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CONSERVATION VALUE OF LOGGING CONCESSION AREAS IN THE TROPICAL RAINFOREST OF THE KORUP REGION SOUTHWEST CAMEROON

December 2007

CONSERVATION VALUE OF LOGGING CONCESSION AREAS IN THE TROPICAL RAINFOREST OF THE KORUP REGION, SOUTHWEST CAMEROON

Dissertation
Zur Erlangung des Doktorgrades
der Mathematisch-Naturwissenschaftlichen Fakultäten
der Georg-August-Universität zu Göttingen

vorgelegt von

Lien
aus Cameroon

Goettingen, 2007

D 7

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Tag der mündlichen Prüfung:	

SUMMARY

Tropical rainforests are home for renewable natural resources for living and non living things. The dynamic and interdependent nature of tropical rainforest components make it a fragile ecosystem and the scale in which human exercise pressure on these forests has increased over the past decades. Extraction of valuable trees for commercial purpose and other logging activities in tropical rainforest has mainly contributed to the reduction of the size of the rainforest belt. Furthermore, current levels of wildlife exploitation in many parts of tropical West and Central Africa pose serious threats to wildlife populations. While the “bushmeat problem” is one of the major problems in conservations science and management, there are few experiences with wildlife management in tropical rainforests at all, and most of the biological and social pre-conditions for a successful application remain obscure. The broad aims of this study are to evaluate the conservation value of logging concession areas of the Korup region through the assessment of tree communities and wildlife populations and to propose a conservation management concept for wildlife in the region.

Many studies are dealing with the effects of selective logging on tree communities, but few studies have attempted to analyse effects of logging at different scale levels and analysed vegetation composition in logged areas in detail. We studied tree assemblages in forests adjacent to Korup National Park in the Southwest of Cameroon. A total of 168 plots of 50 m x 50 m (0.25 ha) were systematically distributed along 24 two-km transects situated within four 16 km² study areas, of which two were in 10 years-old heavily logged forests and two in relatively undisturbed primary (unlogged) forests. Beside the vegetation, primates and hornbills are described to play an important role in the maintenance of tropical forests and the food resources constitute one of the most limiting factors for most wildlife species including primates and hornbills. We investigated food resources for primates and hornbills following the plot, transect and study site design. In addition we studied the population development of eight primate and two hornbill species using the line transect and the Distance sampling models.

A total of 9,134 trees (dbh ≥ 8.0 cm) belonging to 217 species and 55 families were recorded. Community parameters of trees were analysed at plot, transect and study site levels, and compared between logged and unlogged forests. Tree abundance was relatively lower (about 38%) in logged forests compared to unlogged forests. Tree species richness was least affected at the largest sampling scale (16-km² study site). Species richness was reduced from 188 species (Jackknife index= 208 spp.) to 177 species (Jackknife= 213 spp.) at smaller spatial scales, a reduction of 6%. Along the 2-km transects, an average of 87.5 (± 5.0) species were found in unlogged compared to 68.5 (± 3.0) species in logged forest (reduction of 32%). At plot level (50 x 50 m), 32.4 (± 7.6) species were found in unlogged and 22.2 (± 5.7) species in logged forest (reduction of 31%). However, species composition differed markedly between logged and unlogged forests as was shown by two-dimensional ordination of the tree assemblages at species level. An analysis at family level, including the twenty one most abundant tree families did not show significant differences in family importance values (FIV) between unlogged (FIV= 222.58 and 221.51) and logged (FIV= 207.52 and 214.64) study sites, suggesting that logging effects are rather at species than at family level. Food trees were relatively more abundant in unlogged forests (2,556 food trees recorded) compared to logged forests (1,864 trees recorded).

Primates population densities differed from one species to another but also from unlogged and logged study sites. The *C. mona*, *C. nictitans nictitans, C. pogonias, C. torquatus* and *P. troglodytes* population densities were relatively high in logged (28.73 ind./km^2; 23.35 ind./km^2; 1.03 ind./km^2; 6.65 ind./km^2; and 2.03 ind.km^2 respectively) forests study sites compared to unlogged (15.24 ind./km^2; 17.90 ind./km^2; 0.31 ind./km^2; 1.01 ind.km^2; and 0.02 ind.km^2 respectively) forest study sites. *C. erythrotis* had high estimates in unlogged forests (17.55 ind./km^2) compared to logged forests (10.93 ind./km^2) study sites. However the preuss's red colobus (*P. pennantii preussi*) was not observed in logged forest study sites and was estimated at very low density (0.02 ind.km^2) in unlogged forest study sites. Compared with earlier studies, the drill (*M. leucophaeus*) population density has relatively increased in unlogged (1.03 ind.km^2) and in logged (0.91 ind./km^2).

The black-casqued hornbill (*C. atrata*) population was relatively higher in logged forest study sites (23.15 ind./km^2) compared to unlogged forest study sites (21.61 ind./km^2). However, the brown-checked hornbill (*C. cylindricus*) population density was relatively higher in unlogged (25.08 ind/km^2) compared to logged (22.43 ind./km^2) forest study sites.

The relationship between primates and hornbill with their potential food tree resources was investigated. At transect level and in logged II, we found a negative, strong and significant correlation between *C. pogonias* (R= -088 and P= 0.019) and *C. torquatus* (R= -0.94 and P= 0.005) and their potential food tree resources. At tree species level, we also found negative, strong and significant correlation between the *Pycnanthus angolensis* and the *C. mona* (R= -0.70 and P= 0.0001), the *P. angolensis* and *Ceratogymna cylindricus* (R= -0.82 and P= 0.04).

The results of this study support the view that logging in the Korup region has had a negative impact on tree abundance, tree species composition and forest structure. The ecological value of unlogged and logged study sites is not influenced by the difference between unlogged and logged, but by the composition of trees species. The relative differences in food tree abundance between unlogged and logged study sites indicates that logged forest study sites contained a high potential of tree bearing fruits for both primates and hornbills. The relationship between food abundance, primates and hornbills encounter rates, suggest that the studied wildlife species population densities is not influenced by fruit abundance and that food availability is not a limiting factor for primates and hornbills in the Korup region. Other factors such as predation, habitat availability and hunting may contribute to regulate primate and hornbill population densities in the region.

Population density of all studied primate species are below carrying capacity observed in tropical rainforests. The studied primate species seem presently not affected by logging activities, however it may require several years before logging to observe significant decline in primates population densities. The low populations densities of primates estimated in this study compared to primates decline earlier observed could be the result of a combination of hunting, logging and extensive farming. Our study suggests the ecological value of secondary forests of the logged study sites compared to “relatively undisturbed (unlogged) forests. These secondary forests may highly contribute to maintain larger populations of primates and hornbills. The management of these disturbed forests as well as the unlogged forests should constitute a priority for the Cameroonian institutions in charge of forests and wildlife.

ACKNOWLEDGMENTS

This work would not have been completed without the supervision and advices of Prof. Dr. Michael Muehlenberg to whom I express my sincere thanks. He appreciated, encouraged and supported me throughout my studies in Germany. My thanks to Prof. Dr. Matthias Schaefer for accepting to enrol as second supervisor. Thanks also to Prof. Dr. Michael Kessler for accepting to be one of my examiners. I wish to express my gratitude to Dr. Matthias Waltert for his valuable intellectual assistance and friendship. I also wish to express my thanks to Dr. Uwe Muuss for academic guidance and to the GTZ Cameroon and the International Student services of the University of Goettingen for financial support respectively for research field work and the writing of the thesis.

I particularly thank the Eco teams and the people of Bajoh, Bayip Arsibong, Etinkem and Mgbegati for field work assistance and hospitality. I am indebted to late Njokagbor Njok for the supervision of my field work.

My special gratitude to the staff of the Centre for Nature Conservation of the Georg-August University of Goettingen, Prof. Dr. Michael Muehlenberg, Dr. Eckhard Gottschalk, Dr. Jolanta Slowik, Dr. Hermann Hondong, Dr. Choima Dulamsuren, Dr. Martina Meeske, Dr. Innocent Tchigio, Dr. Margaretha Pangau, Monika Deseniss, Andrea Lambertz, Elisabeth Opielka, Christos Astaras, Kamini Kusun Barua, for scientific discussions, technical assistance and moral support. I am grateful to Wokia-Azi Ndangle Kumase and James Batupe Fokam for correcting English mistakes of this thesis and Annette Modoh for editing.

I wish to acknowledge the moral support of the former Korup Project, GTZ Cameroon, WWF, CODEV and WCS staff for moral, logistical and technical support, collaboration and up building comments they provided during my field work in Cameroon. My special thanks to Karin Von-Loebenstein and Vincent Ngangang Awa for their encouragements and moral support. I wish also to thank Dr. Martin Tchamba, Dr. Hansen Njiforti, Dr. Atanga Ekobo, Prof. Isaac Tchouamo, Albert Kembou, Dr. Roger Fotso, Peter Sanga, H.E. Mary Moyali Meboka, Dr. Athanasius Nkwatoh, Okenye Mambo, John Besong, Anthony Ojong for their moral support and scientific advices.

I am also very grateful for the scientific and up building discussions and friendship of Dr. Sebastien Kamga Kamdem, Dr. Bosco Mbom, Dr. Lewis Cheussom, Dr. Jean Marie Sobzé, Martin Ngueho Yemele, Dr. Rose Ngomba, Roger Pedieu, Silas Youmbi, Dr. Laurice and Edmond Tomte, Jean Martial Bell, Prudence Ngantsi, Georges Massock, Ghislain Kouematchoua, Robert Nkwegna, Emmanuel Ngondo, Dr. Moise Nack, Lacour Ayompe, André Edongué, Marc Billong, Fabien Ambassa, Dr. Chicgoua Noubactep, Andrien Djomo and Bat Nkohom.

My heartfelt gratitude to my “Sweet” parents Esther Lien and Gilbert Yebga. Mama “Es” and “Ma king alias Bikô’o bi njock”, I will never forget the suffer you have suffered for your children and thank you very very much for all what you have done for us. We so much love you and will never forget you, never. This thesis is the fruit of your hard labour.

I am very grateful to my sisters and sisters in-law, my brothers and brothers in-law, Sara Ngo Yebga spouse Njock Minyem, Marie Ngo Tang spouse Yana, Sara Ngo Yebga spouse Nkott Bikun, Madeleine Ngo Yebga spouse Longuia Toutoura, Colette and Samuel Libock, Solange and Aaron Nyot Yebga, Priscile and Gilbert Yebga, Elisabeth and Moise Massô, Jean Marc Issounga, Lazare Nken Yebga, Rachel and Njembe Mandeng, Odile and Simb Simb, Josephine Bikun. Many thanks to my nieces, nephews, aunts and cousins.

I acknowledge the moral assistance of my family in-law, papa Sadrack Ngue, Adele Ngo Bell spouse Honla, Christine Ngue spouse Nlend, Geneviève and Didier Ngue, Josué Ngue Ngue, Bell Ngue, Anne Ngo Ngue, Thomas Tjok Ngue.

Many thanks to my spiritual family of the following congregations, Mundemba, Nguti, Kassel English, Goettingen Sud but particularly to brothers and sisters Clovis Ako, Joseph Akuri, Stephen Elongue, Michelle and Joel Bahel, Martine and Moise Fotsop, Brigitte and Samuel Njombe, Daudet Biem, Aaron Mayagui, Margereth and Peter Eshun, Susanna and Juergen Zeuch, Sandra and Julian Eggers, Monica and Peter Jackmann, Maja and Matthias Schneider-Dominco, Virginia and Manuel Bons, Martine Ndongue and Carole Tido.

Finally my most special thank goes to my beloved wife and daughter Sara Lien Ngue and Josée Arielle Ghyslaine Lien. Thank you “Coucou and “Complice” for your valuable moral, financial and spiritual support without which, I wouldn’t have completed this thesis. To you I dedicate this study.

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LIST OF ACRONYMES AND ABBREVIATIONS

a.s.l:	Above Sea Level
CAFECO:	Cameroon Agriculture and Forestry Exploitation Company Limited
CAMFIRE:	Communal Areas Management Programme for Indigenous Resources
C.A.R:	Central Africa Republic
CBWM	Community Based Wildlife Management
CITES:	Convention on International Trade in Endangered Species of Wildlife
CMR:	Cameroon
CO:	Carbon Dioxide
CODEV	Conservation Development Service
COVAREF:	Comité de Valorisation des Resources Fauniques
Dbh:	Diameter at the Breast Height
DFID:	Department for International Development
D.R.C:	Democratic Republic of Congo
D.S:	
ECOFAC:	Ecosystems Forestiers d’Afrique Centrale
E.G:	Equatorial Guinea
€:	Euro
F.A.O:	United Nations Food and Agriculture Organisation
Fcfa:	Francs de la Communauté Financière Africaine
GA:	Gabon
GFW :	Global Forestry Watch
GTZ:	Deutsche Gesellschaft für Technische Zusammenarbeit GmbH
ha:	Hectare
IUCN:	World Conservation Union
Kg:	Kilogram
Km^2:	Square kilometre
KNP:	Korup National Park
KPA:	Korup Project Area
m:	Metre
m^3:	Cubic metre
m.a.rf:	Mean Annual Rainfall
MINEF:	Ministry of Environment and Forests (Cameroon)
MINFOF:	Ministry of Forest and Fauna (Cameroon)

MPL:	Mukete Plantation Limited
n.a:	Non Available
NGO :	Non Governmental Organisation
NTFP:	Non Timber Forest Products
R.C:	Republic of Congo
RF:	Rainforest
$:	United State of American’s Dollar
UFA:	Unité Forestière d’Amenagement
WCMC:	World Conservation and Monitoring Centre
WCS:	Wildlife Conservation Society
WRI:	World Resources Institute
WWF:	World Wide Fund for Nature

1 INTRODUCTION

1.1 Tropical rainforest: location, characteristics and formation

Tropical rainforests are mainly found within the world's equatorial regions. They are restricted to a small land area of 10% of the earth surface between the latitudes 22.5° North and 22.5° South of the equator and between the tropic of capricorn and the tropic of cancer. The main characteristics of tropical rainforests include climate, precipitation, canopy structure, complex symbiotic relationship and a high diversity of species. Assessment, structural, dynamic and composition analysis of these forests have revealed a high biological diversity with an estimate of more than 50% of the world terrestrial species (Struhsaker, 1997). Tropical rainforests have evolved over millions of years to form an heterogeneous environment. They are grouped according to the physical characteristics of their habitats, the rainfall is evenly distributed with the dry season below 3 months per year and the rainfall over 5 (T + 14) cm/ year (Lauer, 1952. Table 1.1). These forests include:

- Evergreen lowland rainforests characterised by wet climate with a mean annual rainfall – m.a.rf over 1800 mm, mean annual temperatures ranging from ca. 28-22 °C and altitude of 0-800 m a.s.l
- Evergreen mountain rainforests found on elevated lands (800 – 2000 m a.s.l) with mean annual rainfall of over 1400 mm and mean annual temperatures of ca. 22-14°C
- Evergreen cloud forests with a m.a.rf of over 1200 mm, altitude ranging between 2000 m and 3200 m a.s.l and mean annual temperatures of ca 14-10°C

Other forest formations in tropical regions include: deciduous moist forests of lowlands (RF 700-1800 mm/year), deciduous mountain moist forests (RF over 1400 mm/year), deciduous moist forests of high elevation (RF 500-1200 mm/year), dry deciduous forests of lowlands (RF under 700 mm/year), dry deciduous mountain forests (RF under 600 mm/year) and dry deciduous forests of high elevation (RF under 500 mm/year).

Table 1.1: Classification of tropical rainforests.

