at the same time, and effective searching required that observers move slow to be sure of detecting all trail and animals. This dual collection of data was a compromise to maximise the quantity of all types of data collected during this study, and made necessary by the logistical constraints of sampling in dense forest. White (1994a) found no detectable effect of censusing at these two speeds.

Table 2: Encounter rates for large mammals during censuses

<u>Species</u>	<u>No. Obs</u>	<u>ER (no.obs/km)</u>	<u>No. auditions</u>
Cercocebus albigena	56	0.121	89
Cercocebus galeritus	2	0.004	
Cercopithecus cephus	79	0.171	53
Cercopithecus neglectus	? 1		
Cercopithecus nictitans	103	0.223	141
Cercopithecus pogonias	65	0.140	91
Colobus guereza	9	0.019	23
Miopithecus talapoin	2	0.004	
Gorilla gorilla	0		
Pan troglodytes	6	0.013	35
Homo sapiens (hunters)	8	0.044	1
Loxodonta africana	4	0.022	4
Potamochoerus porcus	0		1
Syncerus caffer	1	0.006	1
Cephalophus dorsalis	7	0.039	
Cephalophus callipygus	2	0.011	

Cephalophus leucogastor	0	
Cephalophus monticola	6	0.033
Cephalophus sylvicultor	0	

The number of sightings of each large mammal species during 483 km of census are given in Table 2, together with encounter rates. The number of observations of all except the four most common monkeys are inadequate for density calculations. The frequency and distribution of sightings and vocalisations of *C.cephus*, *C.pogonias*, *C.nictitans* and *C.albigena* are illustrated in Figures 6 and 7. These show that monkeys are common throughout the areas sampled, especially near Alat and in the Mekas sector. Lowest numbers were recorded in the northwest around Ekom and Ndengué. Strong patterns exist in the emission of vocalisations by the guenons which are species specific (see Gautier, 1988). Despite this, the frequencies of vocalisations and observations recorded in this study correlate for individual species (significant at  $p < 0.01$  for *C.cephus*, *C.nictitans* and *C.albigena*, at  $p < 0.05$  level for *C.pogonias*).

Densities were calculated for the four common monkey species and are given in Table 3. A summary of the outputs by DISTANCE can be found in Annex 12, which gave Estimated Strip Widths for these four species of 47.7 m, 64.6 m, 66.0 m and 76.9 m respectively. Overall, the most common species is *C.cephus* (1.72 troops/km<sup>2</sup>), followed by *C.nictitans* (1.57 troops/km<sup>2</sup>), *C.pogonias* (1.38 troops/km<sup>2</sup>) and *C.albigena* (0.77 troops/km<sup>2</sup>). All species attain particularly high numbers in Alat, with maximum density for a single species (*C.nictitans* 3.71 troops/km<sup>2</sup>) and for four species combined (9.73 troops/km<sup>2</sup>). Lowest densities were found for Ndengué (overall 2.22 troops/km<sup>2</sup>, *C.cephus* 0.089 /km<sup>2</sup>).

*Colobus guereza* were seen only nine times, and were certainly under recorded due to their low detectability. They are often high in the canopy and remain motionless for long periods. At the time of our field work one hunter near Alat killed three adult colobus during consecutive hunting trips, confirming their presence in the south west, although none were observed during censuses.

Table 3: Densities of four monkey species by sector

SECTOR	SPECIES				total
	<i>C.cephus</i>	<i>C.pogonias</i>	<i>C.nictitans</i>	<i>C.albigena</i>	
Djoliimpoum	0.888	1.574	0.514	0.661	3.638
Malele	1.708	0.981	1.372	0.471	4.531
Ndengué	0.089	0.983	0.321	0.826	2.218
Alat	2.330	1.376	3.706	2.313	9.725
layons botaniques	1.319	1.063	1.821	0.893	5.096
Mekas	2.954	0.844	2.688	0.650	7.137
Ekom	1.298	0.958	0.722	0.681	3.660
overall	1.722	1.376	1.573	0.773	5.443

Fig. 6: Observations of four monkey species per km of census

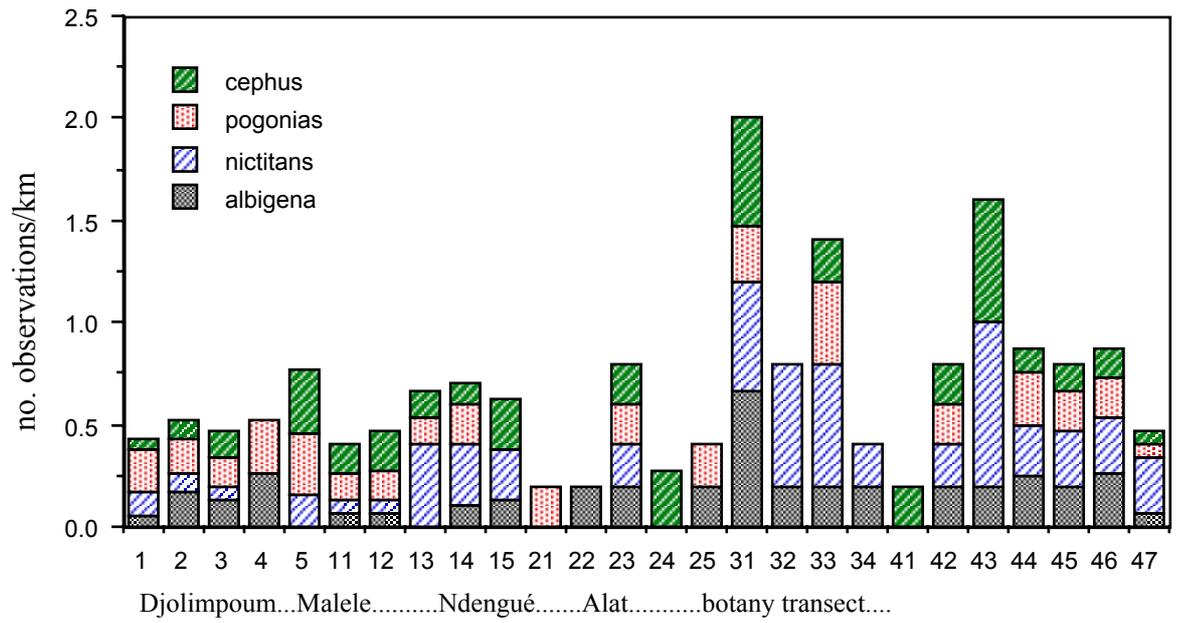


Fig. 7: Vocalisations of four monkey species per km of census

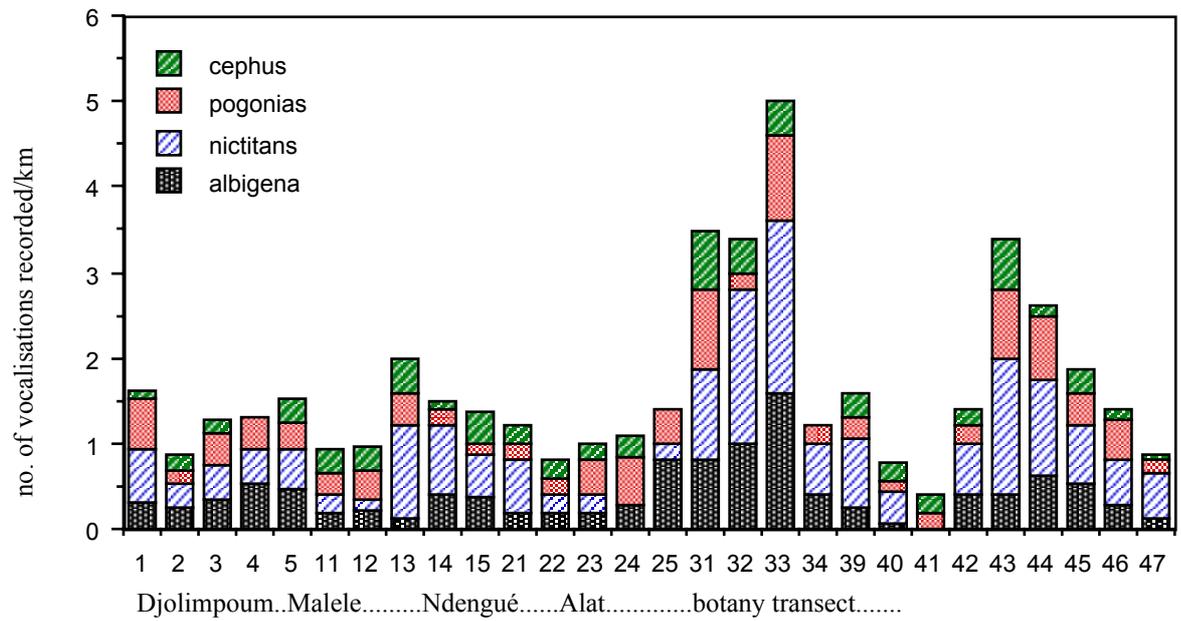
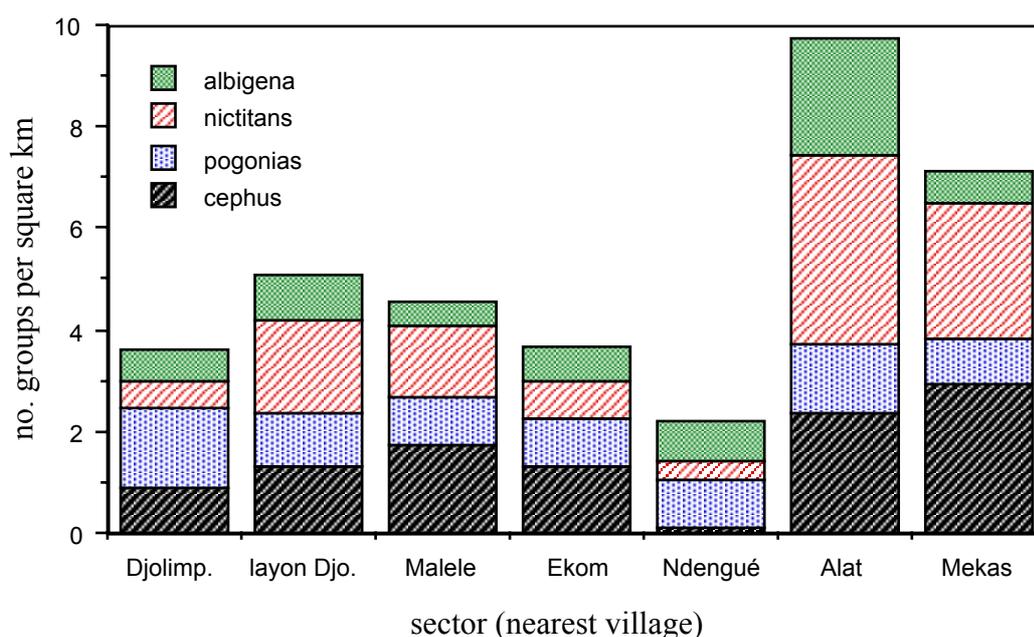


Fig. 8: Densities of four monkey species in different zones of the Dja Reserve



Of the other diurnal monkeys found in the Dja Reserve, *C.galeritus* and *M.talapoin* were each seen only twice, in large troops composed of perhaps 50 individuals, and there was only one probable sighting of *C.neglectus* (Mekas transect near to Bouamir). All three of these species have specific habitat preferences which restrict their distribution, *C.galeritus* and *M.talapoin* being generally associated with riverine forest and *C.neglectus* occurring in swamp forests (Gautier-Hion, 1971; Gautier & Gautier-Hion, 1969; Quris, 1975). Two other species mentioned by Ngandjui (1993) and Bergmans (1994) whose presence was not confirmed are *Cercopithecus mona* and *Colobus satanus*. *Cercopithecus mona* is reputed to occur in the Reserve, but the present study found no evidence to support this. Some confusion exists since *C.pogonias* is generally referred to as the “mone”. *C.satanus* occurs south of the Dja River and is known to occur close to Bi, south-west of the Reserve, but the river seems to form a geographic barrier. Gartlan and Struhsaker (1972) and Mitani (1990) reported the possible presence of *Cercocebus torquatus* in eastern Dja, but again no evidence of this species was found.

### Polyspecificity

The composition of 71 troops of two or more species of monkey, when at least one species was seen, is given in Table 4. Using the frequency with which each species was sighted per transect, pair-wise combinations were tested, and found to be significant for *C.nictitans* and *C.cephus* ( $p < 0.01$ ) and between *C.nictitans* and *C.albigena* ( $p < 0.05$ ). The same correlations proved significant when testing species densities.

Of the 201 groupings analysed, 62.7 % were monospecific. *C.nictitans* were alone 53.3% of times they were seen, *C.cephus* 47.4%, *C.pogonias* 27.4% and *C.albigena* 23.7%. Solitary individuals were recorded seven times, four *C.cephus* and three *C.nictitans*. It seems that *C.cephus* and *C.nictitans* have

the lowest tendencies of association.