Rainfall pattern	Temperature range and mean annual temperature		
	ca. 28-22 °C 0 - 800 m a.s.l	ca. 22-14 °C 800 - 2000 m a.s.l	ca. 14-10 °C 2000 – 3200 m a.s.l
RF evenly distributed D.S < 3 months RF > 5(T + 14) cm/y	evergreen lowland rainforests with RF over 1800 mm/y	evergreen mountain rainforests with RF over 1400 mm/y	Evergreen cloud forests with RF over 1200 mm/y

Source: Lauer 1952

1.2 Ecological value of tropical rainforests

Tropical rainforests such as Korup are home for renewable natural resources. These forests are important in the regulation of climate in which carbon dioxide is dissolved thus enabling air filtration. Tropical rainforests are responsible for the distribution of regional precipitations but also have a greater influence on micro-climate. Biologically, tropical rainforests allow species to continuously adapt to dramatically evolving environmental conditions, and support the ecosystem functions: regulation, supply (food, medicine, timber and non timber) and protection functions (soil erosion). These functions are interdependent and the breaking down of one of them will obviously have an impact on the others. For instance, deforestation affects wildlife population growth and plant regeneration but also contributes to increase the amount of carbon dioxide (CO2) and other traces of gas in the atmosphere. The releasing of carbon dioxide in the atmosphere enhances the greenhouse effect and could contribute to an increase in global temperatures. Trees in tropical regions play an important role in evaporation and evapotranspiration process, enabling large quantity of water return to the local atmosphere thus forming cloud and precipitation.

Tropical rainforests covered a total of 40% of the total land area in tropical zones and these forests have reduced at a considerably high rate. By 1990, the area of tropical rainforest worldwide was shrinking by 1.8% yearly. The reduction of the forest cover in the Korup region through logging activities but also through extensive farming has a great impact on species diversity and abundance.

The species-area and species-abundance relationships have well been described by various authors (Begon et al., 1990; Rosenzweig, 1995; Tilman et al., 1997; Gaston and Blackburn, 2000). Species diversity is described by Gaston and Blackburn (2000) as being dependent of the area sampled but little is known about the impact of habitat modification (logging, habitat fragmentation, extensive agriculture) on diversity. Tilman *et al.* (1997) found a strong correlation between species richness and the size of the area sampled with large surface areas containing more individuals and more species. Besides, species richness also is function to the heterogeneity of the habitat. Kevin *et al*. (2000) observed that species increasing in abundance also tend to increase in space or occupancy. Considering Rosenzweig "theory" (1995) which stipulates that "the greater the habitat variety the greater the species diversity" it become clear that there exist a strong correlation between species diversity and habitat size. However, habitats with the same size and located at different ecological regions might significantly differ in species diversity (Proctor *et al.* 1983, Cowling *et al.* 1989). Species diversity can also be influenced by disturbances as noted by Rosenzweig (1995), who suggested that the disturbance-diversity pattern relies on small scale disturbance, the more often a patch is disturbed the fewer species it contains. Waltert *et al.* (2005) observed a decrease in tree density, diversity and basal area from forest to farmland habitats. Begon *et al.* (1990) pointed out that distribution exhibited by a population depends on the spatial scale on which it is studied. The question therefore is to determine which spatial scale is suitable to study population parameters such as abundance, species richness, diversity, composition and structure?

The dynamic and interdependent nature of tropical rainforest components make it a fragile system and the scale in which human exercise pressure on the ecosystem has increased over the past decades.

1.3 Socioeconomic value of tropical rainforests

Beside their ecological importance, rainforests by virtue of their species richness in both animal and plant resources contribute to the survival of humankind. These forests are home to a large variety of resources. Resources that ensure food supplies, medicine, fuel, clothing, shelter, and industrial raw material.

The sustained potential annual yield capacity of tropical rainforests is described to be over 35 million ha of wood with a growth of 4 m^3 per year and per hectare. This wood provides more than 65% of total energy consumed in Africa, 17% in Asia and 16% in Latin America. Wood industry in tropical countries constitutes one of their main sources of income and employment. In Cameroon for example, wood industry production increased by 35% since 1980 and generated US $ 190 million in 1998 (GFW, 2000). In the Korup region, timber exploitation by MPL and CAFECO has created employment for 140 local people in the area being exploited thus reducing unemployment.

In the Korup region, the number of persons involved in forest activities (hunting and secondary forest products collection) in 1999 was evaluated at 72.43 % generating a total cash income of € 2, 2191,621 (Schmidt-Soltau, 2002).

In Gabon, the forest plays an important socio-economic role. It constitutes one of the main sources of employment (26%) and income revenue after petroleum products. From Allogho's (2002) findings, in 1996, the forest generated 100 to 150 billion Fcfa (1 US $ = 650 Fcfa).

Exploitation of tropical rainforest resources by humans has contributed to increase the livelihood of local populations and has been one of the main sources of revenue to the States of tropical countries thus alleviating poverty. Besides its positive socioeconomic value, exploitation of tropical rainforest resources has also contributed to a large extent to deforestation and to local extinction of both plant and animal species (Skorupa, 1988 and Struhsaker, 1997).

1.4 Central African rainforests

Beside the Amazon rainforests in Brazil, the Congo basin rainforests are the second largest forest complex in the world covering more than one million km². The Congo basin forests extend from the coast of Atlantic ocean in the west to the mountains of the Albertine Rift in the east. This large forest complex covers six countries: Cameroon, Democratic Republic of Congo, Republic of Congo, Central African Republic, Equatorial Guinea, and Gabon (Figure 1.1). Though lower than in south America, the biodiversity of the Congo basin forests is of global significance. It includes more than 10,000 species of plants of which 3,000 are endemic, 400 species of mammals and more than 1,000 species of birds (GFW, 2000). Congo basin forests are known to inhabit wildlife species of significant value such as gorillas, elephants, drill, chimpanzee, buffalos, bongo and okapi. These species still occur in large numbers within the ecological regions of the Congo basin and contribute to maintain the ecological function of the forest. Beside its species richness and diversity, the Congo basin forests does not only contribute in the regulation of the greenhouse gas and carbon dioxide, but also provides a host of natural resources and employment to a large majority of people living in the region and beyond. However, these forests are diminishing with an increasing rate of about 10,000 sq. km per year (Table 1.2). The main causes for deforestation in the Congo basin include logging, urbanisation, intensive agriculture and mining. Deforestation of the Congo basin forests have contributed to forest fragmentation, an increased poaching through the use of logging roads and tracks and have also created large forest gaps which have facilitated the formation of a secondary forest vegetation dominated by pioneer species (*Musanga cecropioides*, *Oubanguia sp.*, *Terminalia spp.*).

Figure1.1: Congo basin rainforests complex in Africa.

Table 1.2: Annual deforestation rates and logging per country in Congo-basin tropical rainforests.

Countries	**Natural forest. (000 ha) 1990**	**Annual defores. (000 ha) 1981-1990**	**% of deforestation 1981-1990**	**Annual population growth (%) 1986-1992**	**Annual logging (000 ha) 1981-1991**
D.R.C	113,275	732	0.6	3.3	26
C.A.R	30,562	129	0.4	2.7	3
E.G	1,826	7	0.4	2.3	n.a
R.C	19865	32	0.2	3.0	78
CMR	20,350	122	0.6	3.0	333
GA	18,235	116	0.6	2.7	126

Sources. World bank, 1995. D.R.C: Democratic Republic of Congo; C.A.R: Central Africa Republic; E.G: Equatorial Guinée; R.C: Republic of Congo; CMR: Cameroon and GA: Gabon. n.a: non available.

1.5 Threats to tropical rainforests

Tropical rainforests are disappearing at a rate of 1.8% per year (GFW, 2000), and their ongoing depletion is caused by many factors among which are anthropogenic disturbances such as logging and forest conversion for agriculture (Van Gemerden, 2003). The number of species disappearing each year as a result of deforestation is estimated to be 0.54 %, of 20 million species, 27,000 species are doomed to die out each year that is 74 species per day and 3 species per hour (Mühlenberg, 2001). But the reduction or the local extinction of species becomes more important when it comes to larger mammals.

There is no doubt that logging activities have great impacts on tree diversity and abundance of tropical rainforest (Struhsaker, 1997; Skorupa, 1988; Cannon *et al.*, 1998 and Jonkers & Van Leersum, 2000). These impacts are much reflected in forest structure and species composition (Kurpick & Huth, 1997; Van Gemerden, 2003 and Lien, 2004). Though logging under highly selective and regulated methods can be considered as sustainable, extraction of timbers in tropical rainforests always results in biological losses and ecological changes (Struhsaker, 1997 and Van Gemerden 2003).

It is obvious that any forest disturbance (biotic or abiotic) creates gaps in forest structure which depending on the size, provides opportunities for light demanding pioneer species and less light demanding gap opportunist species. In contrast to a virgin forest, a logged-over forest temporarily will show increased increment, which subsides when the basal area again approaches the saturation point.

Beside deforestation, mining, industrialisation, overexploitation of secondary forest products and poaching constitute limiting factors to the stability of tropical rainforests.

1.6 Overview of Cameroon rainforests biodiversity

Cameroon's surface area is estimated to be 47.5 million hectares within which 21.6 million hectares is covered by forests (GFW, 2000). Relative to the area, Cameroon forests are among the most species diverse and rich in the Congo Basin. The country is species rich with high levels of biological diversity and endemism particularly in moist evergreen forest region. The biological diversity of Cameroon includes 9,000 species of plants, 297 species of mammal, 849 species of birds, 542 species of fresh water fish and brackish water fish, 190 species of amphibian, 183 species of reptiles and 39 species of swallowtail butterflies. Endemic species include 156 species of plants, 63 amphibians, 3 rodents and 1 bats (MINEF, 2003).

Threatened and endangered species are reported for 18 mammals, 16 birds and 5 reptiles (WRI, 1990 and Alpert, 1993).

1.7 Threats to Cameroon rainforests

Like in other tropical forest regions, one of the main threats to Cameroon's biological diversity is deforestation which is facilitated by an uncontrolled exploitation of forest resources. Deforestation rate in Cameroon is estimated to be 0.6% /year (GFW, 2000). One of the main causes of deforestation in Cameroon is attributed to logging. Cameroon ranks among the world's top five tropical log exporters with twenty five logging companies and individuals holding 81% of Cameroon's unprotected forests. These companies and individuals are exporting 1.7 million cubic meters/year of wood harvested from 80 tree species (GFW, 2000). By 1995, more than 3 million hectares of forests in Cameroon were either logged or transformed into large agricultural areas.

Logging activities in Cameroon were formally concentrated along the coastal and major urban areas but due to the economic crisis that affected the country in the late 80's and the high demand of tropical round wood in the world market, logging activities have extended into the last remote track of undisturbed forest in the Eastern and Southern regions. In 1997, 17,329,000 ha of forests were allocated to concessions for logging.

In addition to logging, extensive agriculture facilitated by large plantations of banana, coffee, cocoa and palm oil contribute largely in the reduction of the forest cover (Figure 1.2). Urbanisation and industrialisation also constitute major constraints to the preservation of the forest vegetation.

Figure 1.2: Forest clear cutting for the establishment of palm oil plantation in the Korup region. Photo Lien, 2003.

1.8 Legal framework of timber harvesting and wildlife conservation in Cameroon

1.8.1 Timber harvesting

Harvesting of timber for commercial purpose in Cameroon is carried out through the following forms: sale of standing volume, exploitation permit, individual felling authorisation. Timber harvesting by means of the sale of standing volume is carried out within the communal forest and can exceptionally be granted within the permanent forest for salvage logging for development projects. Compartments of forest (forest blocks) which could not exceed 2,500 ha are attributed to the company without any limitation of the volume of timber that can be harvested. A company can own more than one block of forest or forest concession. The new forestry law (MINEF, 1994) request the licence timber operator to produce a management plan prior to the exploitation. It also specifies quantity and species of timbers that can be exploited and within a specified period of time. Exploitation licences for sale of standing volume are issued at national level but the supervision and control of logging activities are under the provincial and the departmental delegations of the Ministry of Forests and Environment.

Exploitation permit are carried out in communal forest with no specified surface area but with a maximum of up to 500 m^3 of timber that can be harvested. No management plan is required for the licence owner. Individual felling authorisations are also carried out in communal forest and the priority of timber harvesting using light machinery is given to local people. Harvested timber in this case are locally processed and mainly used in house building. Up to 30 m^3 is allowed to be harvested.

1.8.2 Wildlife conservation

The conservation of wildlife in Cameroon is governed by the January 1994 law on forestry wildlife and fishery (MINEF, 1994) and by its decree of July 1995, determining the conditions for the implementation of wildlife regulations.

The “Arrêté” No. 0565 of 14.08 1998 classifies wildlife into three main categories: category A for rare and threatened wildlife species. These species (e.g.: Mammals: *Panthera leos*, *Gorilla gorilla*, *Pan troglodytes*, *Colobus guereza*, *Manis gigantea*, *Loxodonta spp*, *Giraffa camalopardalis;* Birds: *Struchio camelus*, *Francolinus spp*, *Picathartes gymnocephalus*, *Touraco persa*; Reptiles: *Crocodilus niloticus*, *Cheloniidae spp*;) are totally protected. Their capture or killing is regulated by a special authorisation from the administration in charge of wildlife for scientific research or protection of individuals and their goods.

Category B comprises partially protected wildlife species which could be hunted or captured by individuals who have obtained an exploitation permit. Species in this category are also classified into (1) Mammals: *Hippotamus amphibus*, *syncerus caffer*, *Cephalophus sylvicultor*; (2) Birds: *Bucarvus Abyssinians*, *Touraco leucolophus*; (3) Reptiles: *Pithon sebae*, *Naja spp*, *Varan niloticus*. Wildlife species falling in category C are those not listed neither in category A nor B. In Cameroon, wildlife and their habitats are protected through national parks, forest reserves, wildlife sanctuaries and zoological garden. According to the law, 30% of the land should be set aside as protected areas for wildlife and other threatened plants species. Cameroon’s wildlife law also regulates hunting activities (hunting period, hunting gears, sanctions against defaulters).

1.8.3 Wildlife institutions in Cameroon

In Cameroon, the Ministry of Forests and Fauna (MINFOF) ensures the conservation of wildlife heritage. Beside the MINFOF, an emphasis is put on wildlife education and training via Universities (University of Dschang and Yaoundé I) and schools (wildlife school in Mbalmayo and Garoua). To achieve wildlife conservation goals and objectives, Cameroon has elaborated cooperation with international non governmental organisations such as IUCN, WWF, GTZ, WCS and ECOFAC. Cameroon is also member and signatory to universal conventions as:

- Convention on International Trade in Wildlife and Endangered Species (CITES).
- Convention of Biological diversity.
- Convention of the Conservation of Nature and Natural Resources.
- Accord on joint regulation of fauna and flora within the Lake Tchad Basin.
- Accord of cooperation and concertation among Central African states relating to wildlife conservation.

1.8.4 In-situ and Ex-situ wildlife conservation in Cameroon

In-situ conservation is the process of protecting endangered species of plants or animals in their natural habitat. In Cameroon, the protection of endangered wildlife species (categories A and B) and their habitats is mainly achieved through the establishment of protected areas namely: national parks, biosphere reserves, wildlife sanctuaries and game reserves. These protected areas are established to ensure the protection of endangered and vulnerable wildlife, but also to preserve their genetic diversity which depend mostly on the population size. These areas are managed by the state with the assistance (technical and financial) of international cooperation.

However, protected areas in Cameroon suffer from lack of finance, poor management, insufficient staff in quality and quantity. These shortcomings have resulted to an increased poaching and encroachment of the protected areas by the surrounding village communities. In addition, the inability of Cameroon government to resettle villages that still inhabit protected areas (Korup National Park, Dja biosphere reserve) has resulted in the fragmentation of these fragile ecosystems but also to human-wildlife conflicts.

Beside in-situ conservation, some individual wildlife species (endangered and vulnerable species) are removed from their natural habitat and placed in an unnatural environment or location under the care of humans, this process is known as ex-situ conservation. The objective of this method is to maximise a species' chance of survival in increased breeding and preservation of genetic diversity. The species is introduced to its natural environment when conditions become suitable. In Cameroon ex-situ conservation is carried out in zoological gardens (Limbé, Yaoundé and Garoua). Conservation of wildlife in zoological gardens has an educational value in the sense that the public is informed on the status of the species and factors that cause their transfer from the wild to an artificial environment.