Table 4: Frequency of groupings between monkey species

Monospecific groups (N = 126, 62.7%)

Cercopithecus cephus	36
Cercopithecus pogonias	17
Cercopithecus nictitans	56
Cercocebus albigena	14

Polyspecific groups (N = 75, 37.3 %)

C.cephus + C.pogonias	4	8.2%
C.cephus + C.nictitans	13	26.5%
C.cephus + C.albigena	2	4.1%
C.pogonias + C.nictitans	5	10.2%
C.pogonias + C.albigena	14	28.6%
C.nictitans + C.albigena	9	18.4%
C.pogonias + C.guereza	1	2.0%
C.pogonias + C.galeritus	1	2.0%

Three species

(N = 22, 29.3%)

C.cephus + C.pogonias + C.nictitans	6	27.3%
C.cephus + C.pogonias + C.albigena	5	22.7%
C.cephus + C.nictitans + C.albigena	6	27.3%
C.pogonias + C.nictitans + C.albigena	5	22.7%

Four Species

(N = 4, 5.3 %)

C.cephus + C.pogonias + C.nictitans + C.albigena	4	100.0%
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**Other large mammals observed**

All other species observed are included in Table 2. Elephants were seen four times during censuses and three more times during work on transects. Chimpanzees were observed six times during censuses, and gorillas not at all. Duikers were seen 15 times, whereas buffalo were seen only once where a transect crosses a “rocher” - a grassy area with virtually no trees. Buffalo are easily viewed on the Rocher de Nkoubar and the Rocher de Bouamir. Perpendicular distance was not recorded for encounters with humans as they were seen to be using the transect as a path. All of these meetings took place with hunters from Djaposten on the Ndengué transects.

**II: Elephants, Gorillas & Chimpanzees**

All raw data collected on transects are attached as Annex 8. “Prospection data” or trail recorded on paths are included as Annex 9 (“sentier”). Although all traces seen on botanical transects were recorded and are appended (Djolimpoum, 46.7 km; Alat 4.8 km; Djomedjoh, 9 km), these were excluded from density calculations, as the frequencies with which signs were encountered were considered low and to

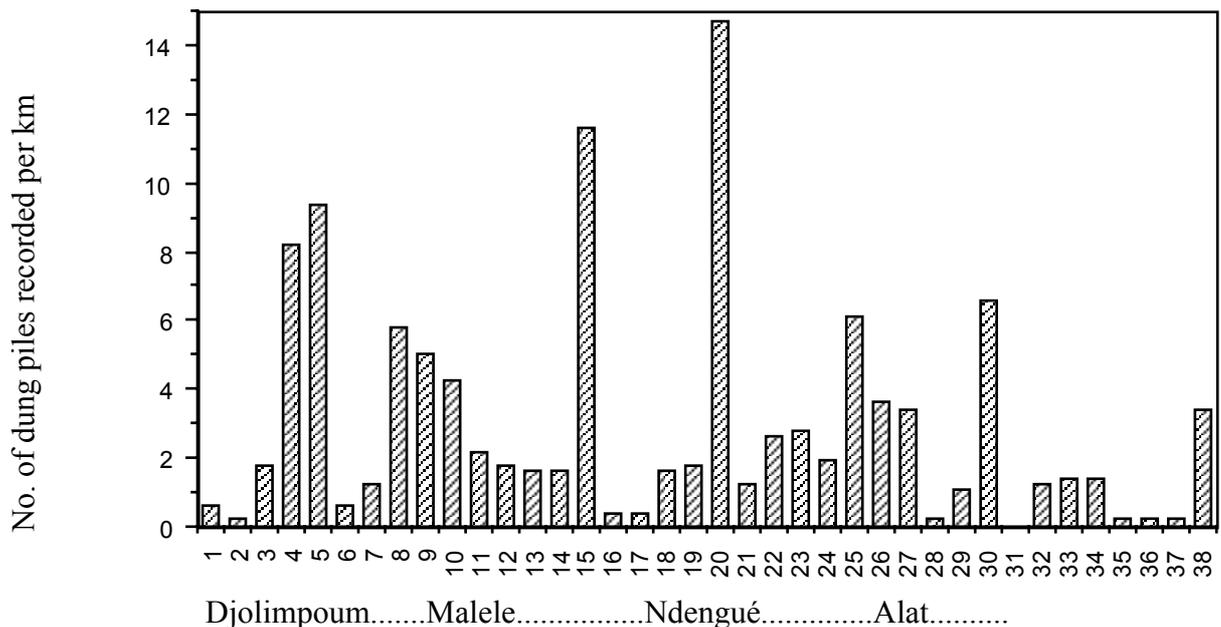
be biased by animals avoiding these transects. A simple change in the habitat may change the behaviour of large mammals, and human activities which indirectly affect animals may still cause changes in behaviour (Lahm, 1993).

**a) Elephants**

A summary of DISTANCE outputs is attached as Annex 13. The estimated pooled density of dung piles was 705.9, which with a mean decay rate of 0.0158, translates to an elephant density of 0.56 per km<sup>2</sup> (0.33-0.96 per km<sup>2</sup>). Densities were analysed by transect and by zone, and stratified with respect to distance from the road/nearest village. A strong pattern emerged, indicating that elephant densities are very variable but reach high numbers at restricted sites as shown in Figure 9. Two areas of high density were identified. The first is along the River M’pép from south of Nkoubar stretching to the junction with the layon de Djolimpoum, where the density of elephants was estimated at 1.72 per km<sup>2</sup> (0.68-4.37 per km<sup>2</sup>). A 14 km ‘prospection’ (rapid collection of data without cutting a transect) effected between these two zones confirmed that elephant dung density remained high. The second area is west of Ndengué, where elephant density averaged 0.72 per km<sup>2</sup> (0.16-3.25 per km<sup>2</sup>). The average density for all transects excluding M’pép and Ndengué is only 0.22 per km<sup>2</sup> (0.15-0.33 per km<sup>2</sup>). The large confidence intervals given are due to an uneven distribution of the population (encounter) not due to detection, and under represent the variation in these estimates as explained in Methods.

When analysed for seasonal differences in densities by sector, the only notable variation occurred at Ndengué where density increased slightly from 0.78 elephants/km<sup>2</sup> in July to 0.82 /km<sup>2</sup> in December (compare transect numbers 21 to 25 with 26 to 30 in Fig. 9).

Fig. 9: Distribution of elephant dung between transects (N = 502)



## b) Gorillas

Gorillas in the Dja built six of the seven nest types defined by Tutin & Fernandez (1983; see Annex 4); only bare ground nests were not seen, which can form up to 44% of sleeping sites (Remis, 1994). Two nest types are shown in Figures 10 and 11 (note the presence of water and mud).

Table 5: Types of nest built by gorillas in the Dja Reserve (N = 147)

<u>Nest type</u>	<u>Number of nests</u>	<u>Proportion of all nests</u>
Herbaceous	118	80.4 %
Minimum	3	2.0 %
Woody	3	2.0 %
Detached Woody	3	2.0 %
Mixed	15	10.2 %
Tree	5	3.4 %

The proportion of tree nests built by gorillas in the Dja is very low at 3 %, but likely to have been underestimate. Herbaceous nests formed only 40% of the Lopé sample (Tutin *et al*, in press) but 80 % of the sample from the present study. Individual nest decay rates given in Tutin and Fernandez (1983) suggest a mean longevity of 59.2 days for nests in the Dja, however, we chose to use the mean duration of 78 days for nest sites at Lopé, since this information is applicable to sites rather than individual nests, and comes from a long term study.

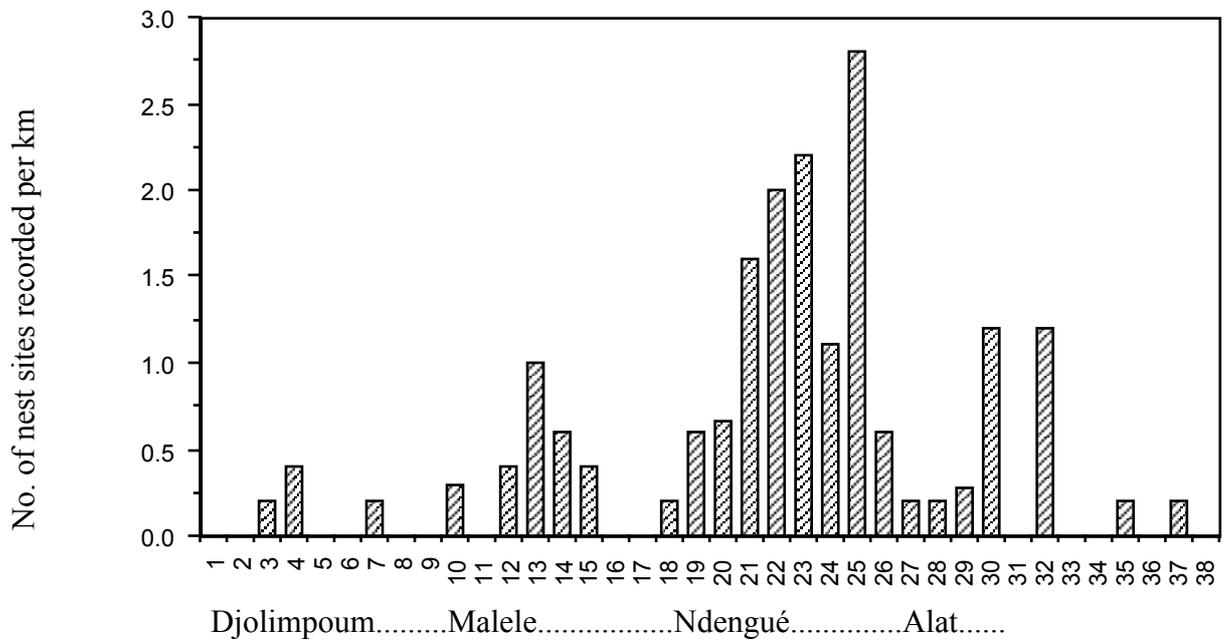
Mean gorilla group size in the Dja was  $3.67 \pm 3.1$  weaned individuals (N = 33, range = 1-12), and the overall density of nest sites was found to be 36.37. This translates to 1.71 weaned gorillas/km<sup>2</sup> (range 1.02-2.86 /km<sup>2</sup>). Distance outputs are summarised in Annex 13.

Fig. 10: Woody gorilla nest in Seasonally Inundated forest (photograph)



Fig. 11: Herbaceous gorilla nest. (photograph)

Fig. 12: Distribution of gorilla nest sites between transects (N = 91)

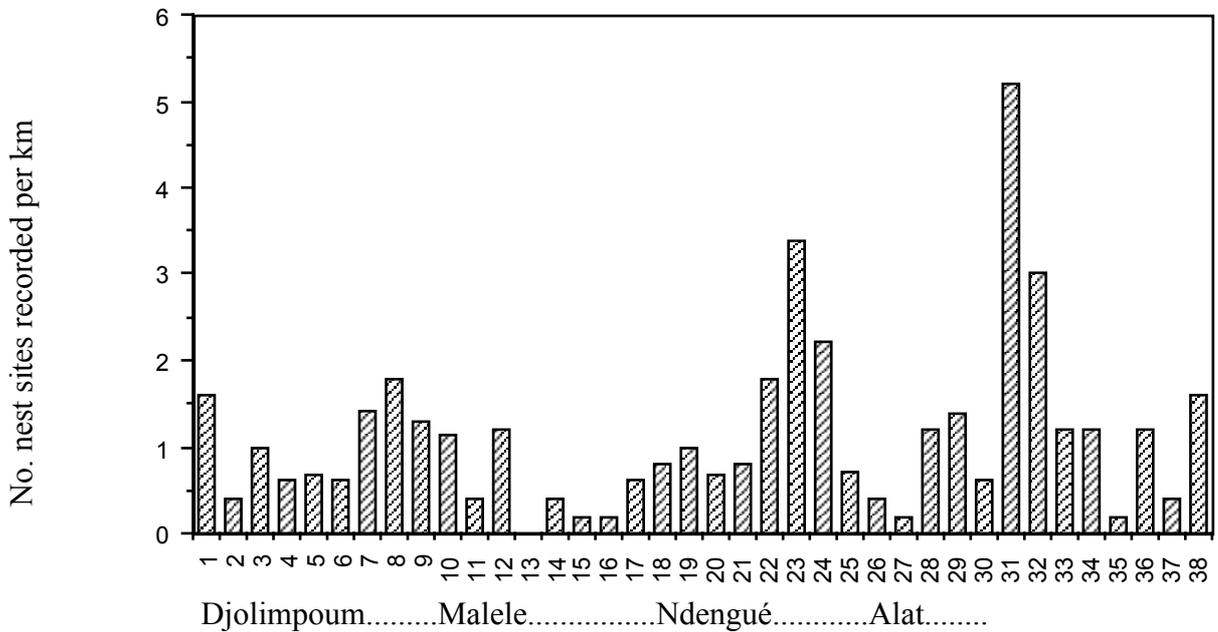


The patchy distribution of nests sites is demonstrated in Figure 12, which shows that many transects were devoid of nests. Again, the strata by which data were grouped for analyses are not strictly defined by distance from a village. The areas of high density show a similar pattern to elephant densities, with concentrations around M’pép and Ndengué. Unlike elephants, the concentration of gorillas around Nkoubar does not extend to the south east, but east towards Ekom (not illustrated). Densities of the two sectors, at least 15 kms south of nearest village, average 1.88 gorillas/km<sup>2</sup> (1.33-2.55/km<sup>2</sup>). Numbers recorded east of Ndengué are extraordinarily high, averaging 5.01/km<sup>2</sup>. In fact the majority of nests sites recorded were found on the Ndengué transects (61 of 94, 64.9%). A very large difference in density was found between July (7.88/km<sup>2</sup>) and December (2.69/km<sup>2</sup>). Overall density excluding these two concentrations is 0.47 per km<sup>2</sup> (0.23-0.99/km<sup>2</sup>).

### c) Chimpanzees

Mean group size for chimpanzees was  $2.16 \pm 1.92$  weaned individuals (N = 62, range = 1-9, median = 1), the overall density of nest sites was 41.63 per km<sup>2</sup>. Since chimpanzee (tree) nests have a greater longevity, this translates to density of 0.79 weaned individuals per km<sup>2</sup> (0.60-1.04 per km<sup>2</sup>).

Fig. 13: Distribution of chimpanzee nests between transects (N=203 sites)



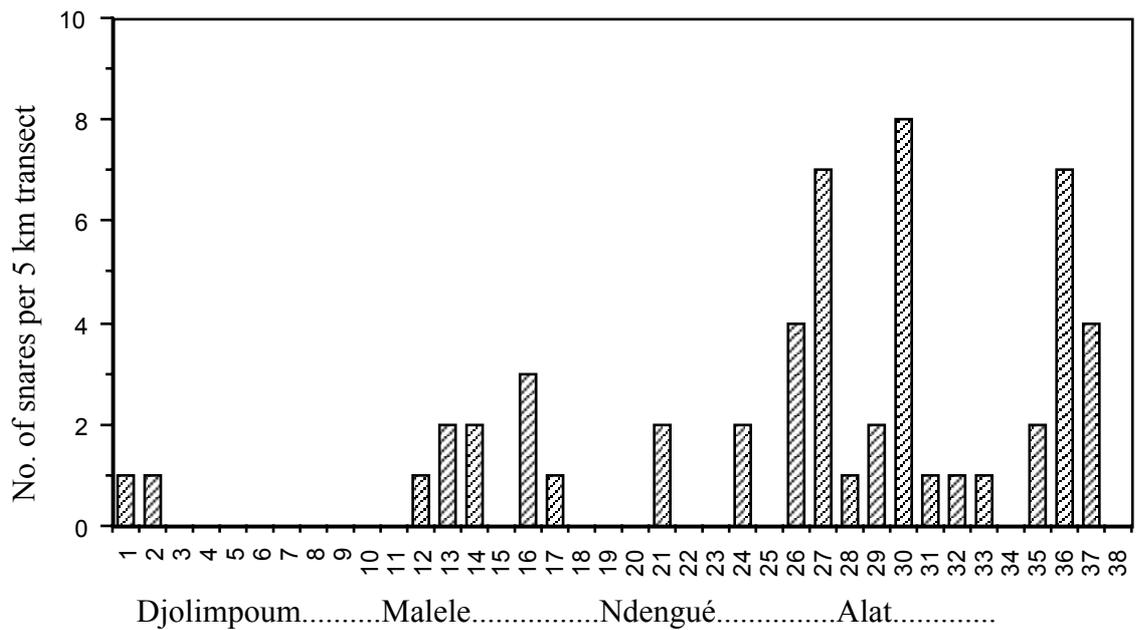
Densities in different sectors were quite variable, but not nearly as marked as with gorillas and elephants. The following mean densities were estimated by sector: Djolimpoum 0.79 /km<sup>2</sup>, Malele 0.40 /km<sup>2</sup>, Ekom 1.07 /km<sup>2</sup>, Ndengué 0.91 /km<sup>2</sup>, Alat 1.29 /km<sup>2</sup>, Mekas 0.11 /km<sup>2</sup>. Seasonal differences were quite pronounced: Djolimpoum May 0.69 /km<sup>2</sup>, Dec. 0.95 /km<sup>2</sup>; Malele June 0.35 /km<sup>2</sup>, Dec. 0.55 /km<sup>2</sup>; Ndengué July 1.33 /km<sup>2</sup>, Dec. 0.56 /km<sup>2</sup>; Alat Aug 2.04 /km<sup>2</sup>, Jan. 0.67 /km<sup>2</sup> (see Annex 13). Despite this variation, the distribution of chimpanzees is relatively even, as shown in Figure 13.

### d) Humans

Several indicators of human presence were recorded but only snares and shotgun cartridges are shown in Figure 14, since these were considered to point to recent activity by hunters. The number of snares found was relatively low in all zones, except for Ndengué and Alat. By comparing transects 21-25 and 31-34 with 26-30 and 34-38, it is obvious that hunters profited from the establishment of transects to install trap lines.

Snares and all other indicators of human activity were tested against each of the large mammal species for which we have estimated densities. Although the density of all species showed an inverse relationship with human signs, only one of these trends was significant (*C.albigena*,  $p < .05$ ).

Fig. 14: Snares found along transect lines



**e) Other Species**

All raw data are included in the trail data annexed, but the analyses presented here are superficial. Footprints have been used as indices in other studies (e.g. Wilkie & Finn, 1990), and Figures 15 and 16 present these data for duikers, bushpigs and buffalo. Although some duiker species are assigned to traces in the raw data, we do not have confidence in these identifications, since it is difficult to distinguish the footprints or dung of “red” duikers. Indices for each of these species were highest on transect 14. Very few signs of leopards *Panthera pardus* were seen; the burrows of giant pangolins *Manis gigantea* were common, whereas only one aardvark *Orycteropus afer* burrow was noted.

Fig. 15: Frequency of duiker trail on some transects

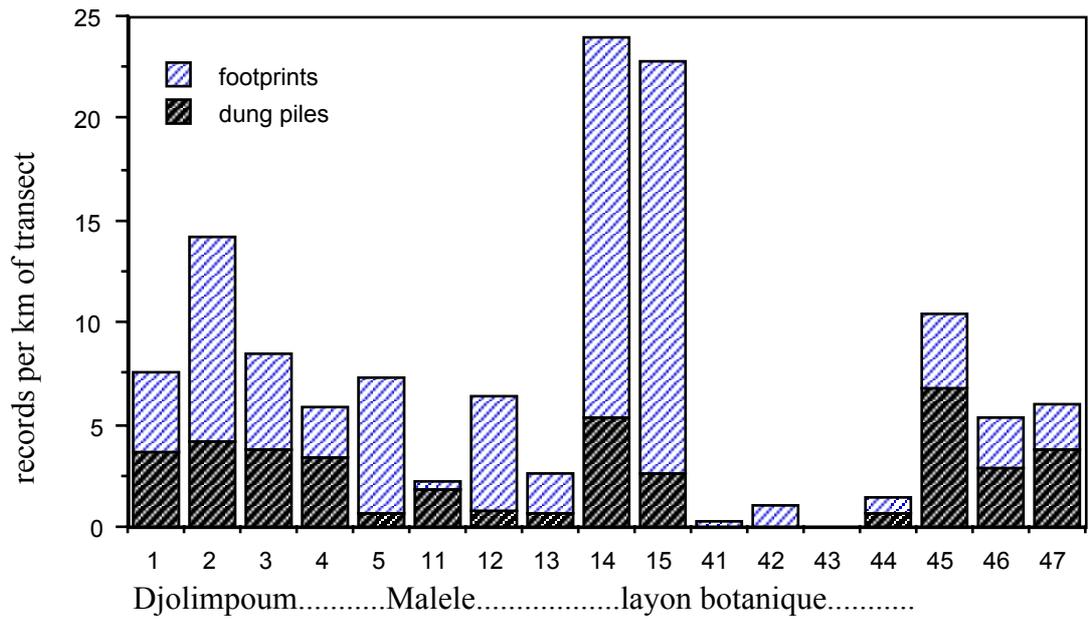
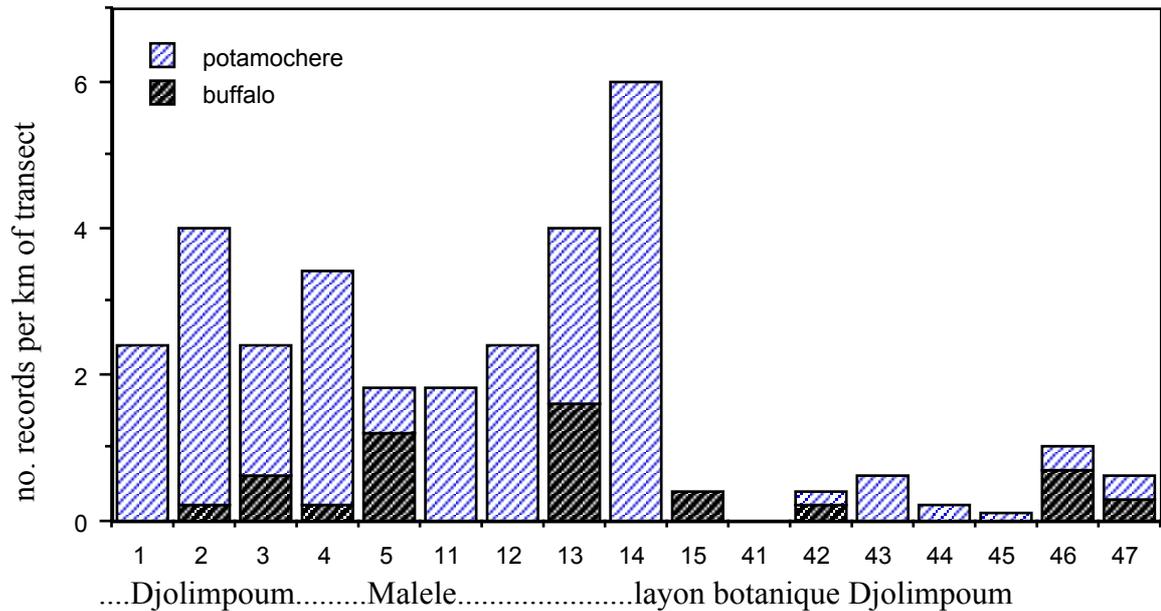


Fig. 16: Distribution of buffalo and potamochoere trail on some transects



### III. Vegetation

The almost monotonous topography of the Dja Reserve has contributed to the creation of numerous marshes, dominated by *Raphia*, or by *Cyperus* with *Pandanus* (Fig. 17). The forest often has a secondary appearance with an abundance of the lianescent herb, *Haumania danckelmaniana*, and thickets of rattan *Ancistrophyllum secundiflorum* (Fig 18). Despite the presence of this well developed herbaceous stratum, Lejoly (1994) considers that the classification “forêt clairsemée à Marantacée” does not apply

to the Dja Reserve.

Due to constraints on the preparation of this report it has not been possible to carry out a quantitative analysis of the information collected on vegetation types and plant species. With respect to large mammals, the importance of *Raphia* swamps should be noted. *Raphia* swamp and seasonally inundated forest with abundant *Uapaca* spp. trees covered large areas of the sectors sampled. An indicator of the dynamics of certain forest types comes from the transects near M'pépé: when transects 3, 4, 5 and 15 were revisited in December, they had become quite overgrown. The vegetation of this river basin showed a high rate of regrowth where *Haumania danckelmaniana*, and *Ancistrophyllum secundiflorum* were particularly abundant. By contrast, it was not necessary to re-cut transects 1 and 2, which were dominated by mature forest with a sparse understorey.

Figure 17. Open swamp dominated by *Cyperus* and *Pandanus*. near Ndengué (photograph)

Figure 18. *Ancistrophyllum secundiflorum* on Transect 5. (photograph)

## 4. DISCUSSION

### I: Primates

To evaluate the density estimates obtained from this study, we need to draw comparisons with other primate communities studied in similar habitats. Table 6 presents some of the information available from forests with similar primate species composition, which are geographically close to the Dja Reserve (Doula Edéa in Cameroun, M'passa in northeast Gabon, Lopé in central Gabon). The data show remarkable agreement, however these monkeys should not be considered in isolation from anthropoid primates and colobines. Biomass estimates which incorporate information about *C.guereza*, *C.talapoin*, *C.neglectus* and *C.galeritus* will provide a more meaningful measure by which to compare different areas. Nonetheless, the density of monkeys found in this study is high and gives cause for optimism.

The frequency with which we recorded polyspecific associations seems to be low (46.7 to 72.6 % of observations per species). Previous studies of these three guenons have shown that between 73 % and 86 % (according to species) of troops are polyspecific (Gautier-Hion, 1988). The difference in our sample may relate to methodology, as we adhered to Whitesides *et al* (1988) recommendation that observers remain stationary for no more than 10 minutes during censuses. It is possible that we detected only one species in some polyspecific troops.

The data suggest an inverse relationship between the abundance of monkeys and that of gorillas and elephants. It is notable that near Ndengué, where gorillas occurred in their highest numbers, monkeys were relatively rare, and at Alat and Mekas where there were most monkeys, gorillas and elephants densities were quite low. However, no significant trends were identified at the transect level.

### II. Elephants, Gorillas & Chimpanzees

#### a) elephants

The mean density of 0.56 elephants per km<sup>2</sup> (0.33 to 0.96/km<sup>2</sup>) estimated during these surveys is higher than in some other forests, for example Merz (1986) found a mean density of 0.23/km<sup>2</sup>, and Alers *et al* (1992) considered 0.32 elephants/km<sup>2</sup> a "high" density for forests in Zaïre, Dja appears to have a similar population density to parts of CAR (0.48/km<sup>2</sup>, 0-2.1/km<sup>2</sup>, Fay, 1991) and Congo (0.7/km<sup>2</sup>, 0.3-0.9 km<sup>2</sup>, Fay & Agnagna, 1991). The highest known densities of forest elephants occur in the sparsely populated zone spanning southeastern Cameroun, southeastern CAR, northern Congo and northeastern Gabon (Barnes *et al*, 1995b). Up to 6 elephants/km<sup>2</sup> are found in parts of southeastern Cameroun (Stromayer & Ekobo, 1991) however this is not a permanent population as elephants migrate in from Congo and CAR (Ekobo, pers.comm.). And in Gabon, elephant densities reach 4 per km<sup>2</sup> at certain times of year when *Sacoglottis* fruits are available in a limited area (White (1994b).

Seasonal movements of elephants can have a large effect on density calculations. These migrations are an adaptation to shifts in food availability within their habitat (White, 1994b). We found evidence of small scale migrations in the Dja with the doubling of dung piles recorded on a transect near to Azem between August and January, in forest with strikingly high densities of *Klainedoxa gabonensis*, *Irvingia gabonensis* and *Panda oleosa* trees. These trees were fruiting in January. Lahm (1993) reported that villages in northeastern Gabon experience marked annual fluctuations in crop-raiding by elephants, and similar claims were made by villagers in the Boucle du Dja. Such seasonal effects cannot be measured in a study of limited duration, but we obtained evidence that they occur.