1.9 Korup rainforests

The Korup forests (Figure 1.3) are ecologically important because of their high species diversity (Gartlan, 1986) and their central location at the Guinea Congolian forest refugium (Maley, 1996). These forests have no evidence of any major historical influence of abiotic factors but have a biomass and productivity equivalent to other African rainforests (Newbery *et al.,* 1997). Korup forests are distinguished by three major layers: emergent large trees are dominated by families such as *Caesalpiniaceae*, *Mimosaseae*, *Meliaceae* and *Bombacaceae*. The midstorey tree formation (trees of about 15-25 m) is dominated by *Annonaceae*, *Euphorbiaceae*, *Rubiaceae*, *Irvingiaceae*, *Amaranthaceae* and *Ebenaceae*. The understorey layer is dominated by *Rubiaceae* and *Sterculiaceae*. The woody vegetation, lianas and herbs are dominated by the *Apocynaceae*, *Icacinaceae* or *Acanthaceae*, *Graminaceae*, *Marantaceae*. The Korup forests are among the Afrotropical rainforests for which data on biological diversity is available (MINEF, 2003).

In addition to its high diversity of plant species, Korup forests are known to contain one quarter of all Africa's primate species, labelling the region as an important site for primates conservation (Waltert *et al*., 2002). The fact that primate populations are declining in areas of high endemism is of major concern. Populations of wild primates decline worldwide (IUCN, 1998). Of about 236 species of primates, 100 species and subspecies are declared either endangered or vulnerable. Plumptre (2001) attributed the declining of primate populations to deforestation, hunting, poaching and inadequate forest and wildlife policies drawn up by governments.

Figure1.3: Overview of Korup rainforests. Photo Lien, 2005

1.10. Problem statement

Not much is known about the status of wildlife in concession and management areas and this study intends to explore the ecological value of forest concession areas of the Korup region in southwest of Cameroon. Activities such as forest clearing for agriculture, logging, development projects induced by human has affected tropical rainforests in many ways. The landscape have been modified into forest patches with a matrix of disturbed land (Turner, 1996; Williams-Linera *et al.,* 1998 and Holl, 1999). The modification of landscape followed by the decrease of the habitat has contributed significantly to the loss of biodiversity (Dale *et al.,* 1994) or to its change within fragmented forests (Turner 1996). Beside the loss and changes in biodiversity, depending on the scale, abiotic as well as biotic factors have influenced the ecological structure of tropical rainforests through (1) microclimate-temperature and an increase in light availability thus increasing the invasion of pioneer species and small mammals (Kapos *et al.,* 1997 and Turton, 1997), (2) disturbed areas are more exposed to wind damage (Saunders *et al*., 1991) and to (3) habitat isolation which may reduce or increase the immigration of fauna thus influencing the species population densities of tropical forests remnant or patches (Turner *et al.,* 1996). Benitez-Malvido (1998) has observed that disturbances such as logging and gap formation affect the abundance, distribution and composition of the seedling in the forest understory. Several authors (Williams-Linera, 1990; Robinson *et al.*, 1992; Matlack, 1994 and Camargo & Kapos, 1995) have concluded that disturbances in tropical forests increase the vulnerability of the forest tree community and have been responsible for environmental changes with high influence on the understorey and irreversible changes on forest structure and composition but also with great and negative impacts on animal wildlife species.

When applied with high intensity, logging can have a negative impact on wildlife population densities, seedling regeneration patterns, and abundance of food tree resources for wildlife (Struhsaker, 1987 and Plumptre, 2001) as well as on the extinction rate of species, including those that are unique to that particular forest (Figure 1.4). Logging and shifting cultivation are regarded as major outcomes of human disturbance of the forest.

When attempting to understand the impact of selective logging on wildlife, primates and hornbills are excellent groups of animals for monitoring for several reasons. They are conspicuous (primates) and can be easily counted, they play an ecological role as seed dispersers and predators, insectivores, pollinators and browsers and some of the primates in the Korup region are actually threatened (e.g.: drill, preuss red-colobus) or affected by population decline (drill, preuss red colobus, chimpanzee, red-capped mangabey). Few forest animals in tropical rainforest present such features. The decrease in abundance of certain animals such as primates (Rylands and Keuroghlian, 1988), birds (Stouffer and Bierregaard, 1995) and other insects (Tscharntke, 1992) and the inability of some of these animals to cross disturbed forest areas (Spears, 1987), could result into the loss or reduction of potential pollinators and seed dispersers thus enhancing in the short term the reduction of tropical forest seed-bearing trees of the original vegetation and in the long term a combined reduction of both animal and food tree resources. However, animal populations decrease and abundance is not only caused by vegetation modification but also by an uncontrolled exploitation through hunting.

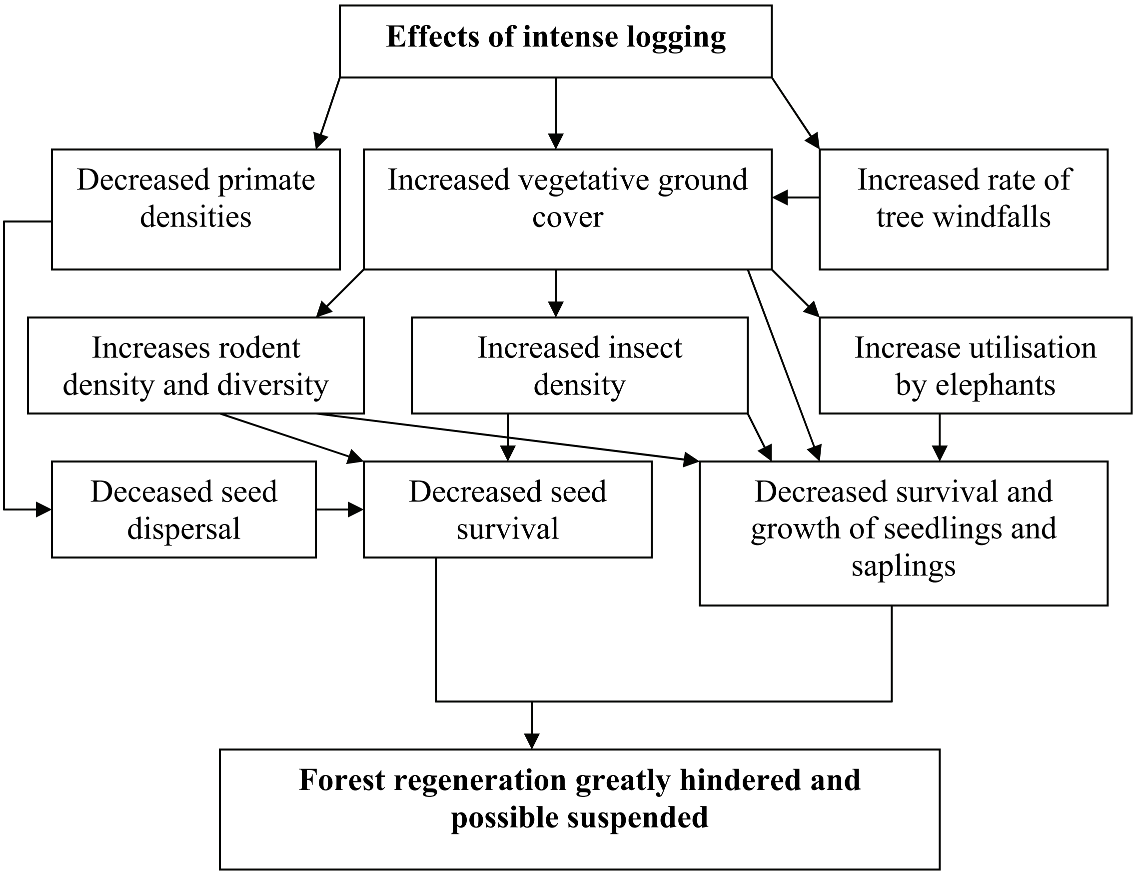

Figure 1.4: Effects of intense logging on the biodiversity. Adapted from Struhsaker, 1997

1.11 Aim and objectives of the study

The broad aims of this study are to evaluate the conservation value of logged concession areas of the Korup region compared to unlogged forests and to propose a conservation and management concept for wildlife in the region. The specific objectives are stated as follow:

- To assess tree communities in unlogged and logged forest areas of the study sites.
- To assess the abundance of food tree resources for primates and hornbills in unlogged and logged study sites.
- To estimate population densities of selected primates and hornbills in unlogged and logged the study sites.
- To evaluate the relationship between tree abundance and population densities of selected primate and hornbill species.
- To look for possible factors other than food tree resources and logging activities which could be responsible for primate and hornbill populations decline.

- To describe wildlife management zone as a concept which could ensure both protection and management of wildlife in the region.

1.12 Questions

1- Do population densities of primates and hornbills differ between unlogged to logged forests?
2- Do logging activities in the Korup region have affected primate and hornbill population densities?
3- Do logging activities in the Korup region have had an impact on food tree abundance for primates and hornbills?
4- What is the value of logging concession forests of the Korup region for the conservation of wildlife?
5- Under which conditions are the local communities in tropical rainforest regions able to manage wildlife in a sustainable way?

1.13 Hypothesis

There exist pre-conditions for all living things to adapt into a given natural environment. Among these pre-conditions are the availability of a suitable environment or habitat and the abundance of food resources in quality and quantity. We assume that logging creates a non suitable wildlife habitat which differ from the natural habitat, thus contributing to the decline of wildlife population densities. The abundance of food resources constitutes one of the significant factors for the physical, social and economic stabilization for both human beings (socio-economic) and animals (socio-physical) in a given environment. A large majority of food is derived from the forest. We also assume that population densities of primates and hornbills are positively correlated with food tree abundance. From these main assumptions the following hypothesis can be derived:

- No matter how selective logging is conducted, the abundance of trees and food resources for animals is reduced causing the decline in frugivores population densities.
- Primates and hornbills respond to logging differ from one species to another and the effects of logging on primates can only be effectively measured in the long term.
- Wildlife management zone in non protected forests can contribute to the protection of threatened wildlife species and to the sustainable harvest of non protected wildlife species.

In order to test these hypotheses, data on primate, hornbill and food resources abundance were collected from two sampling units within the same geographical and ecological region:

unlogged and logged forests. The forest was selectively logged two years prior to data collection (1999 - 2001) thus minimising the effect of disturbances by heavy machinery.

1.14 Structure of the study

The study comprises six main chapters: (1) introduction, (2) material and methods, (3) data assessment, (4) results, (5) discussion and (6) conclusion.

The first chapter introduces the topic in its geographical and environmental context. The second chapter describes the materials and the methods used to achieve the goals and objectives. Chapter three provides details on data collection while chapter four presents the results. In chapter five the results are discussed. This provides the basis for the establishment of a strategy for wildlife management in disturbed tropical rainforest regions. The conclusion is the summary of all the chapters, but also presents recommendations for the conservation of biodiversity in unlogged and logged forest of the Korup region, recommendation which could be applied in other tropical regions of the world.

2 STUDY AREA AND METHODOLOGY

2.1 Geomorphological characteristics

2.1.1 Location

The study was conducted in the eastern sector of the Korup Region of Southwest Cameroon in West Africa. The study area (Figure 2.6) falls within the geographical co-ordinates of 5°20' – 5°25' N and 9° 12'- 9°30' E. This region comprises one of the most diverse rainforests in the world (MINEF, 2003): the Korup National Park (KNP) (1,253 km²). The Korup National Park is surrounded by three forest reserves, namely: Rumpi Hill (438 km²) in the southern sector, Nta ali (313 km²) in the eastern sector and Ejagham (783 km²) in the northern sector. These protected areas are contiguous with Cross River National Park in Nigeria and cover more than 5,000 km² of mainly lowland rainforests.

Within the eastern sector, four study sites of ca. 8 km² were selected among which two in unlogged forests (Bajo and Mgbegati) and two in logged forests (Bayip Arsibong and Etinkem). The unlogged forests study site vegetation is generally characterised by old growth forest and the topography is relatively flat. But human intervention through the establishment of large plantations of cash crops (Palm oil, coffee), as well as natural factors such as elephant disturbance and windfalls have created large gaps in these forests. Logged forest sites are located in the "heart" of the MPL concession (Mukete Plantations Limited) and the forests of this area have undergone logging from 1995 until 1999.

2.1.2 Geomorphology

The southern and the northern sectors of the Korup region (Mundemba and Ejumedjok areas) consist mainly of low and undulating land surfaces characterised by irregular slopes and vallies but also by a huge network of streams and rivers (rivers Monaya, Bake, Mana and Ndian). The eastern sector is characterised by a mountain chain (Nkwende hills) which starts from the Northwest via Nguti region and ends at Mount Yuhan (1,079 m) at the Korup National park. The geographical characteristics of the Korup region are directly linked to its geology.

The Korup region is divided into four main geological sectors: the far north-east sector along rivers Bake and Munaya consist of basalt and andesite rocks in which salt springs used by animals are found the southern sector is more sandy, suggesting a sedimentary rock formation, the eastern and the northern sectors are predominated by precambrian basement rocks such as ectinites, quartzites and gneisses suggesting tectonic activities from the tertiary period. The four geological sector comprises high elevations of tertiary basalt. These rocks determine the structure and texture of the soil (MINEF, 2003).

2.1.3 Soils

There exist four main types (Gartlan, 1985) of soil so far identified in the Korup region. These consist of sedimentary soils (11% of the KNP) and located in the southern and north-eastern sectors of the KNP. Soils of these sectors are acidic with poor water retention capacity and low nutrient contents. The far-north-eastern sector of the Kroup region cover volcanic dark brown fertile soils (5%) while the remaining sectors (about 85%) is predominated by soils deriving from in-situ degradation of the precambrian basement rock: granites, gneiss, schist, embrechites and entinites (MINEF, 2003).

Like soils of the tropical rainforests, soils of the Korup lowland sectors are poor in humus which is confined to the top layer and less fertile, while soils at the high elevation are often more fertile due to the weathering of primary rock which is releasing a sufficient amount of nutrient for plants.

2.1.4 Climate

The climate of the area comprises two major seasons: the wet season which lasts eight months, from March until October, the coldest month occurring at the peak of the rainy season in August, with a monthly mean temperature of 25°C. The dry season is from November to February with the hottest period in February (monthly mean of 33°C). The area receives a mean annual rainfall of 5000 mm (Zimmermann, 2000). Powel *et al.* (1994) observed that the mean annual rainfall in the Korup region is higher in the southern sector (Mundemba region: up to 5,000 mm) and decreases as we move towards the northern sector (Nguti region: 3,515 mm; Figure 2.1). Correlated with rainfall and sun radiation, relative humidity is highest in the wettest months of July and August. The Large and high trees of the Korup forest protect the soil from direct exposure to rain thus to land slide and soil erosion. The radiations in the Korup region are low and data indicate only 3.5 hours of sunshine per day but, this time increases northwards as the rainfall decreases (Gartlan, 1985 and Newbery *et al.,* 1998).

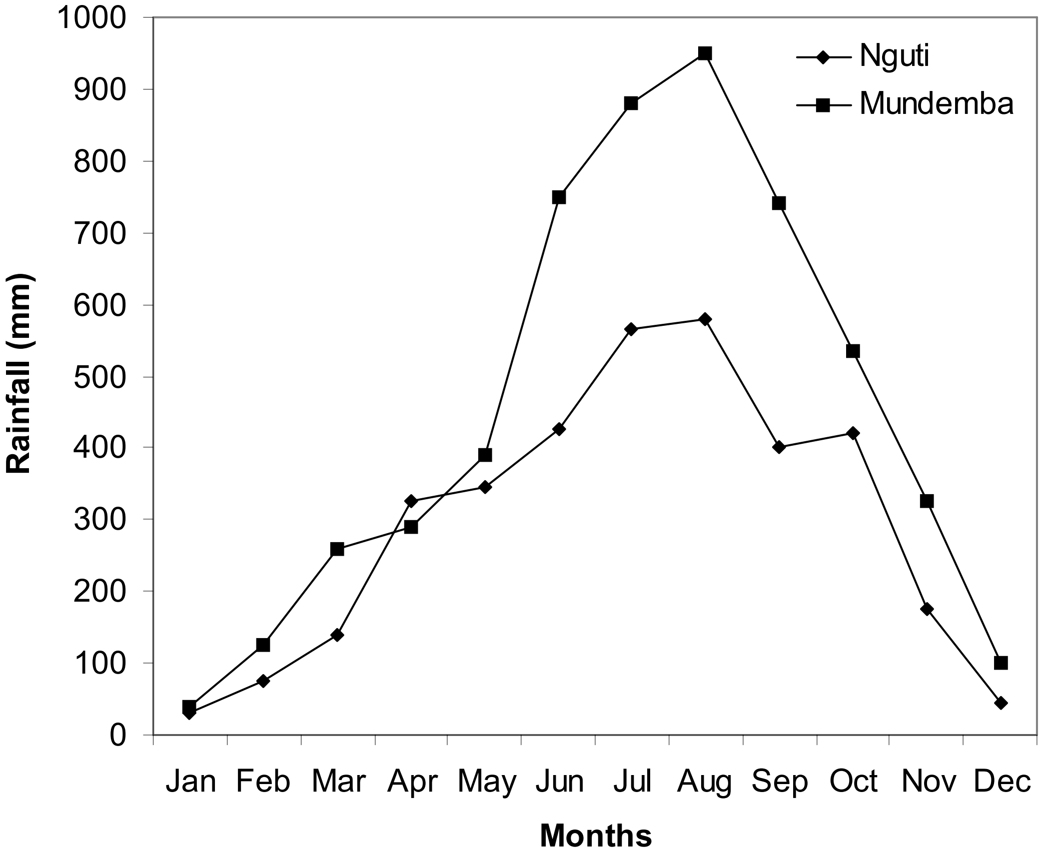

Figure 2.1: Average rainfall pattern in Mundemba and Nguti. Source: Powell *et al.* 1994.

2.2 Biophysical characteristics

2.2.1 Vegetation

The tropical rainforest region in Southwest of Cameroon (Korup and Takamanda forests) constitutes a large forest complex contiguous to Cross River forests in Nigeria.

The Korup forest corresponds to one of the two main Pleistocene refugia proposed for Africa (MINEF, 2003). Within the study area, large trees dominate the vegetation. More than 620 species of trees and shrubs, 480 species of herbs and climbers have been identified so far in the area. The vegetation of the Korup region is classified into four main types (MINEF, 2003) namely:

- The sub-mountain vegetation with a predominance of *Caesalpiniaceae*
- The Atlantic coastal forest with less *Caesalpiniaceae* occurring on medium and low altitudes.
- Low land Atlantic ever-green forests with a predominance of *Caesalpiniaceae*, *Rubiaceae*, *Sterculiaceae*, *Ebenaceae*, *Combretaceae*, *Apocynaceae*, *Irvingiaceae* and *Onchaceae* and

- Rocky vegetation type on exposed slopes predominated by *Mimosaceae* and *Olacaceae*

Beside the emergent trees, the understorey of the Korup forests comprise many small tree species, treelets and herbs. This layer is predominated by the *Rubiaceae* (small trees), *Acanthaceae, Araceae*, *Commelianaceae*, *Graminae* and *zingiberaceae* (treelets and herbs). The liana flora is well represented with *Apocynaceae*, *Connaraceae*, *Dichapetalaceae*, *Icacinaceae* and *Luguminoceae*. The epiphytic flora of the Korup region is not well described and may be relatively poor due to extreme variations of climate. In the Korup region, there are gradients along which some tree species are more common. These gradients include high elevations predominated by *Hymenostegia spp*, *Monopethalanthus letestui*, *Gilbertiodendron grandiflorum* (*Caesalpiniaceae*), the low lands in which species such as *Ceiba pentandra* (*Bombaceae*), *Terminalia superba*, *T. Ivoirensis* (*Combrataceae*), *Pycnanthus angolensis*, *Staudtia Kamerunensis* (*Myristicaceae*) *Musanga cecropioides* (*Moraceae*)are common. The bank of large rivers (Ndian, Monaya and Bake) are predominated by *Lecomptedoxa klaineana*, *Vitex spp*, *Fagara spp. (Rutaceae)*, *Lophira alata* (*Ochnaceae*).

Korup forest are described as the best remaining of tropical diversified forests with no major history of human disturbances (Richards, 1952).

2.2.2 Wildlife

Most of the studies carried out in the area are focused on large mammals. There is still a lack of information on other taxa such as butterflies, insects, reptiles, fish and molluscs.

The Fauna of the Korup Area consists of 161 species of mammals belonging into 33 families, 410 species of birds in 53 families (72 species only recorded in the Support Zone and not yet in the KNP), 82 species of reptiles and 92 species of amphibians, about 130 species of fish and 950 species of butterflies of which 480 have been so far identified (MINEF, 2003). This species richness classifies Korup Area as conservation area of international concern. Large mammals such as forest elephants, buffaloes, and giant pangolin are reported to be found in the area. Oates (1996) described Korup as a biodiversity hot spot for primate conservation.

The anthropoid primates found within the Korup region include chimpanzee (*Pan troglodytes*), putty-nosed monkey (*Cercopithecus nictitans*), mona monkey (*C. mona*), crowned monkey (*C. pogonias*), red-eared monkey (*C. erythrotis*), Preuss's red colobus (*Procolobus pennantii preussi*), red-capped mangabey (*Cercocebus torquatus*), and drill (*Mandrillus leucophaeus*). Of these eight primates, at least three (*P. pennantii preussi*, *C.*

erythrotis, and *M. leucophaeus*), and possibly five (*C. pogonias*, and *C. nictitans*), are species or subspecies endemic to the region (Gautier-Hion *et al*., 1999 and Grubb *et al*., 2000). The IUCN (Hilton-Taylor, 2000) lists four: (*P. troglodytes*, *C. pogonias*, *P. pennantii preussi*, and *M. leucophaeus*) as endangered and one, (*C. erythrotis*), as vulnerable. Other large mammals inhabiting Korup forests include forest elephant (*Loxodonta africana cyclotis)*, forest buffalo (*Syncerus caffer nanus)* and bush pig (*Potamocheerus porcus pictus)*. Small mammals in Korup forests are reparted into 55 different species of bat and 47 species of rodents (Appendix 2). Korup forests are among the most diverse lowland forests in Africa in term of avifauna with a total of 410[3] birds species recorded in 53 families (MINEF, 2003). Among the inventoried Families the *Ralidae*, *Columbidae*, *Cuculidae*, *Musophagidae*, *Alcedinidae*, *Bucerotidae*, *Pyscnonotidae*, *Turdidae*, *Sylviidae*, *Timaliidae*, *Nectariniidae*, *Sturnidae* and *Ploceidae* (MINEF, 2003 and Waltert *et al.,* 2005).

Hornbills (*Bucerotidae*) of the Korup region include the Black dwarf hornbill (*Tockus hartlaubi*), the Red-billed dwarf hornbill (*T. camurus*), African peid hornbill (*T. fasciatus*), Piping hornbill (*Ceratogymna fistulator*), Black-and-white-casqued hornbill (*C. subcylindricus*), Brown-cheeked hornbill (*C. cylindricus*), Yellow-casqued hornbill (*C. elata*) and White-crested hornbill (*Tropicranus albocristatus*).

However this high wildlife diversity is threatened by over/uncontrolled exploitation, extensive farming and logging.

2.2.3 Human population

Human population in the Korup region is estimated at 57,709 inhabitants (Bijnsdorp 2001). This population is distributed over 175 villages and subdivided into three clusters (Table 2.1).). The Mundemba cluster comprises a total of 94 villages (54% out of 175 villages) with an estimate of 22,344 inhabitants. The Oroko, Batanga, Bakoko, Korup, Bima, Ngolo, Balondo and Balue constitute the main tribes of this cluster. The Nguti cluster represents 32% of the human population in the Korup region (18,267 inhabitants). This population lives in 49 villages with an average number of 373 inhabitants per village. The main tribes of the Nguti cluster are Balong, Ejagham and Banyang. The smallest cluster is located at Ejumejock subdivision with a total of 32 villages (18%) and an estimated population size of 17,098 inhabitants (30%) and 534 people per village. Ejagham and Manyu constitute the main tribes of the Ejagham cluster. Although there is a poor documentation of data on the population age and sex for the Korup region, we observe that a large majority of the population is composed of youths (from 1 – 40 years) and predominated by men (about 60%).

Table 2.1: Population size and number of villages of the Korup region.

Cluster	Pop. size	%	No. of villages	%	Av. no. of people/village
Mundemba	22,344	38.72	94	54	238
Nguti	18,267	31.65	49	28	376
Ejumojock	17,098	29.63	32	18	534
Total	**57,709**	**100**	**175**	**100**	

Source: Bijnsdorp 2001, unpublished.

2.2.4 Human activities

The Korup region is inhabited by people living with the forest and from it. Despite their cultural, linguistic and religious background, a large majority of people in the Korup region livelihood depend on agricultural products. Beside farming activities, hunting, fishing, collection of secondary forest products (NTFPs) constitute the main activities carried out by local people of the region. Korup region is composed of two main categories of land units (protected and non protected lands) and each category with a well defined status (Figure 2.2). The non protected lands in the case of Korup region comprise of communal lands in which local communities living in and around have customary rights: the right to farm, to hunt within the regulations laid down by the law (wildlife law), the right to collect secondary forest products, the right to carry out fishing activities and concession lands for timber exploitation. Pamol, an industrial palm oil plantation also constitutes an important land unit. Protected areas of the Korup region on the other hand are set aside for biodiversity protection.

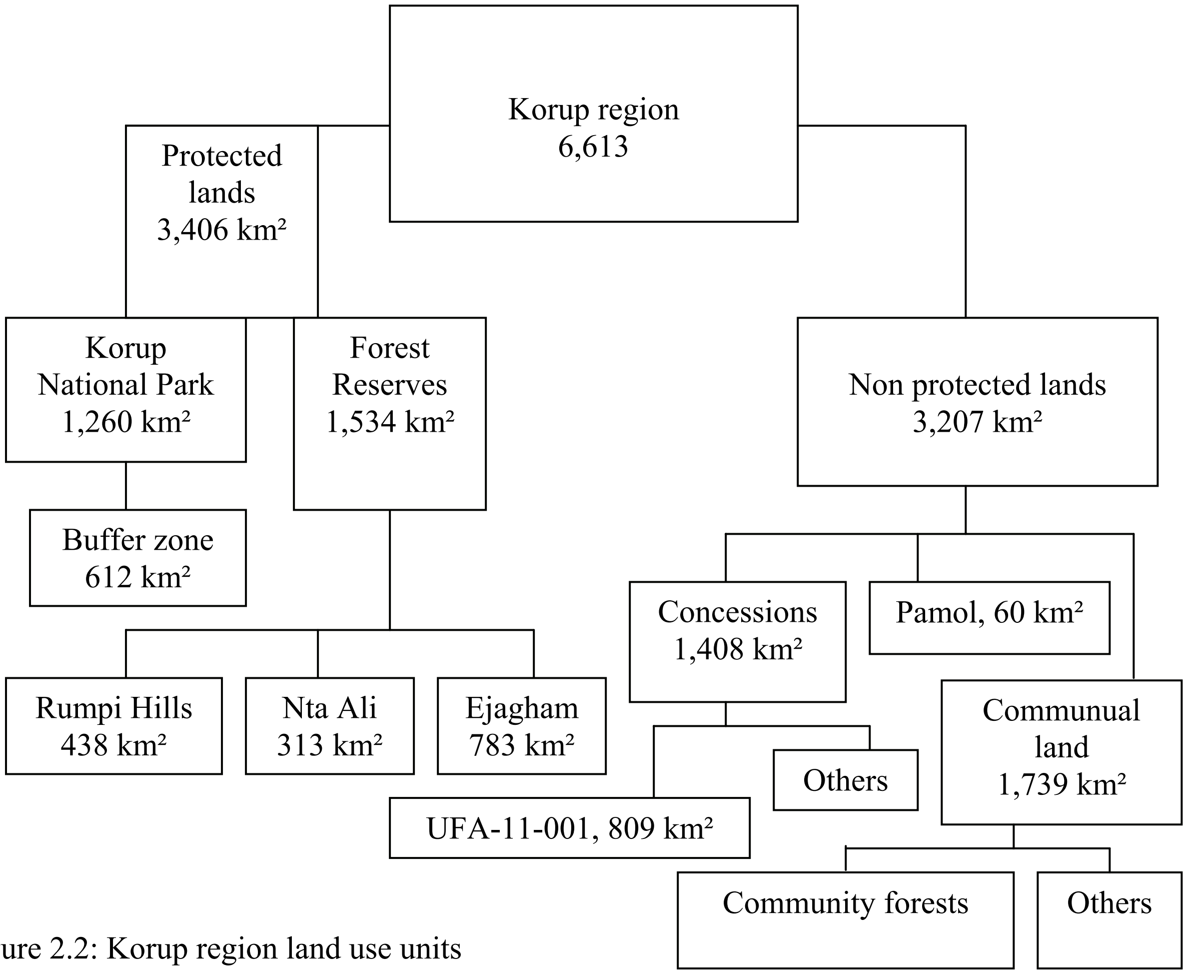

Figure 2.2: Korup region land use units

Source: Adapted from MINEF, 1994.

2.2.4.1 Farming

Farming constitute the main activity of the local people of the Korup region in which more than 51% of the people are involved with a net annual income of 196,964.29 Fcfa per household and per year (Tchigio, 2007). Shifting cultivation is the main method or farming system practised by local people of the Korup region. It is characterised by a short duration of the planting and harvesting period of 2 to 3 years, followed by a long fallow period of 8 to 20 years. People cultivate food crops such as cassava, yams, cocoyam, plantain, and banana while the main cash crops are palm oil, coffee and cocoa. Women tend to cultivate food crops while men are more involved with cash crops. This form of farming system coupled with logging activities which include the construction of logging roads, logging parks and skidding tracks have resulted into large forest gaps and fragmentation of wildlife habitat. Poor farming methods have also contributed to the burning of trees and vertebrates which constitute an important source of food for animals including primates and hornbills.

2.2.4.2 Hunting

Conservation of wildlife species in the Korup region requires not only the preservation of their habitat through sustainable farming methods and other human induced forest activities but also the commitment of relevant stakeholders (local population, government, elites and NGOs). The combination of these factors will obviously ensure an ecologically sound, economically sustainable and socially acceptable harvesting of non endangered wildlife in the Korup region. It is believed and accepted that wildlife in the Korup region is the main source of protein and this explains the high pressure upon this resource.

Hunting is a sensitive issue in the KPA because almost all hunting activities carried out in the region are illegal and the income it generates is high (Usongo, 1995). Tchigio (2007) estimated hunting to be carried out by 20.9% of the people living in the Korup region and generating 80,278.57 Fcfa per year and per household. The basic forms of hunting in the KPA are day hunting, night hunting, overnight hunting and trapping. The main tools used are guns, dogs, wires or cables. Though all kind of animal are targeted during hunting expeditions (Figure 2.3), Usongo (1995) observed that primates are the most hunted animal species in both Rumpi and Nta ali regions.

In day hunting, most of the animal species harvested are primates. Night hunting is carried out during the night with the use of over-head torchlight. Nocturnal wildlife species such as duikers and porcupines are the main target for hunters. In overnight hunting, hunters leave the village and camp for several days (2 days to one week) in the forest. During this period of hunting expedition all species of animal are killed, smoked and dried up in shelves. The hunting success during a day hunting ranges from 2 to 4 animals (including birds), 3 to 7 animals for night hunting and from 8 to 35 animals for overnight hunting. Trapping in the region seems to be more harmful for several species than direct hunting using guns. In a village community, trappers (also called hunters) age class vary between 15 and 55 years, have a minimum of 50 traps each and a maximum of 500 traps (Infield, 1988). Traps are generally inspected after 3 days but could also last for several days without inspection due to a busy schedule (voyage, farming, illness) of the trapper. Traps are mainly set during the dry season while hunting is fruitful in the rainy season. Hunting with gun is mainly carried out in the protected areas of the Korup region (Korup National Park, Nta ali, Rumpi hills and Ejagham forest reserves) and along timber roads while traps are established within the communal forest and around village farms. Though some women do practice hunting, a large majority (95%) of hunters are men (Tchigio, 2007).

Figure 2.3: Hunted animals in the Korup region (blue duikers. long tailed pangolin, and porcupine). Photo Lien, 2003.