It is clear that elephants are not evenly distributed in the Dja Reserve. Previous studies have shown that human impacts are the overriding factor in determining elephant distribution on a large scale (Barnes *et al.*, 1991). The human population associated with the Dja is of low density. Gartlan (1989) gave a figure of 1.5 inhabitants/km<sup>2</sup> for the Reserve, however this population has increased in recent years (Ngandjui, 1984; Seme, pers.comm.) and estimated to be 0.6 to 4 inhabitants/km<sup>2</sup> by Joiris and Tchikangwa Nkanje (1994). No clear relationship between elephant densities and human activities was determined in the present study, although the highest densities recorded in all months were found at distances over 25 km from the nearest village. Surprisingly the number of elephants east of Ndengué during December, when hunting activity on the transects was intense, had increased since July. It is likely that hunters were focusing on other species, nonetheless many animals which are seldom hunted are affected by the general disturbance of human activity. Both game and not game species adopt strategies to avoid human contact, such as changes in habitat use (Lahm, 1993).

Perhaps the lack of an identifiable relationship between elephant densities and distance from the nearest village is because hunters in the Dja Reserve are known to travel up to 40 kms to check their snare lines (Ngandjui & Muchaal, pers.comm.), whilst in northeastern Gabon hunting is usually concentrated within 10 or 15 kms of villages (Lahm, 1993). Elephant hunting is specialised and hunters will certainly travel further for the “grande chasse”.

Realistically, the patterns we are looking at in the Dja are small scale, and vegetation type will play a major role in determining animal distributions. What might cause the concentrations we observed around M'pépé and Ndengué? The Ndengué transect crosses an extensive *Cyperus-Pandanus* marsh (> 700 m) which would provide abundant food and refuge for elephants. The vegetation types which predominate in the M'pépé river basin are forest with a sparse upper canopy, old secondary forest with *Haumania* and *Ancistrophyllum* thickets, secondary gaps and *Raphia* swamps. The high density inferred from dung counts was corroborated by encounters with elephants on these transects yet on no others (these were usually auditions only, as the elephants were extremely wary and simply ran once they detected our presence). Perhaps the river itself is an attraction, as some spots along the river bank evidence intensive use by elephants (see Figs. 19 & 20). Affinities for particular rivers by individual elephants have been observed in the Korup National Park, and preferred river basins may form the focus of an elephants home range (Powell, pers.comm.). Lahm (1993) also found that elephants in

northeastern Gabon are highly dependent on riverine and seasonally inundated forests.

So if elephant distribution is patchy with localised high density, how do we predict their distribution in other parts of the reserve? Can we extrapolate from these results to the Reserve as a whole? We know little of the west, and even less about the north-east or east-central zones. During prospection up to 18 kms west of Djomedjoh, not one elephant dung pile was recorded, and although surveys in the Mekas area found some indications of elephants (Muchaal, per.comm.) it seems that their densities were low. No attempt was made to evaluate hunting intensity during the present study, but it is known that hunting of elephants occurs around Lomié. We also received reports that hunters are generally active in the north east (evidence of this comes from the Ndengué transects), and in parts of the south due to the high demand for bush meat in Djoum (see Fig. 1). Hunters regularly cross the Dja river to enter the Reserve, and check their trap lines. We found many snares near to Alat, although these may not be a good indicator of the level of hunting with firearms.

Alers *et al* (1992) applied estimates from a stratum with low elephant density to a wider area of Zaïre. A similar extrapolation in the Dja gives an elephant population of 1,157 (789-1,736). This figure gives us an idea of the potential elephant population, however, it would be unwise to assume that elephants are present through out the Reserve without further field work to establish whether or not this is true.

At this point, it should be emphasised that much of the discussion above applies equally to other large mammals, including gorillas and chimpanzees.

### **b) Gorillas**

The estimate of 1.71 weaned gorillas per km<sup>2</sup> is surprisingly high, given the impression gained during fieldwork. Gorillas were encountered only twice during the surveys: a lone male was seen on transect 13, and a group was feeding on transect 4 as we returned from cutting. However, we heard frequent chest beats during the night when camped near to transects 5 and 15, both far from villages and in dense vegetation close to the river M'pép, and also at the junction of transects 21 and 25 near Ndengué, where the highest numbers of nest sites were recorded.

Studies elsewhere have estimated average densities of 0.44/km<sup>2</sup> (but up to 9.16/km<sup>2</sup>, Tutin & Fernandez, 1983), 0.89-1.45 km<sup>2</sup> in CAR (reaching 5.6/km<sup>2</sup> in light gaps and 10.96 /km<sup>2</sup> in secondary forest, Carroll, 1986), 1.6 /km<sup>2</sup> also in CAR (Fay, 1989), 1.2 /km<sup>2</sup> in northern Congo (2.4 /km<sup>2</sup> in swamp forest, Fay & Agnagna, 1992) with high densities recorded in the Likouala swamps of Congo (2.6 /km<sup>2</sup>, Fay *et al*, 1989)

Figure 19. Area along the River M'pép where elephant activity is intense. (photograph)

Figure 20. Bank of the River M'pép associated with a high density of elephants (photograph)

Such high local densities are generally associated with swamp forests, as confirmed by Blake (1993) who estimated 5.88 gorillas/km<sup>2</sup> in *Raphia* dominated swamp, and 2.88 /km<sup>2</sup> in *Raphia-Uapaca* forest. Lahm (1993) also found that gorillas showed greater association with inundated and riverine forests than with secondary vegetation. In the Dja, most nest sites were found at Ndengué (7.88 /km<sup>2</sup> in July) and 49 % of these were in *Raphia* swamp. So the question arises, why are gorilla populations concentrated in swamps? Fay *et al* (1989) found that gorillas in swamps feed on *Pandanus candelabrum* and other plants common in this vegetation type, so food is abundant in this habitat type. Perhaps a minor consideration is the relative lack of suitable nesting material in *terre firme* forest in the Dja. At Lopé *Haumania liebrechstiana* is used in 85% of ground nests. The species which occurs in the Dja, *Haumania danckelmaniana*, is covered with spines and may not be suitable for nesting, whereas other herb species of (*Marantochloa* spp. and *Halopogon azurea*) are abundant in swamps and seasonally inundated forest (pers.obs). Blake (1993) explained use of the Likouala swamps as a modification of the gorillas' behaviour to avoid areas of human impact. Swamps marshes and seasonally inundated forests provide refuge from hunters in northeastern Gabon, and many species survive as a result of behavioural modifications (Lahm, 1993).

The presence of hunters on the transect lines in Ndengué seemed to coincide with the recording of high gorilla density in December, however, the hunters were active on the first two kilometres of transect 30, whereas gorilla nests were encountered beyond this distance.

In this study, nests sites were concentrated on transects between 15 and 25 kms from villages. During prospection west of Djomedjoh six nest sites were found, but none within 10 km of the village. We should consider that the high densities at Ndengué may be artifact of analysing the data on a scale which is inappropriate and statistically invalid. It should also be borne in mind that with an Estimated Strip Width of 5.54 m for gorilla nests, the 25 km of transect at Ndengué represents an area of 0.14 km<sup>2</sup> actually sampled. The sample from this study should probably be viewed as a whole without too much dissection. The lower end of the estimate may be the best general indicator of gorilla density (0.47 /km<sup>2</sup>), but this may not be appropriate for the entire Reserve.

### **c) Chimpanzees**

The estimate of 0.79 weaned chimpanzees /km<sup>2</sup> concurs with population estimates given for other regions of central Africa. Tutin & Fernandez (1983) estimated 0.49/km<sup>2</sup> (0 to 1.78/km<sup>2</sup>) chimpanzees/km<sup>2</sup> in Gabon, White (1994a) found 0.2-1.1/km<sup>2</sup> for Lopé, and Stromayer and Ekobo (1991) reported 0.15-0.34/km<sup>2</sup> in south-eastern Cameroun.

Almost all tree nests found during the present study were attributed to chimpanzees, and we must consider the possibility that tree nests could have been misclassified following the recent finding of Tutin *et al* (in press) that “due to the longer lifespan and greater visibility of tree nests, a proportion of gorilla nest sites ‘convert’ to chimpanzee nest sites when only tree nests remain visible”. As a result of

this, gorilla nests sites could be mistaken for chimpanzees during surveys, so that chimpanzee numbers would be over-estimated, by as much as 26%. It seems unlikely that such a large number would also be appropriate in the Dja, but it remains to be established how often gorillas build tree nests. Hall *et al* (in prep.) estimate that only 13% of tree nests 'convert' in Kahuzi-Biega, Zaïre.

It is probable that some tree nests were misclassified during the present survey, especially given the very low number of tree nests attributed to gorillas, but it was considered preferable to have a clear categorisation of tree nests, rather than make a guess at the proportion which might have been made by gorillas. Only six tree nests found in the Dja were in association with ground nests, and could thus be confirmed to have been built by gorillas.

Several tree nests were seen to persist for at least six months (183 days) on the Djolimpoum and Malele transects (N = 10 sites). The decay rate used to estimate abundance has a strong influence on the estimates obtained, so if nest duration in the Dja is greater than 113.5 days, the chimpanzee population will have been over-estimated. Studies of nest decay are needed from this site rather than extrapolating from other studies.

If obliged to estimate the population for the Reserve as a whole, we would again chose the lower limit of density estimates (0.60 weaned individuals /km<sup>2</sup>) which suggests a population of about 3,000 chimpanzees in the Dja reserve.

## **5. CONCLUSIONS & RECOMMENDATIONS**

This study has shown that the Dja Reserve harbours important populations of elephants, gorillas, chimpanzees and at least four species of diurnal monkeys. Four other diurnal monkey species were confirmed to occur at overall low densities, but their status remains to be determined. These preliminary results should be viewed with extreme caution, and further longer-term studies are needed to confirm our findings.

### **I. Questions to be addressed in future work**

Due to the size of the Dja Reserve, and the time allocated for the surveys, there are problems with extrapolating from our small sample. Surveys should be carried out in additional areas of the Reserve, to establish the presence of these patchily distributed animals. Obviously further study is needed to assess the seasonal movements of elephants.

As mentioned above, we need to evaluate decay rates of nests and establish what proportion of tree nests are constructed by gorillas.

Behavioural studies of monkeys are needed to determine troop sizes. It is particularly important to

establish the status of *Colobus guereza*. This species is preferred by hunters because of its large body size, and is made vulnerable by its slow movement striking coat colour and high visibility when strategies to locate them are adopted. *Colobus guereza*, together with *Cercocebus albigena*, *Cercopithecus neglectus* and *Miopithecus talapoin* was eliminated from forests around villages in northeastern Gabon (Lahm, 1993).

## II. Conservation priorities

It is clear that the conservation activities of the Projet Ecofac are having an impact, with an apparent decrease of hunting intensity around Djolimpoum and Malele, which increase dramatically east of Ekom. The distribution of snares on transects shows that hunting activities are reduced where the project has a strong presence. Trap lines were rapidly installed after the establishment of transects in areas which are rarely patrolled, namely Ndengué and Alat. The project in conjunction with the Ministry of the Environment should continue to expand the effective area of patrols and prevent transects becoming snares lines or access routes.

Primates and elephants are important seed dispersers (*e.g.* Chapman *et al*, 1993; Gautier *et al*, 1993; Tutin *et al*, 1991; White *et al*, 1992) and as such play a vital role in the regeneration of rain forests. We recommend that species priorities are established for all conservation actions, and that people are helped to differentiate between vulnerable species and others which are more abundant. If hunting by snares is to be encouraged as a form of sustainable forest use, guns should be banned inside the Reserve. Under no circumstances should sport hunting be allowed. The sectors found to support high densities of elephants and gorillas cover a limited area, and these populations remain vulnerable.

Some people encountered in the reserve recognised the importance of conserving the forest, but said that animals should not be protected “just for tourism”. Given that one of the people who expressed such a view is an Ecofac ‘sensibilisateur’ (Volet Agroforestry), efforts should be made to increase awareness of the importance of maintaining an intact fauna, beginning with the sensibilisateurs, and through them the local population.

Elephants, gorillas, chimpanzees and monkeys are all hunted for their meat, and occasionally for trophies. A problem of particular concern is the killing of gorillas and chimpanzees, especially when their infants are traded. During field work near Ndengué, a hunter shot a female chimpanzee on the transect line. Her infant, in Figure 21, was tied into a gibisière and carried back to the village. The hunter claimed that he could raise the orphan with the aim of selling it to “a white person”. The Ministry of the Environment and other authorities responsible for controlling illegal traffic in wildlife should make every effort to stamp out this trade, and to educate tourists and other visitors to Cameroun that it is inappropriate and illegal to buy young apes.