2.2.4.3 Collection of Non-Timber Forest Products (NTFPs)

Production of NTFPs is one of the major activities of people living within and in the vicinity of the Korup National park. A survey carried out in the area with aim to assess the abundance of NTFPs harvesting methods, period of collection, processing and marketing (Lien and Mambo, 1996) reveals a relative abundance of a variety of NTFPs in the area but also a high dependency of the local population over this resource. Tchigio (2007) observed that NTFPs production in the Korup region constitute the third income generating activities of local people beside farming and hunting. Korup forests is home to more than 75 species of NTFPs and half of these species are unknown to local people whose main focus are on species with higher economical value (Eru *Gnetum africanum,* Njabe *Baillonella toxisperma,* Njansanga *Ricinodendron heudelotii,* Bush mango *Irvingia gabonensis,* Ngakanga *Afroxtyrax lepidophyllus,* Bush pepper *Piper guineensis* and Rattans *Eremospatha spp.*). Schmidt-Soltau (1999) evaluated NTFPs production by local people of the Korup region to 72.43% and generating 37.72% of their household cash income. Tchigio (2007) estimated NTFPs activities to be carried out by 16.9% of the local people of the Korup region and representing a yearly amount of 64,875.57 Fcfa of the household cash income. The production (harvesting, storage and marketing) of NTFPs in the Korup region is still rudimentary. Coupled with a high human population and a network of protected areas, the abundance of NTFPs in non protected forest (communal forests) is low, poorly harvested and poorly stored. These factors have contributed to low productivity of harvested NTFPs but have also increased inter village conflicts (land disputes) over forest resources (Lien & Mambo, 1996).

There is still a lack of data on the actual biological potential of NTFPs for the whole Korup region, and the concept for a sustainable use formerly developed by the GTZ in the region which consisted of building local people capacity on natural resources production is at present giving room to overexploitation and unsustainable harvesting practices of forest resources (Figure 2.4).

In addition to their economic (seed, oil) and cultural value (cola nuts), other uses of NTFPs in the Korup region include medicine (*Enantia chlorantha, Alstonia boonei*), food (*Gnetum africana, Ricinodendron heudelotii*), building material (*Bambusa vulgaris, Xylopia aethiopica*) and handicraft (*Tetracarpidium conphorum, Bambusa vulgaris*). Table 2.2 categorises NTFPs of the Korup region and part that are mainly used of harvested by local people.

Table 2.2: NTFPs main uses and parts harvested.

Food	**Medicine**	**Building material**	**Handicraft**
Seed	Leaves	Bark	Bark
Fruits	Fruits	Stem	Stem
Leaves	Barks	Liana	Leaves
Barks	seed	Leaves	Roots
Roots	Roots	Roots	
Honey	Honey		

Source: Own investigation

Figure 2.4: Unsustainable harvesting of the bark of *Cylicodiscus gabonensis*.
Photo Lien, 2003.

2.2.4.4 Timber harvesting

In Cameroon, timber exploitation is carried out by institutions which have received an exploitation permit or licence from the government (MINFOF). This activity is regulated by the law (MINEF, 1994).

Communal forest areas which surround protected areas of the Korup region have undergone logging since the creation of the Korup National Park in 1986.

Mukete Plantation Limited (MPL) was granted a concession forest in the north-eastern sector of the Korup national Park in 1980 and Cameroon Agricultural and Forestry Exploitation Company (CAFECO) in the southern sector of the Korup national Park in 1993.

The geomorphology of concession forests MPL (114,650 ha) and CAFECO (26,200 ha) shows an accidental relief, which begins at river Munaya and reaches 850 m altitude in MPL concession (Figure 2.5).

Following the acquisition of the concession in 1980, MPL's first exploitation phase was carried out on a small scale around the Abat area in the north-east of the KNP. The second phase started in 1996 and two forest compartments (30 and 35) or blocks of 2,500 ha each were exploited with a total of 47,000 m³ distributed to 36 species with a dominance of *Lophira alata* (10,900 m³), *Terminalia ivorensis* (9,000 m³), *Brachytegia cynometriodes* (8,000 m³) and few species of first class e.g. *Entandrophragma spp*, *Baillonella toxisperma* (3,000 m³). An average of 10 m³ per hectare was exploited.

In 1997 forests compartments 21 and 22 were logged and 22 different species were taken with a total of 50,000 m³, an increase of 3,000 m³ compared to 1996. The total cubic metre exploited in year one and year two is contrary to the clauses or specification of the "cahier de charge" with production of log not exceeding 35,000 m³ per year. The "cahier de charge" point out that 60% of the total production of round log (21,000 m³) must be processed in Cameroon but MPL is not known as a timber processing company and all timbers harvested were exported to Asian and European countries (Mühlenberg *et al.,* 1997). Usongo & Amubode (2000), Struhsaker (1997) noted that, of the 30 different species allocated for extraction, 13 (45%) constitute an important source of food for frugivores species (primates and hornbills). These are: Moabi (*Baillonella toxisperma*), Dabema (*Piptadeniatrum africanum*), Aiele (*Canarium schweinfurthii*), Azobe (*Lophira alata*), Ilomba (*Pycnanthus angolensis*), Nieve (*Staudtia spp*), Nkongu (*Beilschmiedia gabonensis*), Fromager (*Ceiba pentandra*), Ozigo (*Dacryodes spp.*), Eyong (*Eribroma oblonga*), Andok (*Irvingia spp.*), and *Vitex spp.* These species and many others fruiting of seed bearing species are either felled during the construction of logging activities (timber roads construction, timber harvesting). Felling of the tree species which constitute an important source of food for primate, hornbill and other wildlife species could have a negative impact on population densities of these "food-tree-dependent" wildlife species.

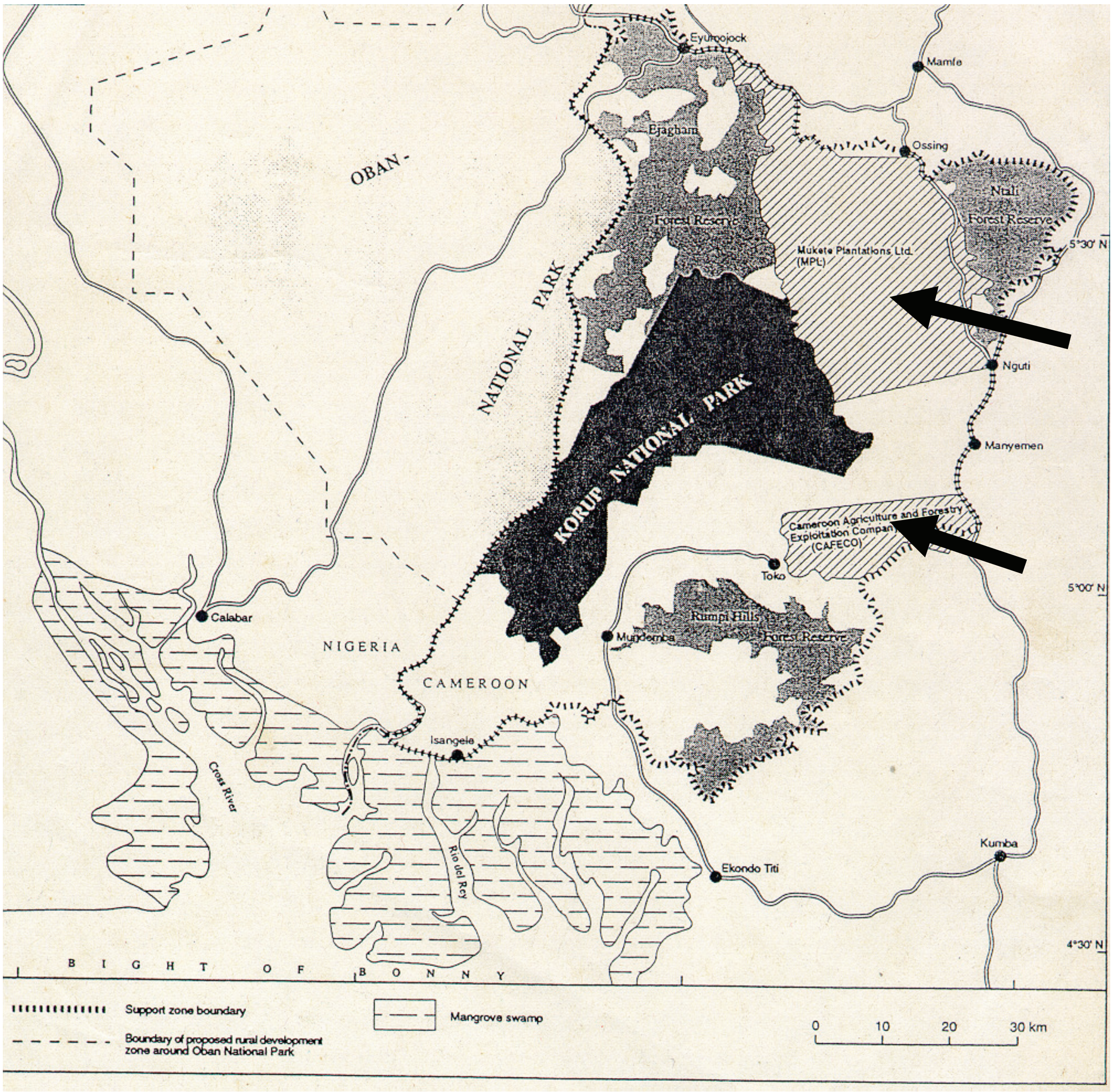

Figure 2.5: MPL and CAFECO concession forests in the KPA. Source: Mülhlenberg *et al*., 1997.

2.3 Ecology of tree species of the Korup region

Korup forests like the majority of tropical rainforests are characterised by a vegetative structure consisting of five distinct layers which include the overstorey, canopy, understorey, shrub and ground layers.

The overstorey is mainly identified by its emergent and huge trees exceeding 65 m height (*Ceiba petandra, Bombax bueopozense, Entandrophragma cylindricum*). Species belonging to this class have adapted into climatic conditions of their living environment. The seeds of some species are light and contain some parts which enable the wind to disperse the seed for long distances from the mother tree (*Ceiba pentandra, Bombax bueopozense*). Shade tolerant species (e.g.: *Entandrophragma cylindricum*) contain seeds which can develop under a minimum amount of light. Before fruiting, these tree species shade all their leaves which are either alternates or opposite. The top of these trees form the uppermost part of the stem constituted of ramified branches which also support branchelets. The stem of trees belonging to this class is circular, generally vertical (*Entandrophragma cylindricum, Lophira alata*) and may often stretch right up to the heights of the tree. Barks of these species are often smooth (*Entandrophragma cylindricum*), lightly cracked or little rough (*Lophira alata*). The base of species of the overstorey is cylindrical (*Lophira alata*), thickened or conical (*Cylicodiscus gabunensis*) or with large buttresses (*Piptadeniastrum africanum, Ceiba pentandra*). These emergent trees are in most cases covered with epiphytes and lianas.

The canopy structure of trees of the Korup forests is dense with closely spaced trees and branches. Canopy trees constitute more than 60% of the Korup forests vegetation. The top of some of the canopy layer exceed 40 m height (*Alstonia boonei*, *Terminalia ivorensis, T. superba, Baillonella toxisperma, Afzelia bipidensis, Nauclea diderrichii, Milicia excelsa*). The shape of the crown of this layer is as a parasol with a wide convex surface (*Baillonella toxisperma*), or as a sphere (*Guibourtia tessmannii*) with simple or unifoliolate leaves. The trunk of canopy trees has many forms: circular (*Milicia excelsa*), flat sides (*Triplochiton scleroxylon*) fluted or star-shaped (*Alstonia boonei*). The base of these trees is either concave (*Pterocarpus soyauxii*), straight (*Terminalia ivorensis*) or with small buttresses (*Afzelia africana*). Fruits of the canopy species layer are elongated or cylindrical with numerous seeds, or ellipsoidal buds with dehiscent fruits, thick without marginal or longitudinal nerves (*Guibourtia tessmannii*). The high density of trees which constitute the canopy layer is correlated with a high rate of photosynthesis and thus a higher fruits, seeds, flowers and leaves production. This layer is the site of interchange and also plays an important role in regional and microclimate regulation.

Trees of the understorey layer are characterised by large leaves whose role is to intercept light in the sun-dappled lower layer of the forest.

The forest of the Korup region are predominated by families such as *Caesalpiniaceae*, *Rubiaceae*, *Annonaceae*, *Myristicaceae*, *Anacardiaceae*, *Ebenaceae*, *Samydaceae*, *Papilionaceae*, *Olacaceae*, *Sterculiaceae* and *Moraceae*. The forest structural composition denotes similarities in diameter distribution. A large majority of trees belong to the diameter class of 10-50 cm diameter at the breast height (dbh) while the emergent trees with dbh above 60 cm are few. Vegetation on elevated altitude in the Korup region (over 300 m a.s.l) is relatively poor in species with a sharp decline on high altitude 800 – 1,000m a.s.l (Gartlan, 1985).

Flowering and fruiting of tree species of the Korup region is not sharply defined. There exist trees with longer periods of flowering and with high level of pollination (shade tolerant trees) and some with shorter periods of flowering to avoid pests (pioneers species). But also species that fruit annually (e.g. *Musanga cecropioides*) or species that fruit in longer irregular intervals (e.g.: *Baillonella toxisperma Terminalia ivorensis*). Most of the tree species in Korup forests are well represented by a natural regeneration which is favoured by a sufficient quantity of viable seeds and suitable growing conditions in the early stages of development. These factors have enabled the stand to survive biotic and abiotic disturbances.

2.4 Ecology of monitored primate and hornbill species

2.4.1 Biological indicators

Biodiversity is the variety of life in all its forms, levels and combination and includes ecosystem diversity, species diversity and genetic diversity (Begon *et al.,* 1990). But in most cases, the term biodiversity is used to define the number of different species in a defined area. Biodiversity can therefore be measured and monitored on many biological levels ranging from genetic diversity within a species to the variety of ecosystems on Earth. Biodiversity measurement gives information on species abundance and density while monitoring of biodiversity (Biomonitoring) refers to the evaluation of sustainability of forest use. Biomonitoring are used to assess spatial and temporal trends of biological diversity with an emphasis on evaluating the efficiency of management policies. It provides relevant information on the impact of disturbances on the forest ecosystem (Mühlenberg *et. al*., 1997). However, biological monitoring objectives can be subdivided into two: scientific objectives which enable the development of an understanding of system behaviour and dynamics which is based on the analysis of time series of population abundance often in a retrospective. The management objective identifies the system state and provides information on the system response to management action. Biological monitoring is much effective through the use of indicator species.

Indicator species could be defined as species whose presence, absence, or relative well-being in a given environment is indicative of the health of its ecosystem as a whole, to assess the magnitude of anthropogenic disturbance or a species used to locate another, less visible species.

Primates and hornbills have been the most intensively studied groups of mammals as an indicator species to monitor hunting pressure (Usongo, 1995; Oates, 1996 and Infield, 1988) or to evaluate the impact of logging activities on the vegetation (Struhsaker 1997; Plumptre, 2001; Waltert *et al*., 2002 and Harcourt and Doherty 2005). Some primate species of high conservation importance (preuss's red-colobus, drill) are known to be sensitive to hunting pressure while others may not respond quickly to habitat change (chimpanzee, mona monkey). In the Korup region, primates and large hornbills represent the main target group of animals for hunters and local people could easily identify an individual primate species from direct observations (animal seen) to indirect cues (dung, food prints, call and noise) thus easy to monitor while using a community based approach. Primates and hornbills also could appear in a quantity which ensure the collection of a reasonable amount of data for statistical analysis within a limited period of time.