Figure 21: Young chimpanzee whose mother was killed for meat, December 1994 (photograph)

## BIBLIOGRAPHY

- Alers, M.P.T., Blom, A., Sikubwabo Kiyengo, C., Masunda, T. & Barnes, R.F.W. (1992) Preliminary assessment of the status of the forest elephants in Zaïre. *African J. Ecol.* 30: 279-291.
- Barnes, R. F. W. (1993) Indirect methods for counting elephants in forest. *Pachyderm* 16: 24-30.
- Barnes, R. F. W. & Jensen, K.L. (1987) How to count elephants in forests. *IUCN African Elephant & Rhino Specialist Group Technical Bulletin* 1:1-6.
- Barnes, R. F. W., Alers, M.P.T. & Blom, A. (1995b) A review of the status of forest elephants *Loxodonta africana* in central Africa. *Biol. Conservation* 71: 125-132.
- Barnes, R. F. W., Barnes, K. L., Alers, M.P.T. & Blom, A. (1991) Man determines the distribution of elephants in the rain forests of northeastern Gabon. *African Journal of Ecology* 29: 54-63.
- Barnes, R. F. W., Blom, A., Alers, M.P.T. & Barnes, K. L. (1995a) An estimate of the numbers of forest elephants in Gabon. *J.Tropical Ecol.* 11: 27-37.
- Barnes, R. F. W., Asamoah-Boateng, A., Naada Majam, J., Agyei-Ohemeng, J., Tchamba, M.N., Ekobo, A. & Nchanji, A. (1994) *Improving the accuracy of forest elephant census methods: studies of dung decay rates in Ghana and Cameroun*. Report to the African Elephant Conservation Coordinating Group.
- Bergmans, W. (1994) *Liste Provisoire des Mammifères de la Reserve de Faune du Dja et de sa Peripherie*. Comité Néerlandais pour l'UICN. 42 pp.
- Blake, S. (1993) *A reconnaissance survey in the Likouala swamps of northern Congo and its implications for conservation*. MSc. Thesis, University of Edinburgh.
- Bourlière, F. (1985) Primate communities: their structure and role in tropical ecosystems. *Int.J.Primatology* 6: 1-26.
- Buckland, S.T., Anderson, D.R., Burnham, K.P. & Laake, J.L. (1993) *Distance Sampling: Estimating abundance of biological populations*. Chapman & Hall, London.
- Carroll, R.W. (1988) Relative density, range extension, and conservation potential of the lowland gorilla (*Gorilla gorilla gorilla*) in the Dzanga-Sangha region of southwestern Central African Republic. *Mammalia* 52: 309-323.
- Chapman, C., Fedigan, L.M. & Fedigan, L. (1988) A comparison of transect methods of estimating population densities of Costa Rican primates. *Brenesia* 30: 67-80.
- Fay, J.M. (1989) Partial completion of a census of the western lowland gorilla (*Gorilla gorilla gorilla* (Savage & Wyman)) in southwestern Central African Republic. *Mammalia* 53: 203-215.
- Fay, J.M. (1991) An elephant survey (*Loxodonta africana*) using dung counts in the forests of the Central African Republic. *J.Tropical Ecol.* 7: 25-36.

- Fay, J.M. & Agnagna, M. (1991) A population survey of forest elephants (*Loxodonta africana cyclotis*) in northern Congo. *African J.Ecol.* 29: 177-187.
- Fay, J.M. & Agnagna, M. (1992) Census of gorillas in northern Republic of Congo. *Amer.J.Primatol.* 27: 275-284.
- Fay, J.M., Agnagna, M., Moore, J. & Oko, R. (1989) Gorillas (*Gorilla gorilla gorilla*) in the Likouala swamp forests of north central Congo: preliminary data on populations and ecology. *Int.J.Primatol.* 10: 477-486.
- Gartlan, S. (1989) *La conservation des écosystèmes forestiers du Cameroun*. UICN gland, Suisse 164-173.
- Gartlan & Struhsaker (1972) Polyspecific associations and niche separation of rain forest anthropoids in Cameroon, West Africa. *J.Zool.Lond.* 168: 221-266.
- Gautier-Hion, A. (1971) L'écologie du talapoin du Gabon. *Terre et Vie* 25: 427-490.
- Gautier-Hion, A. (1988) Polyspecific associations among forest guenons: ecological, behavioural and evolutionary aspect. In: *A Primate Radiation: evolutionary biology of the African guenons*. Gautier-Hion, A., Bourlière, F., Gautier, J-P. & Kingdon, J. (eds), pp. 452-476.
- Gautier, J-P. & Gautier-Hion, A. (1969) Les associations polyspécifiques chez les Cercopithecidae du Gabon. *La Terre et La Vie* 23: 164-201.
- Gautier-Hion, A., Gautier, J-P. & Maisels, F. (1993) Seed dispersal versus seed predation: an inter-site comparison of two related African monkeys. *Vegetatio* 107/108: 237-244.
- Hall, J., White, L.J.T., Williamson, E.A., Walsh, P., Sikubwabo, C., Inogwabini, I-B., Ndumbo, B., Kisweli, P.K., Ilambu, O., Simons-Morland, H., Vedder, A., Saltenstall, K. & Sestrich, K. (in prep.) A Survey of *Gorilla g. graueri* and *Pan t. schweinfurthii* in the Extension of Kahuzi-Biega National Park in Zaïre.
- Harrison, M.J.S. & Hladik, C.M. (1986) Un primate granivore: le colobe noir dans la forêt du Gabon; potentialité d'évolution du comportement alimentaire. *Revue d'Ecologie (Terre et Vie)* 41: 281-298.
- Joiris, D.V. & Tchikangwa Nkanje, B. (1994) *Systemes foncier et sociopolitique des populations de la Réserve du Dja*. Rapport Final Préliminaire, Ecofac.
- Lahm, S.A. (1993) *Ecology and economics of human/wildlife interaction in northeastern Gabon*. PhD. Thesis, New York University.
- Lejoly, J. (1994) *Remarques sur la forêt hétérogène du Dja*. ECOFAC-Cameroun.
- Letouzey, R. (1963) *Flore du Cameroun*. Mus.Nat.Hist.Nat., Paris.
- Merz, G. (1986) Counting elephants (*Loxodonta africana cyclotis*) in the tropical rainforests with particular reference to the Tai National Park, Ivory Coast. *African J.Ecol.* 22: 61-68.
- Mitani, M (1990) A note on the present situation of the primate fauna found from south-eastern Cameroon to northern Congo. *Primates* 3: 625-63.

- Ngandjui, G. (1993) *La Réserve de la Biosphère de la Boucle du Dja: Inventaire des Ressources Fauniques et des Impacts Humains*. Rapport Final. I.R.Z.V., Cameroun.
- Oates, J.F., Whitesides, G.H., Davies, A.G. Waterman, P.G. Green, S.M., Dasilva, G.L. and Mole, S. (1990) Determinants of variation in tropical forest primate biomass: new evidence from West Africa. *Ecology* 71: 328-343.
- Prins, H.H.T. & Reitsma, J.M. (1989) Mammalian biomass in an African equatorial rainforest. *J.Anim.Ecol.* 58: 851-862.
- Quris, R. (1975) Ecologie et organisation sociale de *Cercocebus galeritus agilis* dans le nord-est du Gabon. *La Terre et La Vie* 29: 337-398.
- Remis, M.J. (1994) *Feeding ecology and positional behavior of western lowland gorillas (Gorilla gorilla gorilla) in the central African Republic*. PhD. Thesis, University of Yale.
- Samba, D. (1994) *Etude d'Abondance de quelques mammifères de forêt dense tropicale humide en relation avec la perturbation humaine de l'habitat - cas de la Réserve de Faune du Dja, Layon Nord-Sud de Djo'olimoum*. Mémoire présenté en vue de l'obtention du diplôme d'Ingenieur des Eaux, Forêts et Chasses. Université de Dschang, Cameroun.
- Stromayer, K.A.K. & Ekobo, A. (1991) *Biological surveys of southeastern Cameroon*. Report to Wildlife Conservation International.
- Tchamba, M.T. (1992) Defaecation by the African forest elephant (*Loxodonta africana cyclotis*) in the Santchou Reserve, Cameroon. *Mammalia* 56: 155-158.
- Thomas, S.C. (1991) Population densities and patterns of habitat use among anthropoid primates of the Ituri forest, Zaïre. *Biotropica* 23: 68-83.
- Tutin, C.E.G. & Fernandez, M. (1983) *Recensement des Gorilles et des Chimpanzés du Gabon*. C.I.R.M.F., Franceville. 84 pp.
- Tutin, C.E.G. & Fernandez, M., Rogers, M.E., Williamson, E.A. & McGrew, W.C. (1991) Foraging profiles of sympatric lowland gorillas and chimpanzees in the Lopé Reserve, Gabon. *Philos. Trans. of the Royal Society*, B, 334: 179-187.
- Tutin, C.E.G, Parnell, R.J.P., White, L.J.T. & Fernandez, M. (in press) Nest building by lowland gorillas in the Lopé Reserve, Gabon: Environmental influences and implications for censusing. *Int.J.Primatol.*
- White, L.J.T. (1994a) Biomass of rain forest mammals in the Lopé Reserve, Gabon. *J.Anim.Ecol.* 63: 499-512.
- White, L.J.T. (1994b) *Sacoglottis gabonensis* fruiting and the seasonal movements of elephants in the Lopé Reserve, Gabon. *J.Tropical Ecol.* 10: 121-125.
- White, L.J.T. (in press) Factors affecting the duration of elephant dung-piles in rain forest in the Lopé Reserve, Gabon. *African J. Ecol.*
- White, L.J.T., Tutin, C.E.G. & Fernandez, M. (1993) Group composition and diet of forest elephants, *Loxodonta africana cyclotis* Matschie 1900, in the Lopé Reserve, Gabon. *African J.Ecol.* 31: 181-

- Whitesides, G.H., Oates, J.F., Green, S.M. & Kluberanz, R.P. (1988) Estimating primate densities from transects in a West African rain forest: A comparison of techniques. *J. Animal Ecology* 57: 345-367.
- Wilkie, D.S & Finn, J.T. (1990) Slash-burn cultivation and mammal abundance in the Ituri forest, Zaïre. *Biotropica* 22: 90-99.
- Williamson, E.A., Tutin, C.E.G., Rogers, M.E. & Fernandez, M. (1990) Composition of the diet of lowland gorillas at Lopé in Gabon. *Amer. J. Primatol.* 21: 265-277.
- Wing, L.D. & Buss, I.O. (1970) Elephants and forests. *Wildlife Monographs* 19: 1-92.
- Wrangham, R.W., Chapman, C.A. & Chapman, L.J. (1994) Seed dispersal by forest chimpanzees in Uganda. *J.Tropical Ecol.* 10: 355-368.

**INTEGRATED MONITORING PROGRAM FOR TRANS-BOUNDARY FOREST CONSERVATION AND MANAGEMENT IN CONGO, CAMEROON AND THE CENTRAL AFRICAN REPUBLIC.**

BOMASSA WORKSHOP, SEPTEMBER 1994.

A discussion document prepared by Lee White for The Wildlife Conservation Society

LOCATING & CUTTING TRANSECTS

The first process to be undertaken is a stratification of the area of interest. Elephant densities are generally determined by human activity (e.g., Barnes et al., 1991; Fay 1991) and it is likely that other large mammals will follow this pattern. Hence this should be a main feature of any stratification of the area of interest. The following factors should be considered:

- zones of human settlement (not always near roads);
- areas of or adjacent to extractive activities such as gold mining, commercial meat trade, logging;
- existing or past roads, or trails used by humans for movement between centres of population;
- sample randomly in strips or concentric bands 10 km wide moving away from settlements, human activities and access routes.
- areas of past settlement where old secondary vegetation may result in increased densities of gorillas, elephants and some other species (Barnes et al., 1991; Tutin & Fernandez, 1984);
- major forest types such as monodominant stands, mixed forests, hill regions, internal savannas, extensive swamps, major river valleys;
- sample each vegetation type including secondary vegetation.
- geographic coverage.
- sample in all parts of the area of interest if possible.

Once a (preliminary) stratification has been undertaken transects should be located from a randomly selected starting point within each strata and should cross the stratum. They should be oriented to cross major drainage features in order to sample a representative proportion of all vegetation types (Norton-Griffiths, 1978).

To cut a transect one needs a team of two, one of whom can use a sighting compass. Choose a starting point. Cut a stake which, when planted into the ground, is at eye level. Place the sighting compass on the stake, orient it on the correct bearing so you can sight through it without holding it. One assistant then traces a path away from the compass person on the bearing, cutting just enough vegetation such that it is easy to see which route they took. Each time they deviate off the path call out a correction (left or right). When it becomes difficult to see them tell them to stop, check that they are standing in the centre of the line, and move forwards with compass and stake to where they are waiting (they must not move in the meantime). Cutting should be restricted to the minimum necessary to facilitate passage and identify the location of the transect.

DATA TO BE COLLECTED:

1) APES:

Nest counts and the diameter of faeces associated with fresh nests have been used to census and to follow demographic trends of gorillas living in montane vegetation (Aveling & Harcourt, 1984; Harcourt & Fossey, 1981; Harcourt & Groom, 1972; Murnyak, 1981; Schaller, 1963; Weber & Vedder, 1983; Yamagiwa *et al.*, 1993). These studies showed that examination of successive fresh nest-sites (generally three successive sites) allows accurate determination of group size and age-class structure, except for infants less than a year old.

Systematic application of these methods to gorillas in lowland tropical forest habitats is not possible, because of differences in vegetation, (tracking is more difficult in lowland forests) diet, ranging and nest building behaviour. The frugivorous diet of gorillas in tropical forests results in: 1) wide ranging (making tracking difficult and the finding of three successive nest-sites virtually impossible); 2) soft faeces (making it impossible to assess age-class consistently from faecal diameter); and 3) a high proportion of tree nests at least in some habitat-types (intact faeces are rarely found under tree nests) [see Tutin *et al.*, 1992; Williamson *et al.*, 1990; Yamagiwa *et al.*, 1992].

Population densities will be low so the frequency of direct sightings will not provide sufficient data. In most areas, apes will be wary of human observers and will flee on sight. Nest-counts conducted along line transects are the only feasible alternative. Nests not only remain stationary but are many times more common than individual apes, as a new nest is built each night. Thus, they are a potentially powerful tool for census work.