2.4.2 Biology of Primate species

2.4.2.1 Morphology and behaviour

Morphologically, primates differ from one species to another. The mona monkey, one of the most abundant primates in the Korup region is easily recognised by its rounded, furry head that has an off-white brow band and pale cheek. The back of this monkey is brown and terminates with a long tail. The average body mass is around 4.4 kg for a male and 2.5 kg for female. The Putty-nosed monkey has a black and dark grizzle and a white spot on the nose. This species is possibly represented in the Korup region by two sub-species: *C. nictitans martini* and *C. nictitans nictitans* (Waltert 2002). The crowned monkey is relatively small in size with a long tail. The back of this guenon is greyish while the chest is yellowish. The average body mass of the male adult of this monkey is about 5 kg while the female weighs about 3 kg. The red-eared monkey is recognised by its purplish blue face, grizzled brown back and long red tail. The nose and the ears of this guenon are red. Under the leadership of a dominant male, the group size of the red-eared monkey varies between 10-40 individuals. The red-capped mangabey is one of the largest monkey in the Korup region with a body mass of about 10 kg for the male and 7 kg for the female. This monkey is easily recognised by it slate-grey colour and white underside inner limb surfaces. The limbs are long as well as the tail. Beside the *Cercopithecidae*, the *Colobinae* in the Korup region are represented by the Preuss red-colobus. This species is recognised by its flat profile face with the nostril forming a peculiar woollen structure. The upperparts of the face are black or dark while the under parts range from red to light orange (Kingdon, 1997). The hair around the pubic area is white.

There is almost no difference in weight between the male and the female (8.4 kg and 8.2 kg respectively). This species is non territorial but larger groups (up to 120 individuals) will supplant smaller ones in feeding areas (Estes, 1991). The Chimpanzee is one of the largest primate species whose height ranges from 60 cm to 196 cm and weighs about 30 kg for the female and 40 kg for the male. The chimpanzee is a robust Ape with long and tufted black hair. In the Korup region, this species has a facial skin that is pink in colour, but which darkens with age. The group of chimpanzee is composed of 3 to 10 individuals among which exist a dominant male. Females in the group that are not related will not show much interaction (Nishida, 1979). Chimpanzees belong to the family *Hominidae*. The drill is a diurnal species, which like the mona monkey, belongs to the family *Cercopithecidae*. Like the other great Apes, the drill walk using the flat surfaces of their feet and hands. The drill is recognised by its large-headed olive brown baboon with an off-white underside and a broad, leaf-shaped white ruff surrounding a naked black face. Male drills are more larger than the female and weigh between 15 kg to 25 kg. Drills have long canine teeth similar to those of big cats which are used to dominate other males in the group. The drill has an unimale social system with the leader male receiving most of the copulations (lee *et al*., 1988). The drill is primarily terrestrial, but can also be found on tree canopy in search for food. The group size of this species varies between 25 to 200 individuals (Kingdon, 1987 and Appendix 2.1).

2.4.2.2 Habitat

The primates of the Korup region habitat vary from primary undisturbed forest to secondary forests. The mona monkey is an arboreal species inhabiting lowland forests but also mangroves and degraded upland forests. The mona is a canopy species but can also be found at the middle storey forest layer. Putty-nosed monkeys are common in evergreen forests from lowland to mountain, primary, secondary and narrow gallery forest patches. The crowned monkey is however confined to the area between the river Cross, Sanaga and Bioko (Kingdon, 1997). This species is represented in the Korup region by the mainland form which might be subspecifically different from the nominate species *Cercopithecus pogonias pogonias* occurring at Bioko island. The crowned monkey inhabit mature forests and it occurs commonly in the canopy, but also can be found in secondary and gallery forests. Like the crowned monkey, the red-eared monkey is confined to the region between river Cross and river Sanaga. In the Korup region, this species is mainly found on lowland forests of the northeastern region of the Korup National Park, but also occurs at the mountainous regions of the Ntal ali forest reserve. The red-capped mangabey is described to inhabit swamp and dryland forests (Kingdon, 1987). This species is also reported to live in disturbed forest areas (Waltert, 2000). Chimpanzees are described as rainforest species but could also inhabit woodland (Kingdon, 1987). In the Korup region, chimpanzees are found both in primary and degraded forest areas. According to Kingdon (1987), the chimpanzee is currently restricted within a strip of 120 km to 60 km and mainly occurring in primary undisturbed forest areas of the Korup region. The form of the preuss red colobus present in Korup region has a geographical distribution ranging from the low-lying river Cross to the formerly forested uplands of Cameroon. The preuss red colobus can also be found in secondary forest areas in search for food. The drill geographical distribution is restricted from river Cross to river Sanaga but also to the west African island of Bioko. The drill inhabits evergreen forests, mountainous forests and savannah mosaics. The drill can also be frequent in rocky areas within the forest (Kingdon, 1987).

2.4.2.3 Feeding

The monitored primate species of the Korup region are described as true frugivores but which also take invertebrates and leaves (Kingdon, 1987). The mona monkeys diet consist of nuts, fruits, grains, roots, wild honey, bird eggs and snails. This species is known to store food in the cheek pouches which can hold as much food as their stomach. Their tooth system is characterised by low ridges on the teeth which enable them to grind their highly varied food. As the mona, the putty-nosed monkey feeds on fruits, seed, leaves, arthropods and gum while the crowned and the red-eared monkeys diet is consists 80% of fruits and 20% of invertebrates such as insects, termites and caterpillars. The red-capped mangabey, also known as collared mangabey (Edwards, 1992) feeds mainly on fruits from the canopy. But the diet of this species also consist tree flowers, insects, animal prey, mushrooms and shoots of monocotyledons. Chimpanzee of the Korup region are reported to feed on seed, fruits, tree flowers, young leaves, pith, honey, insects, eggs, but also barks, resin and gall during the dry period when fruits become less abundant. Chimpanzees are also carnivorous species which feed on vertebrates including other monkeys (Preuss red colobus). Estes (1991) observed that chimpanzees could spend 78% of the morning activities eating fruits. Feagle (1988) described chimpanzees as animals hanging or suspending their body below or among tree branches, moving around within the feeding source (suspensory behavior).-The diet of Preuss red colobus, as well as of the drill, consists of immature leaves, roots, fruits, mushrooms, fungi, but also invertebrates such as termites, ants, worms and spiders. The Preuss red colobus however likes to forage for leaves in the upper stratum of the forest (Estes, 1991).

2.4.2.4 Reproduction

The mona, putty-nosed, crowned, red-eared monkeys and red capped mangabey are sexually mature by the age of 3 to 5 years and give birth to a single offspring but could occasionally also give birth to twin. The gestation period of these species is between 5 to 6 months and birth occurs on the tree canopy. Mona monkeys as well as other guenons can live up to 26 years in captivity. The preuss red colobus female also gives birth to one offspring. Sexual activities within the chimpanzee are in most cases sollicitated by the female who presents her sex to the adult male or by making noise and shaking tree branches to attract the male. Copulations are dorso-ventral and the female can give birth to only one offspring (Estes, 1991). Female drill are sexually mature at the age of 4 to 5 years while the male's sexual maturity is between 5 to 7 years. The pregnancy lasts between 82-179 days and gives birth to a single offspring with an after birth interval of 17-19 months (Boer, 1987). The drill lifespan can reach 30 years in captivity.

2.4.2.5 Association

In the Korup region, beside the red-capped mangabey who seems to avoid association with other groups of monkeys, all other guenons have been observed in association with other groups. There is however a lack of data describing association of chimpanzee with other groups of monkeys and in the Korup region the chimpanzee and the drill have not yet been observed in association with other groups of monkeys. Chimpanzees are among the main predators of the preuss red colobus that often seek the company of mona monkeys to act as sentinels (Cowlishaw, 2000). But in the Korup region, the red colobus seems to avoid association with mona monkeys as well as with other monkeys.

2.4.2.6 Threats and status

The main threat to primate as well as other wildlife species of the korup region is hunting (Edwards, 1992; Usongo, 1995; Infield, 1998; Waltert, 2002 and Tchigio 2007). Coupled with hunting, extensive agriculture and logging have respectively contributed to primate's habitat destruction and fragmentation (Struhsaker, 1975, Skorupa, 1988).

The IUCN has listed the mona monkey, the putty-nosed monkey and the crowned monkey as not endangered while the red-eared monkey, the preuss red colobus, the chimpanzee and the drill are listed as endangered. The red capped mangabey is however classified as vulnerable (IUCN, 2000)

Table 2.3: Biological characteristics of the studied primates of the Korup region.

Morphology	**Voice**	**Size (Kg)**	**Diet**	**Group Size**	**Association**	**Vertical stratum**	**Status[1]**	**Interpretation**
Yellow chest, black marking on head (black line from nose)	Deep “mmh”,	3 to 5	Frugivorous	8 to 20 individulas	With *C. nictitans*	Usually canopy	Not Endangered	*C. pogonias*
White under parts including inner limbs, dark head and white above face	disyllabic“ mmh-mmh”	4 to 5	frugivorous	5 to 20 individuals	With *C. pogonias* and other guenons	Canopy but occasionally lower down	Not Endangered	*C. mona*
white nose-spot, large monkey	Nasal “pyow”	4 to 7	Omnivorous and frugivorous	14 to 30 individuals	With *C. mona*, *C. erythrotis*	Canopy	Not Endangered	*C. nictitans*
tail red above and white below	“krrh-krrh	3 to 5	Frugivorous and insects		All other monkeys	Not too high in canopy	Endangered	*C. erythrotis*
grey, large and red head	“â-ooh””â-oooh”	7/10	frugivorous	12 to 23 ind.	Not frequently as	Canopy	Vulnerable	*Cercocebus torquatus*
big, four fingers, red like deer	Thin voice,	8/12	Frugivorous and leaves	Large group up to 120 ind.	Move alone in KPA	High canopy	Endangered	*Procolobus pennantii preussi*
Tufted black hair, bare face, rounded brows		30/35	fruits and omnivorous	3 to 5 ind.		Ground and understorey	Vulnerable	*P. troglodytes*
large-headed olive brown, naked black face	Crowing call	15/20	fruits and omnivorous	25 and up to 200 ind.		Ground but sleep in the trees	Endangered of extinction	*M. leucophaeus*

Source: Adapted from Kingdon (1997) and own investigation.

2.4.3 Monitored hornbill species

Hornbills in tropical rainforest as well as in the Korup region are regarded as an important component of the forest ecosystem. They play an important role as seed dispersers. Enhanced by the decline of large mammal populations, hornbills in the Korup region constitute one of the main targets for hunters. As seed dispersers, hornbills rely on the biological potential of the forest in term of the abundance of tree bearing food.

The hornbill species of the Korup region include: the black-and-white-casqued hornbill *Ceratogymna subcylindricus*, black-casqued wattled hornbill *Ceratogymna atrata*, brown-cheeked hornbill *Ceratogymna cylindricus*, piping hornbill *Ceratogymna fistulator*, yellow-casqued wattled hornbill *Ceratogymna elata* (Appendix 2.2).

Hornbills belong to the family of the *Bucerotidae*. The genus *Ceratogymna* contains a total of 7 species which includes the five listed above, the *C. bucinator* and the *C. brevis*, all endemic to Africa. The *Ceratogymna spp.* ranges from small (*C. fistulator*), medium (*C. cylindricus* and *C. subcylindricus*) to large size (*C. atrata* and *C. elata*).

The *C. fistulator* is recognised by his white tail colour and black wings, the casqued is small compared to other large hornbills. It is a noisy bird whose length may reach 45 cm. The brown-cheeked hornbill, *C. cylindricus*, and the black-and-white-casqued hornbill *Ceratogymna subcylindricus*, are recognised by their black heads with red-brown feathers. The tail is white with broad black across the centre (*C. cylindricus*) or entirely black, but with two white bands from left and right (*C. cylindricus*). The casqued of these two species is large and tabular with grooves along the sides and wrinkles at base (*Ceratogymna subcylindricus*). The *C. cylindricus* and *C. subcylindricus* length ranges from 60 to 70 cm. The call of these two birds is loud. The *C. atrata* and *C. elata* are the largest hornbill of the Korup region. These two species are recognised by their black plumage with a large casque. The tail is long with two long white bands (*C. elata*) or with two small white bands (*C. atrata*).The throats of these hornbills are blue while both species eyes are reddish.

Hornbills habitat varies from one species to another. In the Korup region, the *C. fistulator* is common in secondary forest ecosystems, but also in agroforestry land of palm oil, coffee and cocoa plantations. This species is also known to inhabit edges of low land primary forest but also could frequent dense forests during the fruiting period. The *C. cylindricus, C. atrata* and *C. elata* of the Korup region are mainly found in primary mature forests where altitudes range between 100m to 500m a.s.l.

The described hornbills have common particularities of being frugivorous and seed dispersers but also forest canopy species. They usually move in pairs (*C. fistulator*).or in group of 6 to 8 individuals (*C. cylindricus* and *C. subcylindricus*) or even in groups of family individuals of 4 to 5. They feed on seeds and fruits from one tree to another resulting in seeds/fruits being dropped to the forest floor which will be later used by other forest animals (duikers), humans (seed of *Dacryodes edulis*) or as natural regeneration strategy.

Hornbills of the Korup region live in the nests of tree holes from 10 m (*C. fistulator*) to 25 m (*C. cylindricus, C. atrata* and *C. elata*) above the ground level where they breed. Though little is known about the breeding conditions and periods of the Korup region hornbills, Kemp (1995) observed that in Cameroon, the *C. cylindricus* and the *C. subcylindricus* are in breeding condition from November to April and in July for the *C. elata*. Hornbills generally lay many eggs but only one offspring gets to maturity (Kemp,1995).

Though present in the Korup region, this group of wildlife suffer from lack of information on diet, breeding behaviour, population density and interaction between other wildlife species. Based on practical reasons (large species are easily recognised by local people and mostly hunted), among the eight monitored hornbills, we selected only two species: the black-casqued hornbill (*Ceratogymna atrata*) and the brown-checked hornbill (*Ceraytogymna cylindricus*). Hornbills in Cameroon as well as in the Korup region are considered not threatened.

2.4.4 Research Method

2.4.4.1 Field design

The Korup region constitutes of a mosaic of forest ecosystems of primary undisturbed forests, secondary forests, logging concession forests, agroforestry lands, gallery forests, mangrove forests and cloud mountain forests. These forests belong to either protected areas or to an area of common use (communal forest). The study area was stratified between primary forests and logging concession forests with a total surface area of 16 km² for each stratified forest. Site **A** was located in primary forest land (unlogged) near the Korup National Park, while site **B** was located at the logging concession forest land (logged). Both sites (Figure 2.6) are situated at the eastern sector of the Korup National Park. Study sites one and two were again divided into two, each site covering a total of ca.8 km² (I, II, III and IV). In each of the ca.8 km² sites, six straight permanent transect lines of 2 km length and 1 m width each were systematically established and paralleled ca. 200 m from one to another. Along these transects, metal plates (pegs) were placed at 50 m intervals from the start (0 m) to the end of the transect (2000 m). The vegetation in both logged and unlogged study sites is either old growth, mature, moderately disturbed and disturbed while the topography is either flat or hilly (Table 2.4).