Line-transect sampling is the most robust and practical method to estimate nest density (Buckland *et al.*, 1993). This method has been used to estimate gorilla nest density in several areas of lowland rain forest in central Africa (Carroll, 1988; Fay, 1989; Fay *et al.*, 1989; Tutin & Fernandez, 1984). To interpret census nest counts it is essential to know how many days nest-sites remain recognisable. Nest decay is complex as the lifespan will be influenced by nest group size and by the types of nest construction. Nest-type varies with habitat-type and season and possibly other factors. In that visibility decreases with distance from a transect line (Burnham *et al.*, 1980), the observed duration of nest-sites monitored from a fixed transect will follow a similar pattern.

Mean duration of gorilla nest-sites during a study I conducted in Lopé was 78 days (see Tutin *et al.*, in press). This is 32% longer than the figure given by Tutin & Fernandez (1984) who followed 223 gorilla nests at Belinga, in NE Gabon. At Belinga, the mean duration varied from 4.3 to 61.7 days depending on the type of nest and gave an overall mean nest duration of 53.6 days given the frequency of different nest-types in their sample. The difference between the Lopé and Belinga figures in part reflects the fact that in the former, nest-sites were aged whereas in the latter, nests were considered individually, but other factors such as climate and habitat-type also varied. In particular, the species used for tree nest construction were different: At Belinga most were in Musanga, a fast growing secondary species with soft wood, and decay was rapid. The difference between these two figures illustrates the danger of extrapolating results between areas. Nest decay studies are laborious and time consuming, but essential if the census is to give reliable results.

Since gorillas and chimpanzees are sympatric we will have to be sure we can distinguish between their nests. Tutin and Fernandez (1984) reported that while some members of a gorilla group might nest in trees, whole groups would not do so and thus the presence of one, or more, ground nest(s) at a site allowed nests of gorillas to be distinguished from those of sympatric chimpanzees. A larger data set of 2435 nests in 373 gorilla nest sites at Lopé shows this statement to be inaccurate: 8% of fresh gorilla nest groups contained only Tree nests. My data from transects showed that during the aging process, both because of the longer lifespan and better visibility of Tree nests, a proportion of gorilla nest-sites 'convert' to chimpanzee nests-sites when only Tree nests remain visible. Such sites that would, on a one-off census, have been identified as having been built by chimpanzees, accounted for 26% of all nest-sites. This would lead to over-estimation of chimpanzee densities and under-estimation of gorilla densities.

## PROPOSED METHODS.

### *Nest counts .*

For each gorilla and chimpanzee nest site sighted, note: location along the transect; estimated age (fresh - odour still present; recent - vegetation still green for the most part; old - intact but all vegetation dead; very old- decomposition advanced); vegetation type (see below) and the distance to all nests sighted from the transect (measured with a tape or topofil). Maps of each nest site should be made and detailed data taken for all nests (including those not visible from the transect, which should be noted). Record nest type (see below), height, tree species it was in, construction materials for ground nests, age class (diameter of dung) of occupant if fresh dung is present. The distance to the nest group centre is determined by calculating the average distance of all nests from the transect, scoring one side positive and the other side negative if nests occur on both sides. Nest site density calculation will follow Buckland *et al.*, (1993).

Nest types will be defined as follows:

Zero: No nest structure exists and the gorilla has slept on the ground. The sleeping site appears as a flattened patch, usually with scattered leaves or small flattened plants. The presence of faeces, hair, and sometimes the smell of gorilla, aids in identification of the 'nest'.

Minimum: The nest consists of one or two stems of herbaceous plants that have been bent (sometimes several times) to form a rudimentary pad on which the gorilla has slept.

Herbaceous: The nest consists of 3-20+ stems of herbaceous plants that have been bent, and sometimes interwoven, to form a substantial platform with a roughly circular depression where the gorilla has slept.

Mixed: Similar to the above but woody vegetation (lianas, shrubs, saplings or detached branches of small trees) have been incorporated into the nest.

Tree: Nests built in trees, constructed by bending and breaking branches to form a sleeping platform. This is the only type of sleeping nest built by chimpanzees, although they occasionally build day nests on the ground.

Woody: Nests built on the ground made entirely of woody vegetation from bent lianas, shrubs or saplings.

Detached woody: Similar to the above but built entirely from detached leafy branches that have been carried to the site and assembled into a nest.

Other nest types may need to be defined as we encounter them.

*Mean group size and nest decay rates.*

To calculate gorilla densities we then need to know mean group size and mean duration of nest sites. Mean group size should be calculated from sites where we are sure all nests were located (fresh nest sites). Data on nests built by a known gorilla group (Porthos' group) over a four year period at Lopé show that extrapolation from the number of nests per site to the number of gorillas should be based on many nest-sites as only 30% of nest counts accurately reflected group size (Tutin et al., in press).

Studies of relative proportions of different nest types and mean duration of nest sites need to be undertaken in as many areas as possible. This may only be possible in long-term research sites such as in the tri-national area where it need not take up too much of a researcher's (or team's) time whilst they go about their other interests.

It is best done from a permanent transect, such as one would use for standard animal and plant inventory work and could be undertaken alongside these activities (see below). If it would take too long to build up a decent sample size one could search for nest sites and then set up several short pathways (simulation transects) at differing distances and relative positions to the nest sites to maximise data efficiency. Identify nests as they appear on the transect and record data for each nest site as above. Then monitor regularly from the transect, making no attempt to approach the nest site, (say every 2 weeks) the visibility of both the nest site and all individual nests, until no nests are visible.

Different gorilla nest types vary in mean longevity (Tutin & Fernandez, 1984). Proportions of different nest types differs between populations of eastern gorillas (Schaller, 1963) and in different parts of the western lowland subspecies' range (Remis, 1993; Tutin et al., in press). Decay experiments will not be possible in all areas, but by collecting data on mean duration of nest types, as well as nest sites, we will be able to correct for ratios of different nest types (cf. Tutin & Fernandez, 1984).

From my experience nest site duration will be neither normally distributed nor conform to Poisson predictions, because different nest types have different mean durations and nest sites will have different nest type composition. This poses a problem if one wants to calculate 95% confidence limits (see Barnes & Barnes, 1992). However, sample sizes of 50 nest sites in Lopé for both gorillas and chimpanzees were sufficient to calculate decay rates with reasonable accuracies (White & Barnes, unpublished)

Finally, one needs to be able to distinguish between day and night nests, which is generally easy when fresh due to night nests' flattened appearance and the presence of faeces and urine, hair, and sometimes an apish odour. I have only rarely had day nests on censuses, but this may not be the case everywhere so must be borne in mind.

*Towards a Barnsian Poor Man's Guide to Counting Gorillas.*

It would be useful to develop a method that does not require the expensive, time consuming process of transect cutting. The tri-national area would be an ideal opportunity to attempt this by recording all gorilla and chimpanzee sign (feeding remains, knuckle prints, day and night nests, dung, smell) along transects, and recording similar data along game trails and human paths in the same area during more

rapid prospections, to see if general correlations of amount of sign and gorilla density emerge. Areas in which prospections have already been undertaken (e.g., Fay, 1991) might therefore be selected as priorities for more systematic line-transect work. Such studies have already been undertaken in Maiko, Zaire (Hart & Sikubwabo, 1994) and Kahuzi, Zaire (Hall et al., in prep.). Hence, all signs that can be definitely assigned to gorillas, chimpanzees or apes should be noted on transects along with their age, location and the vegetation type.

## 2) ELEPHANTS.

Dung counts are the standard method for censusing elephants in forests (Barnes & Jensen, 1987). This will be undertaken along the same transects. For each dung pile (set of boli) the distance along the transect, perpendicular distance from the transect line to the middle of the dung pile, vegetation type and age of dung should be noted. Dung ages can be difficult to estimate. Barnes & Jensen (1987) proposed 5 age classes based on the degree of intactness of boli, but disintegration of boli is not necessarily related to age (Richard Barnes, pers. comm.). A simpler system used in Ituri by John Hart is: *Fresh* - warm; *Recent* - odour present (break the boli), there may be flies; *Old* - over all form still present although boli may be breaking down; *Very Old* - flattened, dispersed, tending to disappear. I would add a fifth category - *Fossilised* - baked by exposure to sun, visibly once an elephant dung pile but with no substance remaining.

Dung densities can be calculated using the DISTANCE Programme in conjunction with Buckland et al. (1993). The Fourier Model that has been used previously may well not be the best adapted for analysis of these data.

For monitoring purposes dung density is perhaps the only measure necessary within the tri-national area. In order to calculate elephant densities from dung counts one requires measures of mean duration or decay rate and defecation rate.

As for ape nests, long-term projects in the tri-national area are well placed to contribute data to efforts to evaluate factors which govern the decomposition of elephant dung in forests, and indeed have already done so. Due to high elephant density in Lopé, Gabon, I was able to monitor over 40 freshly deposited elephant dung piles found on five permanent transects in all but two months of a two year study (White, in press).

Observation of elephant dung piles found on major elephant paths and old logging roads (where access was easiest) were found not to give representative figures for mean duration, and hence decay rate. Future studies should avoid this method in favour of monitoring dung piles encountered in vegetation representative of the area to be censused, and this is perhaps best achieved on a permanent line-transect that can be walked repeatedly.

Whilst statistically significant differences in dung duration were found in Lopé in different months, this was not a simple dry season / wet season relationship as found in other studies (Wiles, 1980; Wing & Buss, 1970). Short (1983) obtained the same decay rate for samples in the wet and dry seasons in Bia, Ghana, but based his calculation on the mistaken assumption that decay is exponential (Barnes & Barnes, 1992), and his published data show that there was probably a higher decay rate in the wet season. There was no simple statistical relationship between rainfall and dung duration, but the negative correlations

between rainfall in the previous three months and mean humidity between 13:00 and 15:00 with mean dung duration suggested that differences were indeed related to climate.

Dung decay is a complex process. Dung piles deposited on stream banks or in gulleys can be washed away overnight by rain, but dung that remains moist, due to contact with marshy ground can remain apparently fresh for long periods. Dung exposed to direct sunshine can be baked dry, becoming "fossilised" and maintaining its form for a year or more. Dung beetles (Scarabeidae) and termites (Termitidae) are important decomposers of dung piles, but show seasonal activity patterns (e.g., Wiles, 1980; Wing & Buss, 1970). Red river hogs (*Potamochoerus porcus*), mandrills (*Mandrillus sphinx*), African civets (*Viverra civetta*) and squirrels (*Funisciurus lemniscatus*) forage in elephant dung piles for seeds and insects (pers. obs.), breaking and dispersing the boli, and this behaviour may also be seasonal, depending on the species of seeds present in dung, or fruit availability elsewhere.

Another factor which could affect dung duration is diet (Koster & Hart, 1988; Wiles, 1980). The diet of elephants in Lopé showed marked seasonal variation, principally in fruit content, since fruit availability was low in the dry season (White *et al.*, 1993). During June 1990 to May 1991, 311 fresh elephant dung piles were searched for fruit remains, principally seeds. The mean number of fruit species present in elephant dung in any given month was positively correlated with habitat-wide fruit availability (White *et al.*, 1993). Despite small sample size, there was a strong negative regression between the mean number of species of fruit found in dung piles each month and corresponding values for the means of the square root transformed duration of elephant dung piles. This shows that dung containing increased proportions of fruit remains, which consequently was less fibrous, tended to decay faster. The fact that this regression was stronger than any involving climatic variables (which influence patterns of fruit production) suggests that fruit content is at least one of the principle determinants of elephant dung decay rates in the tropical rain forest environment at Lopé.

If mean decay rate is calculated as the reciprocal of the mean survival time in days (Dawson, 1990), the range is 0.015 - 0.024 (mean 0.018). Barnes & Barnes (1992) discussed various methods for estimating instantaneous mortality rate from dung survival data and three methods considered suitable gave estimates of 0.021 or 0.022 for a data set collected during the wet season in northeast Gabon. This is comparable to the most rapid decay recorded in Lopé (December 1989 and November-February 1991). Other studies should be undertaken in forested areas with higher rainfall than Lopé to see if a generally applicable relationship can be found to relate weather and elephant dung decay rate, since this would enable researchers undertaking brief surveys to apply decay rates from other sites with more confidence.

Similarly for defecation rates, the projects in the tri-national area are ideally placed to record such data since observation conditions in clearings are good - although one would have to be sure that observations in salines were representative for the forest in general.

In addition to dung counts, feeding trails, tracks, rubbing trees, scars on trees due to bark feeding and wallows can also be noted. In areas of high density this can be very time consuming, but again work in the tri-national area would then contribute data to efforts to find correlations of elephant sign with density that could be of use for establishing more rapid census methods for use in reconnaissance trips and in surveys of areas with fewer elephants elsewhere in Africa.

### 3) OTHER UNGULATES

Again dung counts are the way to go for large scale survey work although it should be borne in mind that seasonal differences in decay rate are significant (Koster & Hart, 1988; White, 1994a) so comparisons should only be done for data collected in the same season. Data should be recorded as for elephant dung. Where species cannot be accurately determined, as for medium sized duikers, the species group should be noted instead. Dung pellets should be classified as: *Fresh and Recent* - odour and a sheen (fatty acids) still present; *Old* - pellets with dulled surface, may have a patina of mould, pellets beginning to break down; *Very Old* - pellets crumbling, dispersed and covered by leaf fall. Buffalo dung should be classified as for elephants. Again other sign of these species should also be noted.

#### 4) SIGHTINGS OF ANIMALS

All sightings should be recorded as for Repeat Censuses (see below).