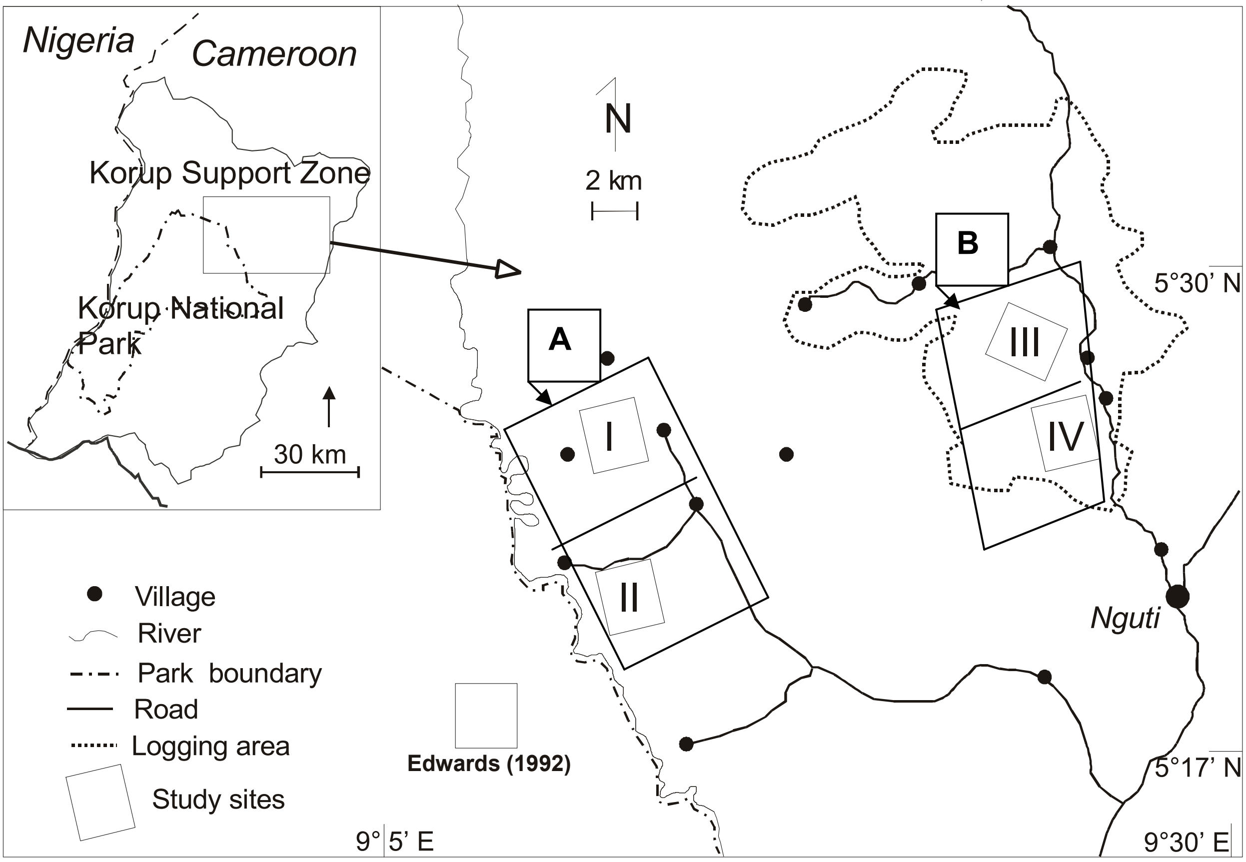

Figure 2.6: Field design and the study area. **A**, **I** and **II** represent unlogged study site, unlogged I and unlogged II respectively while **B**, **III** and **IV** represent logged study site, logged III (or logged I) and logged IV (or logged II) respectively. Source: adapted from Edwards 1992.

Table 2.4: Ecological and topographic characteristics of transects of the study areas.

Village	Transect	Logging history	Vegetation	Topography
Bajo	1	Unlogged	Old growth	Flat
Bajo	2	Unlogged	Disturbed	Flat
Bajo	3	Unlogged	Old growth	Flat
Bajo	4	Unlogged	Old growth	Flat
Bajo	5	Unlogged	Old growth	Flat
Bajo	6	Unlogged	Old growth	Flat
Mgbegati	1	Unlogged	Mature growth	Flat
Mgbegati	2	Unlogged	Mature growth	Flat
Mgbegati	3	Unlogged	Mature growth	Flat
Mgbegati	4	Unlogged	Mature growth	Flat
Mgbegati	5	Unlogged	Mature growth	Flat
Mgbegati	6	Unlogged	Mature growth	Hilly
Bayip	1	Logged	Moderately disturbed	Hilly
Bayip	2	logged	Moderately disturbed	Hilly
Bayip	3	Logged	Moderately disturbed	Hilly
Bayip	4	Logged	Moderately disturbed	Hilly
Bayip	5	Unlogged	Old growth	Hilly
Bayip	6	Unlogged	Old growth	Hilly
Etinkem	1	Logged	Moderately disturbed	Hilly
Etinkem	2	Logged	Moderately disturbed	Hilly
Etinkem	3	Unlogged	Old growth	Hilly
Etinkem	4	Unlogged	Old growth	Hilly
Etinkem	5	logged	Moderately disturbed	Hilly
Etinkem	6	Logged	Moderately disturbed	Hilly

Source: own investigation

2.4.5 Data collection

2.4.5.1 Approach

Basically there exist several approaches to collect biological data and each approach is subject to advantages and disadvantages. Beside the use of scientists, trained local people with experience in animal tracking and hunting were selected within the villages of the study sites. This approach which is termed as community-based prepares local people for wildlife conservation and management of their village forest territory but also promotes the sense of ownership over forest resources, resulting to enhance local people's commitment towards natural resource management.

2.4.5.2 Vegetation

The vegetation was studied in plots of 0.25 ha each or 50 m x 50 m (O'Brien and Kinnaird, 1997; Rosenbaum *et al.*, 1998) established systematically left and right along transect lines commencing from point 0. The distance between one plot to another was 250 m. The starting point (point 0) in each transect was selected at random and a total of 7 plots were sampled per transect.

In each plot, all trees higher or equal to 10 inches or 8,02 cm diameter at breast height (dbh) were identified and measured (Struhsaker, 1997). Trees were measured with the use of a diameter tape and all measured trees were thereafter marked to avoid double counting. For stems with irregular circumferences, the average of the largest and smallest diameter was used and trees with buttresses were measured above the buttresses in case they reached over breast height. An average of two hours was spent in each of the plots for counting, marking and identifying all trees within the required dbh in a plot. About 98% of trees were rightly identified to species level. Barks, leaves seeds/fruits and other parts of unidentified trees were taken to the herbarium of the Korup project headquarter for further identification.

2.4.5.3 Primate species

Prior to the study, a rapid survey was carried in the area with the objective to establish a list of primates present in the Korup region. This list was cross-checked with available literatures (Infield, 1988; Edwards, 1992; Usongo, 1995; Oates, 1996; Struhsaker, 1997; and Kingdon, 1997), but also through participatory rural appraisal methods: semi-structure interviews with hunters, village meetings and household interviews. After the production of the species list (primates and hornbills) in the local dialect, the selected team members were trained in ecological fieldwork and identification skills. Identification of primates was also facilitated by the use of colour plates redrawn from Kingdon (1997). Calls and other primates behaviours were also recorded and used during the training sessions. Perpendicular distance estimation (Figure 2.7 and Figure 2.8) was conducted at regular intervals and with the use of the laser rangefinder. Though trained at the same level, each of the three team members was assigned with a specific function. The team leader filled the form using information from his colleagues who were to identify the species and estimate perpendicular distance from the observer to the object. The monitoring team was under the supervision of a trained field supervisor who was supported by the project leader. Primates data were collected along the two kilometres transect line using Distance Sampling in which measurements of the distances of the objects observed from the transect line are used to estimate the probability of observing an object and hence to estimate its density (Buckland *et al.*, 2001 and Thomas *et al.*, 2002). Estimates were made of the perpendicular distance from the transect to the estimated centre of primate groups, both for visual and acoustic encounters. Group sizes were estimated from visual encounters. Each transect was surveyed once a week at different time intervals from 06:30 to 09.00 am and from 15.00 to 18.00 pm with an average speed of < 1 km/h, direct (animals seen) and indirect (calls, noise) animal cues were recorded.

The team was advised to avoid making noise, lightening fire or smoking while walking along the transect.

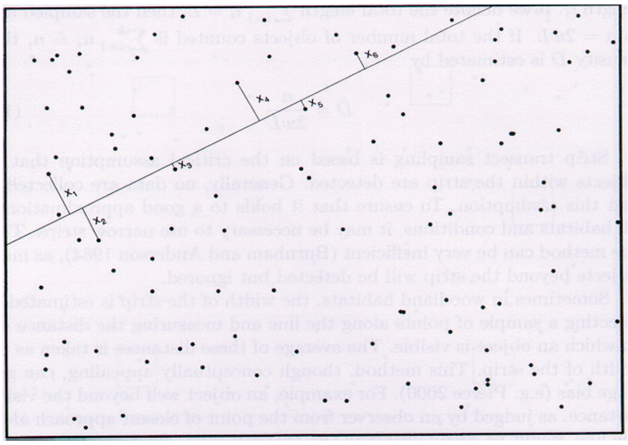

Figure 2.7: Line transect sampling approach with a single, randomly placed line of length L. Six objects were detected at distance x_1, x_2,….x_6,. Source: Buckland *et al.*, 2001.

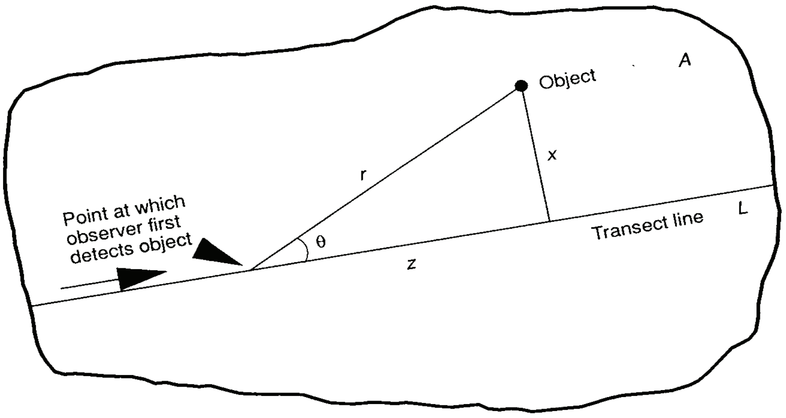

Figure 2.8: Measurement of perpendicular distance. ***A*** is the size of the area, ***L*** is the transect length, ***θ*** is the sighting angle to allow perpendicular distance ***x*** while ***r*** is the sighting distance. Thus the distance from the observer parallel to the transect at the moment of detection is: z = r cos (θ). Source: Buckland *et al*., 2001.

2.4.5.4 Hornbill species

Hornbills data were collected using the approach and methods described for primates data collection. Estimates were made of the perpendicular distance from the transect to the estimated centre of hornbill clusters, both for visual and acoustic encounters. Estimation of perpendicular distance of animals in movement (flying) was avoided as well as surveys which were disturbed by rain and other unforeseen events.

2.4.5.5 Food resources for primates and hornbills

Data on food bearing trees (fruits, seed, leaves barks) used by the monitored primates and hornbills were collected using the same method described for the vegetation survey. In addition, a list of food resources for primates of the Korup region was compiled by an experienced field botanist. This list was compared with existing literatures (Usongo, 1995; Lien & Mambo, 1997 and Astaras *et. al.,* 2007), but also with the traditional knowledge of local people.

In each plot, all food trees from our species list, higher or equal to 10 inches or 8,02 cm diameter at breast height (dbh), were identified and measured (Struhsaker, 1997). Trees were measured with the use of a diameter tape and all measured trees were thereafter marked to avoid double counting. Parts of the trees (bark, leaves, flowers, seed, fruits) that were considered as potential food resources for primates, but unknown by the field botanist were taken to the herbarium for further identification.

2.4.6 Data evaluation

Though data on primates, hornbills, food and non food trees were collected with precision and accuracy the following major constraints were noted during the surveys:

- Poor estimation of perpendicular distance.
- Hunting and trapping activities noted along the transect lines and gun shots during the survey period.
- Insufficient data for endangered primate species such as the preuss red colobus, the drill and the chimpanzee.
- Some surveys were not conducted due to the involvement of team members in various village events (wedding, death, traditional festivities, political meetings).

2.4.7 Data analysis

2.4.7.1 Data processing

Field data on primates, hornbills and vegetation (food and non food resources) were recorded on field forms designed for that purpose. Recorded data were cross-checked by the field supervisor and the project leader and entered into the computer on Excel Software, where they were again cross-checked. From Excel data bank, they were imported to other Software (Distance Sampling, EstimateS version 5.0.1, Statistica) for analysis. Field forms were kept for eventual verifications.

2.4.7.2 Vegetation

Differences in tree abundance and species richness between study sites were analysed using One-Way ANOVA and Tukey's HSD test (Fowler & Cohen 1996). In all statistical tests, STATISTICA for windows was used (StatSoft, 2001). Species richness was observed using EstimateS 5 version 5.0.1 (Colwell, 1997) from the number of species observed in the pooled number of samples (Sobs). These methods of tree abundance and species richness analysis fit into this study, in the sense that density of small trees in logged forests is usually much higher than in unlogged forest and therefore can have higher species richness within a small sample than unlogged forest predominated by large trees with fewer undergrowth. With reference to Kessler (2005), we compared the taxonomic and structural composition of tree families (family diversity) between logged and unlogged study sites. For each tree family, we calculated the number of individuals (NI) per hectare, the number of species(NS) per hectare, the basal area (BA) per hectare, the family relative density (FRd= % of NI of a family of the total NI), the family relative diversity (FRdi= % of the number of species of a family relative to the total species number), the family relative dominance (FRdo= % of the BA of a family of the total BA) and the family importance value (FIV= FRd+FRdi+FRdo). The structural composition was determined by comparing the distribution of tree diameter classes between sites. A two dimensional ordination of the species composition of the different transects was based on tree abundance data and was being carried out using correspondence analysis (StatSoft, 2001).

2.4.7.3 Primate and hornbill population densities

Primate and hornbill population densities were estimated using the programme Distance Sampling Programme (Buckland *et al*., 2001). Prior to data analysis, the following assumptions were considered:

- Primates and hornbills on the transects line are detected with certainty
- Primates and hornbills are detected at their initial location prior to their movements
- Measurements of detected primates and hornbills on line transect are exact.

Perpendicular distances were measured to the nearest meter from the line to the position of each detected selected animals (primates and hornbills). The survey effort was calculated for each transect as the sum of all distances that were walked without disturbance by rain or other unforeseen events. Density (D) of selected animals was calculated as the number of groups (clusters) observed (n) divided by the transect width (w), the transect length (L) and the probability that randomly chosen group within the survey area $a = 2wL$ is detected (P_a). An estimate of P_a was obtained using the Distance Sampling software 4.0 (Thomas *et al*., 2002).

$D = n/(2wLP_a)$

Models describing a different way in which the probability of sighting an object decreases with distance from the line transect centre (half-normal, hazard rate and uniform models) were fitted to the data and the Akaike Information Criterion (AIC) was used to select models with the least number of parameters and the best fit (Buckland *et al*., 2001). Observations were pooled by transects. As for the detection function, all observations beyond 100m for primates and 50 m for hornbills were discarded (right truncation). For the truncation of the cluster size estimation , all observations beyond 30m (for primates) and 20m (hornbills) were discarded. Densities were estimated at global and stratum levels while encounter rates and cluster sizes were estimated only at stratum level. We used Half-normal cosine key function for all analysis and the mean of observed cluster for the cluster size estimation. The truncated data enable an increase in precision of the estimates. The relationship between primates and food resources was checked with the Spearman Rank Correlation Coefficient (Fowler and Cohen, 1996). The value of the correlation coefficient (r) could be either positive or negative. The correlation was considered very week ($0.00 \geq r \leq 0.19$), weak ($0.20 \geq r \leq 0.39$), modest ($0.40 \geq r \leq 0.69$), strong ($0.70 \geq r \leq 0.89$) and very strong ($0.90 \geq r \leq 1.00$). These parameters determine the degree of relationship between the two measured variables (animals and food resource). The value of the coefficient correlation was tested (Tukey's honest significance test P) to determine whether the correlation was statistically significant or not.

2.4.7. 4 Survey effort

From 1999 until 2002, the four ecological teams from Bajo (unlogged I), Mgbegati (unlogged II), Bayip Arsibong (logged I) and Etinkem (logged II) covered a total of 962 km as indicated in Table 2.5

Apart from logged II, in which no transect was established in 1999, primate and hornbill surveys started in the other three study sites in which only two permanent transect lines were by then established and a total of 326 km were walked (survey effort) from unlogged I (118 km), unlogged II (106 km) and logged I (102 km) respectively. In order to have a representative sample for the strata, a new study area (logged II) was selected based on logging activities, but also from the ecological parameters such as climate, topography and vegetation and additional permanent transect lines were established.

In 2001 each study site was made up of six permanent transect lines and a total of 356 km were walked from unlogged I (90 km), unlogged II (82 km), logged I (98 km) and logged II (86 km). In 2002, due to the phasing out of the Korup project, the survey effort dropped to 266 km with an average of 66.5 km per study site.

This study takes into account only surveys that were effectively covered (2 km effectively walked from peg 0 m until peg 2000 m) without disturbances from rain, village events (wedding, funeral, and other traditional ceremonies) and absence of at least two of the survey team members.

Transects were walked by the three team members according to a designed schedule and with an average speed of 1h30 mn per kilometre.

Table 2.5: Survey effort in unlogged and logged study sites from 1999 – 2002.