#### 5) HUMAN ACTIVITY

To the extent possible, observations of human sign from transects should be put in a socio-economic context for the entire region surveyed. Information on settlement locations, economic activity, ethnic associations and history of land use are essential, but will demand ancillary or complimentary studies. Information on human activity that can be gained from transects provides an index of the type and intensity of human use of an area. These indices can be directly correlated with faunal abundance in different areas over time. They also provide a measure to relate to people's own perceptions of their use of and impact on forest resources.

For each encounter of human sign, the type of evidence, (including a detailed description if necessary) the estimated age and the distance along the transect should be recorded. Common signs are:

- Roads - used or disused;
- Old village sites;
- Machete cut or broken stems - a single passage - count cuts;
- (Once) Regularly used human trails;
- Snare line - active or abandoned;
- Shot gun shells;
- Honey extraction;
- Camp sites - active or abandoned;
- Current or past agricultural activity;
- Mining activity;
- Bark stripping for construction, mining sluices, chords, medicines etc.;
- Large mammal carcasses, especially elephant.

#### 6) HABITAT DESCRIPTION.

A running *relevé* of vegetation type, slope, altitude etc. should be kept. All physical features of note should be recorded, such as streams and rivers (note size and direction of flow), marshes (size), major tree falls(?), valley bottoms (note altitude), ridge tops (note altitude). I use a schematic representation of the

transect to record this data. In addition to these features I grade each 50m segment by angle of slope both in the line of travel and along the perpendicular: zero or gentle slope; medium slope; steep slope.

Forest Types generally have to be simplified if records taken by different observers are to be comparable:

- Mature Mixed Forest;
- Monodominant Forest (note dominant species);
- Swamps;
- Seasonally Inundated Forest;
- Marantaceae Forest;
- Liana Forest;
- Gallery Forest;
- Mature Secondary;
- Young Secondary;
- Logged (how many years ago?).

More experienced observers can make supplementary notes to add detail to these categories.

## 7) REPETITIONS

If surveys are to be repeated in the future as part of a monitoring process one needs to be able to locate where they were. Furthermore, much of the environmental data taken has possible application in ground truthing of satellite images and this is important if we are to improve the capacity to use satellite images to monitor large scale changes in forest cover (Wilkie, in press). With access to GPS equipment this should prove relatively easy. The location of the start and end of each transect should be recorded (from the nearest convenient open area) and waypoints should be taken at regular intervals along the line as opportunities arise, particularly at prominent points likely to feature on maps, photographs or satellite images, such as river confluences. It would be worthwhile leaving the transect to get such fixes if a suitable location is found close by.

## PRACTICAL DETAILS

- Who should make the observations ?

If all of the above data is to be recorded then more than one observer will be required. Each observer should have a particular task (search image): dung and sign; nests; human sign and topography. Local trackers tend to be good at spotting sign, but have short concentration spans resulting in variable quality results. Therefore all data recorders should be experienced at looking for sign. Working in such a team is a good training exercise.

## **THE NEXT STEP: REPEAT CENSUSES IN PARTICULAR STUDY SITES.**

The one-off survey described above will indicate key areas, such as those with animal concentrations or high levels of human activity and will serve as a baseline for future monitoring. They will also involve conservation personnel getting out into remote parts of the protected area and this is likely to

provide other useful information. However, for some groups of mammals the data will be of little use. For example, monkey sightings will be low because some groups will flee the noise of transect cutting before observed. One way around this is to set up base camps in the various strata sampled and to undertake animal sighting censuses along the pre-traced transects. Alternatively, a number of areas of particular interest where further research would be worthwhile might be located during the wider survey.

'Primate censusing' (e.g., Whitesides et al., 1988) on permanent transects can be modified as a means of estimating total large mammal biomass (e.g., White 1994a). There are very few estimates of total mammalian biomass for tropical rain forest areas, particularly in Africa. In Lopé mammalian biomass varies from just over 1000 kg km<sup>-2</sup> to almost 6000 kg km<sup>-2</sup> (White 1994a). Some of this variation can be related to differences in vegetation type. Primate biomass in African rain forests varies by more than a factor of ten (Oates et al., 1991) and to date this variation is little understood. Before we can hope to understand reasons for differences between areas there is a need for more long-term community level studies of rain forest mammals and further estimates of animal biomass and corresponding botanical variables from around the world. Such studies should be considered a priority considering the current rate of habitat loss, as the survival of many rain forest species may depend on our ability to evaluate and perhaps eventually manipulate carrying capacity of limited protected areas. In addition, an understanding of how vegetation type affects mammalian densities and how animal densities change seasonally will be of direct management benefit.

#### *Animal sighting censuses (by day).*

If access allows, censuses to record animal sightings should begin as early as visibility is sufficiently good to distinguish species high in the canopy. If rain falls continuously for more than 15 minutes the census should be abandoned, as rain and subsequent noise of dripping water may affect animal behaviour and/or detector efficiency, altering the probability of detecting animals. Successive censuses should be conducted in opposite directions if possible. Censuses should be conducted at regular intervals throughout a period of at least a year, say once a fortnight or once monthly, depending on time available. You should aim at about 40 repetitions per transect.

Whitesides *et al.* (1988) describe methodology for primate censuses, equally applicable to other mammals and some large birds: move slowly and quietly along the transect at a rate of about 1 km h<sup>-1</sup>, never leaving the line, stopping periodically to watch and listen for animals. Upon detecting a group or individual animal, spend up to 10 minutes *in situ* recording data (you may move up to 25m in reverse to obtain a better view). For the first individual of each species seen detection method, time, height, behaviour, distance along transect, distance from the observer, sighting angle and perpendicular distance from the transect should be recorded. Distances are generally estimated by eye. This requires experience and you should test your accuracy periodically. If training project staff to census it may be better to send teams of 2 equipped with a topofil. After data collection is complete one observer continues along the transect whilst the second records the perpendicular distance to the location of the first animal seen using the topofil before rejoining their colleague. The number of individuals seen and estimated to be present and estimated group spread should also be recorded. When more than one species is present data should be recorded for the first individual of each species seen, and any species detected (e.g., by vocalisation) but not seen should also be noted. Primates are considered to be in polyspecific associations if sighted within

50m of one another (do people prefer 100m ??); to be considered solitary an individual should be at least 50m (?100m) from any other individual. 'Loud vocalisations' of all species should be recorded (observer location, species, time, bearing, estimated distance). Record data on a checksheet, and simplify data to be collected if observers are not capable to reliably record all these variables.

In Lopé I collected these data for *Gorilla g. gorilla* (western lowland gorilla), *Pan t. troglodytes* (chimpanzee), *Mandrillus sphinx* (mandrill), *Colobus satanas* (black colobus), *Cercocebus albigena* (grey cheeked mangabey), *Cercopithecus nictitans* (greater spot-nosed monkey), *Cercopithecus pogonias* (crowned guenon), *Cercopithecus cephus* (moustached monkey), *Loxodonta africana* (elephant), *Syncerus caffer* (buffalo), *Cephalophus monticola* (blue duiker), *Cephalophus leucogaster* (Gaboon duiker), *Cephalophus callipygus* (Peter's duiker) *Cephalophus dorsalis* (bay duiker), *Cephalophus ogilbyi* (Ogilby's duiker), *Cephalophus sylvicultor* (yellow-backed duiker), *Hyemoschus aquaticus* (water chevrotain), *Potamochoerus porcus* (red-river hog), *Protoxerus stangeri* (giant forest squirrel), *Epixerus wilsoni* (Wilson's splendid-tailed squirrel), *Heliosciurus rufobrachium* (red-legged sun-squirrel), *Funisciurus lemniscatus* (LeConte's four-striped tree squirrel) and *Myosciurus pumilio* (pygmy squirrel).

*Animal sighting censuses* (by night).

Using a head lamp at night will enable censuses for species not/rarely encountered by day. Unfortunately many observers will find this rather scary, particularly in forests where large mammals such as elephants or gorillas are common, more so if they are hunted in surrounding areas. If these can be undertaken along the same 5km transects it will be a great addition to the data set. Data is collected in the same way, using a head lamp to search for animals - often detected by their eye shine. This is particularly good for duikers since they tend to be dazzled by the light and not to flee.

#### *Data Analysis.*

Our crude data unit is 'number of encounters per species per census'. For each species on any given transect this should conform to a Poisson distribution. Statistical tests to check for differences in densities (encounter rates) will use this data. If parametric tests are to be used first check the data do not differ significantly from that predicted by the Poisson probability, and if they do not, use square-root transformed data for parametric tests. If testing for differences between transects first test to see if visibility differs between sites. If it does adjust encounter frequencies for the transect with greater visibility down by a factor equal to the ratio of the two means of detection distance. For some species encounter frequencies will be low and statistical resolution poor. Sampling resolution can be determined using a parametric formula (Anon, 1981; Janson & Terborgh, 1980; Skorupa, 1988). All three of these papers make use of an equation which differs slightly in each case. The most recent version is:

$$D = 4 (C. V. ) / (N)^{0.5}$$

where,

D= minimum % difference in sample mean that indicates a statistical difference.

C. V. = coefficient of variation.

N = number of replicate samples.

Using this formula the difference in the mean encounter rate that indicates a statistical difference (i.e., the resolution) can be calculated for each species in each site.

To make comparisons between sites we want to present data as density or biomass. This involves further data analysis and generally also requires at least one variable that is difficult to measure and must therefore be guessed (people tend to refer to 'informed estimates by experienced observers'). These tend to include one or more of: mean group size; mean group spread; and weight of an "average" individual.

Whitesides *et al.* (1988) discuss and compare various analytical possibilities for calculating densities. Buckland *et al.*, (1993) have the most up to date views on statistically correct analytical techniques. Where data sets are large enough (25 - 80 encounters per species depending on your reference) Fourier, hazard-rate and other probability functions can be fitted to sighting distance data. These are not always easy to comprehend, especially to research assistants with limited academic training, so the simpler Whitesides' type analyses may be more appropriate for training purposes. However, calculation of 95% confidence limits of the area sampled is not possible using the inspection of histograms method of Whitesides, so resulting densities are calculated as a point value without a range, which is not very satisfactory. There is rarely systematic data available on mean group spread of group-living species so estimates (again without confidence limits) tend to have to be used. This is a problem for hazard and Fourier analyses, since data corrected by adding a factor to allow for group spread will not allow calculation of statistically correct 95% confidence limits. We should aim to collect representative group spread data and accurate group counts for species present in our long term sites.

#### *Biomass calculation*

To calculate this the mass of an "average" individual must be known. Body masses generally have to be taken from the literature. Such data rarely include confidence limits. Researchers with access to hunting should routinely collect body weight data. The weight of an "average" individual must take into account differences between sexes and age classes, and relative proportions of these. This type of group composition data is rare and we should aim to collect it where possible (see below). In Lopé I 'made do' in the following fashion: for *Cercopithecus* spp. and *Cercocebus albigena* an average individual was assumed to be 75% the mass of an adult female (cf. Oates *et al.*, 1990). For *Colobus satanas* group composition was assumed to be as for *Colobus polykomos* reported in Oates *et al.* (1990) and the weight of the average individual was calculated following their protocol. For *Mandrillus sphinx* group composition was assumed to be as reported by Hoshino *et al.* (1984) in Cameroun, sub-adult males were assumed to be the weight of an adult female, and juveniles were assumed to be half the female weight (cf. Oates *et al.*, 1990). For apes it was assumed that there were two juveniles half the female weight for each male and female. For elephants the ratio was assumed to be one male, one female and two and a half juveniles of half the female weight (White *et al.*, 1993). For ungulates the ratio was assumed to be one juvenile half the adult weight to two adults. For *Potamochoerus porcus* and for squirrels the ratio was assumed to be one juvenile to one adult. Average weights of males and females were used where available, and for ranges the mid-point was assumed to be representative. These ratios need to be reviewed and corrected as data become available.

#### **OTHER ANIMAL SPECIES ?**

Inventory could be a never ending process. How far is this the responsibility or concern of a conservation organisation or project ? Beyond offering support to visiting scientists should we go beyond large mammals, and should studies of key species such as bongo or elephant be considered a priority? This is perhaps the point at which inventory and monitoring ends and applied research begins - where there is less a need for standardised methodologies than for regular communication to avoid needless repetition and to ensure that studies on the same species in different areas compliment one another.

#### **DATA THAT CAN BE COLLECTED WITH LITTLE ADDITIONAL EFFORT.**

- 1) Keep log books in all vehicles and for each voyage record: time of departure; time of arrival; route; distance travelled; number of passengers; speed (slow, normal, hurried). Note for all mammal sightings: species; age / sex; number seen; distance; time; activity.
- 2) Keep a book for data on all dead animals (e.g., poachers bags). Record species, age / sex, weight, reproductive status and take standard body measures (see Rabinowitz, 1993).
- 3) For large mammals, record all complete group counts and young infants.
- 4) For rarely sighted or key species (e.g., bongo) record all sightings.

#### **REFERENCES.**

- ANON. (1981). Techniques for the study of primate population ecology. National Academy Press, Washington D.C.
- AVELING, C., and HARCOURT, A.H. (1984). A census of the Virunga gorillas. Oryx **18**: 8-13.
- BARNES, R. F. W. & JENSEN, K. L. 1987. How to count elephants in forests. IUCN African Elephant and Rhino Specialist Group Technical Bulletin 1:1-6.
- BARNES, R. F. W. & BARNES, K. L. (1992). Estimating decay rates of elephant dung-piles in forest. African Journal of Ecology **30**: 316-321.
- BARNES, R. F. W., BARNES, K. L., ALERS, M. P. T. & BLOM, A. (1991). Man determines the distribution of elephants in the rain forests of northeastern Gabon. African Journal of Ecology **29**: 54-63.
- BUCKLAND, S. T., ANDERSON, D. R., BURNHAM, K. P. & LAAKE, J. L. (1993). Distance Sampling: Estimating abundance of biological populations. Chapman & Hall, London & New York.
- BURNHAM, K. P., ANDERSON, D. R. & LAAKE, J. L. (1980) Estimation of density from line transect sampling of biological populations. Wildlife Monographs **72** 1-202.
- CARROLL, R. W. (1988) Relative density, range extension, and conservation potential of the lowland gorilla (*Gorilla gorilla gorilla*) in the Dzangha-Sangha region of southwestern Central African Republic. Mammalia **52**(3), 309-323.
- DAWSON, S. (1990) A model to estimate density of Asian elephants (*Elephas maximus*) in forests habitats. M.Sc. thesis, University of Oxford.
- FAY, J. M. (1989). Partial completion of a census of the lowland gorilla (*Gorilla g. gorilla* (Savage and Wyman)) in southwestern Central African Republic. Mammalia **53**: 203-215

- FAY, J. M., AGNAGNA, M., MOORE, J. & OKO, R. (1989). Gorillas (*Gorilla gorilla gorilla*) in the Likouala swamp forests of north central Congo: Preliminary data on populations and ecology. International Journal of Primatology **10**: 477-486.
- FAY, J. M. (1991). A survey of the proposed Nouabale Ndoki National Park Conservation Area, northern Congo. Unpublished Report.
- HARCOURT, A.H. and FOSSEY, D. (1981). The Virunga gorillas: decline of an 'island' population. African Journal of Ecology **19**: 83-97.
- HARCOURT, A.H. and GROOM, A.F.G. (1972). Gorilla census. Oryx **11**: 355-363.
- HART, J. & SIKUBWABO, C. (1994). Maiko Report. The Wildlife Conservation Society, New York.
- HOSHINO, J., MORI, A., KUDO, H. & KAWAI, M. (1984). Preliminary report on the grouping of mandrills (*Mandrillus sphinx*) in Cameroon. Primates **25(3)**, 295-307.
- JANSON, C. & TERBORGH, J. (1980). Censo de primates en selva humeda tropical. Publicaciones del Museo de Historia Natural "Javier Prado", Lima, Peru. Serie A Zoologia **28**, 3-39.
- JONES, E. W. 1955. Ecological studies on the rain forest of Southern Nigeria IV. The plateau forest of the Okomu Forest Reserve. Journal of Ecology **43**, 564-594.
- JONES, E. W. 1956. Ecological studies on the rain forest of Southern Nigeria IV (continued). The plateau forest of the Okomu Forest Reserve. Journal of Ecology **44**, 83-117.
- KINGDON, J. (1990). Island Africa: the evolution of Africa's rare animals and plants. Collins, London.
- KOSTER, S. H. & HART, J. A. (1988). Methods for estimating ungulate populations in tropical forests. African Journal of Ecology **26**, 117-126.
- MALEY, J. (1992). The African rain forest vegetation and paleoenvironments during the late quaternary. Pp. 79-98 in N. Myers (ed.) Tropical forests and climate. Kluwer Academic Publishers, The Netherlands.
- MURNYAK, D. F. 1981. Censusing the gorillas in Kahuzi-Biega National Park. Biological Conservation **21**: 163-176.
- NORTON-GRIFITHS, M. 1978. Counting Animals. African Wildlife Foundation, Nairobi, Kenya.
- OATES, J. F., WHITESIDES, G. H., DAVIES, A. G., WATERMAN, P. G., GREEN, S. M., DASILVA, G. L. & MOLE, S. (1990). Determinants of variation in tropical forest primate biomass: new evidence from West Africa. Ecology **71(1)**, 328-343.
- OSLISLY, R. (in press) The middle Ogooué valley, Gabon, from 3500 yrs bp.: cultural changes and palaeoclimatic implications. AZANIA.
- RABINOWITZ, A. (1993). Wildlife field research and conservation training manual. The Wildlife Conservation Society, New York.
- REMIS, M. J. (1993). Nesting behavior of lowland gorillas in the Dzanga-Sangha Reserve, Central African Republic: implications for population estimates and understanding of group dynamics. TROPICS **2(4)**, 245-255.
- SCHALLER, G.B. (1963). The Mountain Gorilla: Ecology and Behavior. University of Chicago Press, Chicago.
- SHORT, J.C. (1983) Density and seasonal movements of the forest elephant (*Loxodonta africana cyclotis* Matschie) in Bia National Park, Ghana. African Journal of Ecology **21**, 175-184.
- SKORUPA, J. P. (1988). Effects of selective timber harvesting on rain-forest primates in Kibale forest, Uganda. Ph.D. Thesis, University of California Davis, U.S.A.

- TUTIN, C. E. G. & FERNANDEZ, M. (1984). Nationwide census of gorilla (Gorilla g. gorilla) and chimpanzee (Pan t. troglodytes) populations in Gabon. American Journal of Primatology **6**, 313-336.
- TUTIN, C.E.G., FERNANDEZ, M., ROGERS, M.E. and WILLIAMSON, E.A. (1992). A preliminary analysis of the social structure of lowland gorillas in the Lopé Reserve, Gabon. In Itoigawa, N., Sugiyama, Y., Sackett, G.P. and Thompson, R.K.R.(eds.), Topics in Primatology Vol. 2, University of Tokyo Press, Tokyo, pp. 245-254.
- TUTIN, C. E. T., PARNELL, R. J., WHITE, L. J. T. & FERNANDEZ, M. (in press). Environmental influences on nest building by lowland gorillas in the Lopé Reserve, Gabon. International Journal of Primatology.
- WEBER, A.W. and VEDDER, A. (1983). Population dynamics of the Virunga gorillas 1959 -1978. Biological Conservation. **26**: 341-366.
- WHITE, L.J.T. (1994a). Biomass of rain forest mammals in the Lopé Reserve, Gabon. Journal of Animal Ecology. **63**(3), 499-512.
- WHITE, L.J.T. (1994c). Sacoglottis gabonensis fruiting and the seasonal movements of elephants in the Lopé Reserve, Gabon. Journal of Tropical Ecology **10**: 121-125.
- WHITE, L. J. T. (in press). Factors affecting the duration of elephant dung-piles in rain forest in the Lopé Reserve, Gabon. African Journal of Ecology.
- WHITE, L.J.T., TUTIN, C.E.G. & FERNANDEZ, M. (1993) Group composition and diet of forest elephants, Loxodonta africana cyclotis, Matschie 1900, in the Lopé Reserve, Gabon. African Journal of Ecology **31**, 181-199.
- WHITESIDES, G. H., OATES, J. F., GREEN, S. M. & KLUBERDANZ, R. P. 1988. Estimating primate densities from transects in a West African rain forest: A comparison of techniques. Journal of Animal Ecology **57**: 345-367.
- WILES, G.J. (1980) Faeces deterioration rates of four wild ungulates in Thailand. Nat. Hist. Bull. Siam Soc. **28**, 121-134.
- WILLIAMSON, E.A., TUTIN, C.E.G., ROGERS, M.E. & FERNANDEZ, M. 1990. Composition of the diet of lowland gorillas at Lopé in Gabon. American Journal of Primatology **21**: 265-277.
- WING, L. D. & BUSS, I.O. (1970) Elephants and Forests. Wildlife Monographs **19**, 1-92.
- YAMAGIWA, J., MWANZA, N., SPANGENBERG, A., MARUHASHI, T., YUMOTO, T., FISCHER, A. & STEINHAEUER-BURKART, B. (1993). A census of the eastern lowland gorillas Gorilla gorilla graueri in Kahuzi-Biega National Park with reference to mountain gorillas G. g. beringei in the Virunga Region, Zaire. Biological Conservation **64**: 83-89.
- YAMAGIWA, J., MWANZA, N., YUMOTO, T. & MARUHASHI, T. (1992). Travel distances and food habits of eastern lowland gorillas. In Itoigawa, N., Sugiyama, Y., Sackett, G.P. and Thompson, R.K.R.(eds.), Topics in Primatology Vol. 2, University of Tokyo Press, Tokyo, pp. 267-282.

### Annexe 3a: Explication de la fiche de Recensement des Grands Mammifères d'ECOFAC

Il y a certaines règles importantes à respecter pendant les recensements:

*Faites des arrêtes de 10 minutes* - pas moins et pas plus - chaque fois que vous rencontrez des singes. Cela est important pour vérifier si une espèce et seule, ou s'il est accompagné par d'autres espèces. Souvent vous pouvez constater que plusieurs espèces de singe se trouvent ensemble, et dans ces cas il faut prendre des informations pour chaque sorte de singe.

*Marchez lentement* - la vitesse idéale est 1 à 1,5 kilomètres par heure. La vitesse est importante pour assurer qu'on voie bien et qu'on entend bien est aussi pour ne pas rencontrer la même groupe de singes plusieurs fois.

*Gardez le silence* - les voix humaines, les coupes de machettes et d'autres bruits avertissent les animaux que quelqu'un s'approche, et ils se cachent ou ils fuient.

*N'appellez pas les animaux.*

*Recensez un minimum de 5 kilomètres.*

Cont: Numéro du contact - 1,2,3 etc. Les espèces vues ensemble (souvent les association de singes mais aussi lorsqu'un céphalophe est détecté sous les singes) sont listés sous le même numéro de contact.

Heure: heure de la première indication de la présence de l'animal (cris ou bruits de déplacement) :

M Det.: Méthode de détection de l'animal:

Cris = vocalisations entendues

Vu = animal vu

E Mvt = bruit de mouvement entendu

V Mvt = mouvement des branches vu

Odeur = animal senti (gorilles, potamochères, éléphants)

H-vue: heure de la première observation de l'animal

Dist sur layon: position de l'observateur sur le layon quand l'animal est détecté

Espèce: Genus et espèce si possible. Pour les céphalophes de taille moyenne si l'observation n'est pas parfaite, marquez "céphalophe rouge".

QUAND VOUS VOYEZ L'ANIMAL:

D-O/A: Distance entre l'observateur et l'animal. Pour les animaux en groupe, la distance de l'observateur au premier individu vu est prise.

Angle: l'angle de vue de l'animal vis-à-vis du layon. L'angle avec la distance 0/è permettra de calculer la distance perpendiculaire post hoc (voir Whitesides et al. 1988).

D-Perp: distance perpendiculaire de l'animal au layon. Cette distance sera utilisée dans les calculs de densité. Il est difficile de l'estimer avec précision, il est plus précis de mesurer.

N° vue: nombre d'individus vus

N° est: nombre additionnel d'animaux dans le groupe par les mouvements ou cris. Surtout important de distinguer entre les solitaires et les groupes pour les primates.

Type de forêt: forêt mature, forêt secondaire, marécage, rocher ou d'autres.

Commentaires: Pour les animaux entendus mais jamais vus, donnez la direction et une idée de la distance des cris repérés. Tout autres renseignements utiles, par exemple, age/sexes de l'animal, présence ventrale des jeunes chez des primates, fruits mangées, etc.

#### Annexe 4a: Explication de la fiche pour Comptage des Traces sur les layons ECOFAC

Date: jour/mois/année

Layon: location et numéro

Direction: direction de marche

Location début et Location fin: distance au début et à la fin de la prise de données

Type de traces: nid, crotte, empreinte, broutage, pièges, etc.

Distance: Distance sur le layon, estimez la position à 5m près.

Espèce d'animal: n'oubliez pas traces humaines (piège, campement, cartouche, etc.).

Distance Perpendiculaire: distance entre la trace et le layon mesurée au centimètre près pour les crottes et au mètre près pour les nids plus distants.

Age de traces: mettre le nombre de jours, semaines ou mois si possible. Si il n'est pas possible de donner avec certitude, dire fraîches, récentes, vieilles ou très vieilles. Pour la classification des nids:

frais - feuilles toujours vertes, souvent crottes encore visibles

(à peu près 1-6 jours) ;

récent - feuilles mortes mais nid toujours intact (à peu près 7-20 jours)

vieux - feuilles complètement mortes et sèches mais toujours rattachées aux branches (21-40 jours)

pourri- nid toujours reconnaissable par sa forme mais pour nids dans les arbres, les feuilles sont tombées des branches cassées et pour les nids au sol, les repousses de la végétation herbacée sont visibles (1,5 à 3 + mois)

L'estimation de l'âge des nids aide à placer les nids du même âge par groupe n'est pas toujours évidente car la végétation utilisée dans la construction vieillit différemment. Excepté les nids très frais ces données seront difficiles pour des débutants. Pour des layons permanents seulement des nids frais et récents seront enregistrés si un recensement est fait tous les 15 jours.

Type de forêt: il est importante à distinguer entre forêt mature, forêt secondaire, rocher et marécage. Si vous connaissez certaines plantes, vous pouvez indiquer leur présence, comme par exemple, *Uapaca*, *Raphia*, *Aframomum*, *Haumania*.

Commentaires: tout autres renseignements utiles, par exemple, identification des graines vues dans les crottes.

#### Nids de Gorille et de Chimpanzé

Faites attention aux nids des gorilles dans les arbres qui peuvent être confondus avec ceux des chimpanzés. A la Lopé, 35% des nids des gorilles sont construits dans les arbres à une hauteur moyenne de 10 m mais il est assez rare que tous les nids dans un groupe soient dans les arbres (85% des groupes à la Lopé). Il est nécessaire de quitter le layon pour approcher des nids et chercher les nids au sol ou les crottes pour aider à l'identification de l'espèce.

Gauche/Droite: côté du layon du nid (nécessaire pour un calcul *post hoc* de la distance du centre d'un groupe de nids au layon). Visibilité (ou non) depuis le layon est aussi une information très importante.