Study sites	**1999-2000**			**2000-2001**			**2001-2002**			
	Transect	**Length**	**km walked**	**Transect**	**Length**	**km walked**	**Transect**	**Length**	**km walked**	**Total km walked in logged area**
Logged I	1	2	62	1	2	22	1	2	10	
	2	2	60	2	2	24	2	2	10	
Bayip	3	2		3	2	20	3	2	14	
	4	2		4	2	22	4	2	8	
	5	2		5	2	4	5	2	14	
	6	2		6	2	4	6	2	14	288
Unlogged II	1	2	54	1	2	22	1	2	12	
	2	2	52	2	2	22	2	2	10	
Mgbegati	3	2		3	2	14	3	2	8	
	4	2		4	2	14	4	2	10	
	5	2		5	2	2	5	2	10	
	6	2		6	2	4	6	2	10	244
Unlogged I	1	2	58	1	2	44	1	2	10	
	2	2	60	2	2	42	2	2	10	
Bajoh	3	2		3	2	2	3	2	12	
	4	2		4	2	2	4	2	12	
	5	2		5	2	0	5	2	12	
	6	2		6	2	0	6	2	12	276
Logged II	1	2	0	1	2	26	1	2	10	
	2	2	0	2	2	22	2	2	10	
Etinkem	3	2	0	3	2	16	3	2	12	
	4	2	0	4	2	14	4	2	10	
	5	2	0	5	2	4	5	2	14	
	6	2	0	6	2	4	6	2	12	154

Source: Own investigation

3 RESULTS

3.1 Vegetation

3.1.1 Tree abundance

A total of 9,134 trees (dbh ≥ 8.00 cm) belonging to 217 species and 55 families were recorded (Table 3.1 and Appendix 3.1).

At study site levels, tree abundance in logged forests was ca. 38% less compared to unlogged forests. The highest number of trees was recorded in unlogged sites with a total of 5,626 individuals compared to logged sites with 3,508 individuals.

Analysing tree abundance at transect level (7 plots à 0.25ha), the difference was significant between unlogged II and the two logged forest study sites while there was no significant difference between unlogged I and the two logged forest study sites (One way ANOVA, $F_{3,20} = 14.95$, $P< 0.01$). We found a higher mean number of trees per transect in unlogged forests (468.5 ± 75.9) than in logged forests (291.9 ± 40.3 Figure 3.1).

At plot level (0.25 ha plot, Figure 3.2), significant differences were noted between unlogged II, logged I and logged II while there was no significant difference between sites of the same vegetation category: unlogged and logged (One way ANOVA, $F_{3,20} = 21.43$, $P< 0.01$). The mean number of trees was numerically also higher in unlogged study sites (69.3 ± 20.7) than in logged study sites (41.7 ± 12.6). At plot level, tree abundance in logged forests was ca. 40% less compared to unlogged forest study sites (Appendix 3.2).

In logged forest areas we found a high number of *Musanga cecropioides* (also known as umbrella tree) and *Pycnanthus angolensis*, species described as typical pioneer species (Struhsaker, 1997) which colonise forest gaps after disturbances, but also constitute two of the main food resources for primates and hornbills.

Table 3.1: Tree abundance at different spatial scale levels in unlogged and logged study sites.

	Unlogged			**Logged**		
Tree abundance	Plot	Transect	Site	Plot	Transect	Site
	69.3 ± 20.7	468.5 ± 75.9	5,626	41.7 ± 12.6	291.9 ± 40.3	3,508

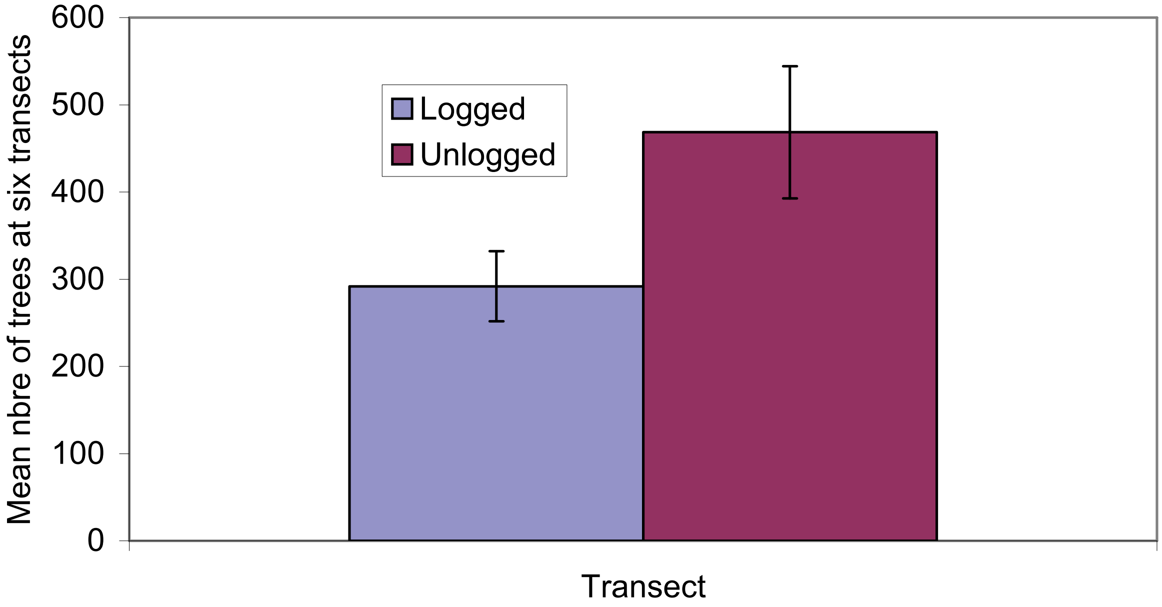

Figure 3.1: Mean number of trees at six transects in unlogged (I+II) and logged (I+II) study sites

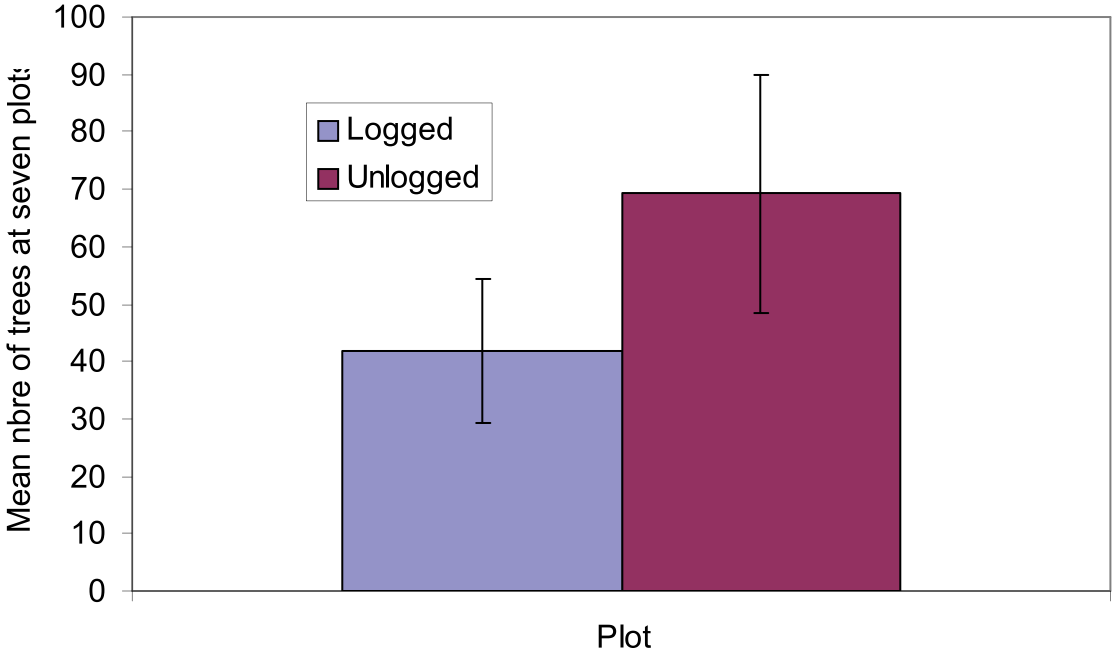

Figure 3.2: Mean number of trees at seven plots in unlogged (I+II) and logged (I+II) study sites

3.1.2 Abundance of food trees for primates and hornbills

Food tree resources for primates and hornbills were investigated along the transect lines and following the plot design. All trees within the dbh ≥ 8 cm and above recognised by the investigator (local people) to have been eaten by the studied primate and hornbill species were recorded (Appendix 3.3 and appendix 3.4). We recorded a total of 4,418 food trees in both unlogged und logged forest study sites (48.4% of the total) belonging to 52 species and 17 families.

At transect level (n= 6) and within unlogged I and unlogged II, the abundance of food trees was ca. 2.8% less compared to non food trees (Table 3.2). In logged I and logged II, we obtained relatively more food trees per study site with a difference of 0.5% and 1.9% respectively compared to non food trees (Figure 3.3).

Comparing food tree abundance within the same vegetation type (n= 12), we obtained higher abundance of food trees in unlogged forests (28%) compared to logged forests (20.4%). However, the abundance of food trees in unlogged forests was relatively low by ca. 5.6% compared to non food tree abundance but high by ca. 2.3% in logged forests.

Overall (n= 24), non food trees were relatively more abundant in unlogged/logged forest study sites by ca 3.2 % compared to food trees in unlogged/logged forest study sites.

Table 3.2: Food trees abundance for primates and hornbills in logged and unlogged study sites.

Study sites	**Area (ha) sampled**	**Food tree abundance/studysite**	**%**	**Non food treesabundance/ study site**	**%**
Unlogged I	10.5	1120	12.3	1379	15.1
Unlogged II	10.5	1436	15.7	1693	18.5
Logged I	10.5	982	10.8	941	10.3
Logged II	10.5	882	9.6	703	7.7
Total	**42**	**4418**	**48.4**	**4716**	**51.6**

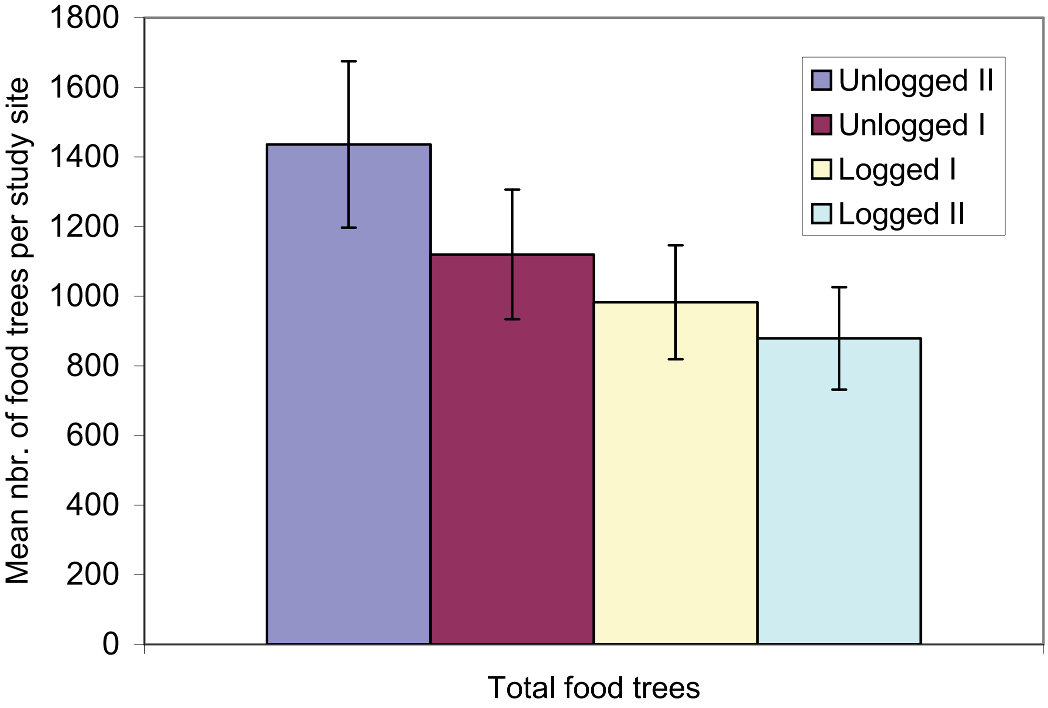

Figure 3.3: Mean number of food trees in unlogged (I and II) and logged (I and II) study sites

3.1.3 Tree species richness

A total of 217 tree species were identified in both unlogged and logged study sites. Species richness differed relatively from unlogged to logged study sites but also from plot to transect levels (Table 3.3).

At site level, we found a relatively higher number of species (188 species) in unlogged forests compared to logged forests (177 species) making a species richness in logged forest ca. 6% less compared to unlogged forests (Table 3.3).

At transect level (7 plots à 0.25 ha) tree species richness in logged study sites was ca. 22% less compared to unlogged study sites. The mean number of species per transect was higher in unlogged forests (87.5 ±5.0) compared to logged forests (68.5 ± 3.0). Detailed analysis were performed through One way Anova ($F_{3,20} = 5.43$, $P < 0.01$) where we found significant differences in species richness between unlogged and logged forest sites. However only unlogged II differed significantly from logged II (Tukey's hsd test, $P < 0.01$). Differences in species richness between unlogged I and both logged forests were not significant (Tukey's hsd test, $P < 0.06$).

At plot level (0.25 ha plot), the mean number of tree species richness per plot in logged study sites was ca. 31% less compared to unlogged study sites. The mean number of species per plot was higher in unlogged forests (32.3 ± 7.6) compared to logged forests (22.2 ± 5.7). From detailed analysis, we observed on plot level that tree species richness differed significantly between study sites (One way Anova, $F_{3,20} = 10.99$, $P< 0.001$). Species richness was significantly higher in unlogged II than in logged I and II (Tukey's hsd test $P< 0.01$) but also between unlogged I and logged II (Tukey's hsd test $P< 0.05$). Species richness was also marginally between unlogged I and logged I (Tukey's hsd test $P = 0.052$, Figure 3.4). Tree species richness did not differ between the same sample units (Tukey's hsd test, $P = 0.41$ for the unlogged forest and $P = 0.92$ for the logged forests).

The mean estimate by EstaimateS from samples (plots) pooled by transect provides detailed analysis of the differences in species richness within the same and different study sites (Appendix 3.5).

At large sampling scale (both unlogged and both logged), the difference in species richness is relatively higher in logged study sites (Jacknife 213 ± 5.7) than in unlogged forests (Jacknife 208 ± 5.0) making a difference of ca. 2% in species richness in unlogged forests compared to logged forests (Appendix 3.6 a,b,c,d).

At transect levels we observed different patterns of species richness among study sites. The number of estimated species richness differed from one site to another (unlogged and logged) but also within the same site (unlogged or logged). The number of estimated species was numerically higher in unlogged I compared to logged I and II (Jacknife: 189 ± 6.7, 177 ± 6.0 and 164 ± 5.3), a difference of ca. 7% and ca. 12 % respectively. The same pattern was also observed with unlogged II and the logged forests.

The number of estimated species richness in unlogged I (Jacknife 189 ± 6.7) was almost similar with unlogged II (Jacknife 186 ± 5.6) with a difference of about 2%. However, the number of estimated species richness in logged I was high (Jacknife 177 ± 6.0) compared to logged II (Jacknife 164 ± 5.3) a difference of about ca. 8%.

We therefore observe that the number of estimated species richness is bigger at small spatial scale (25 – 50 sample plots), but decrease as the scale is enlarged (51 – 85 sample plots). While at the study site levels (unlogged I, unlogged II, logged I and logged II), the difference in species richness is more pronounced between unlogged forests and logged forests.

Table 3.3: Tree species estimated (Jacknife index) at different spatial scale levels in logged and logged study sites

Spatial scale levels	**No. of Species observed (Sobs)**	**No. of Species estimated (s.d)**
Transect unlogged I (transect level)	157	189 (± 6.7)
Transect unlogged II (transect level)	161	186 (± 5.5)
Transect logged I (transect level)	144	177 (± 6.0)
Transect logged II (transect level)	135	164 (± 5.3)
Bothunlogged (study site I)	188	208 (± 5.0)
Bothlogged (study site II)	177	213 (± 5.7)
Total (study site I and II)	217	231 (± 3.7)

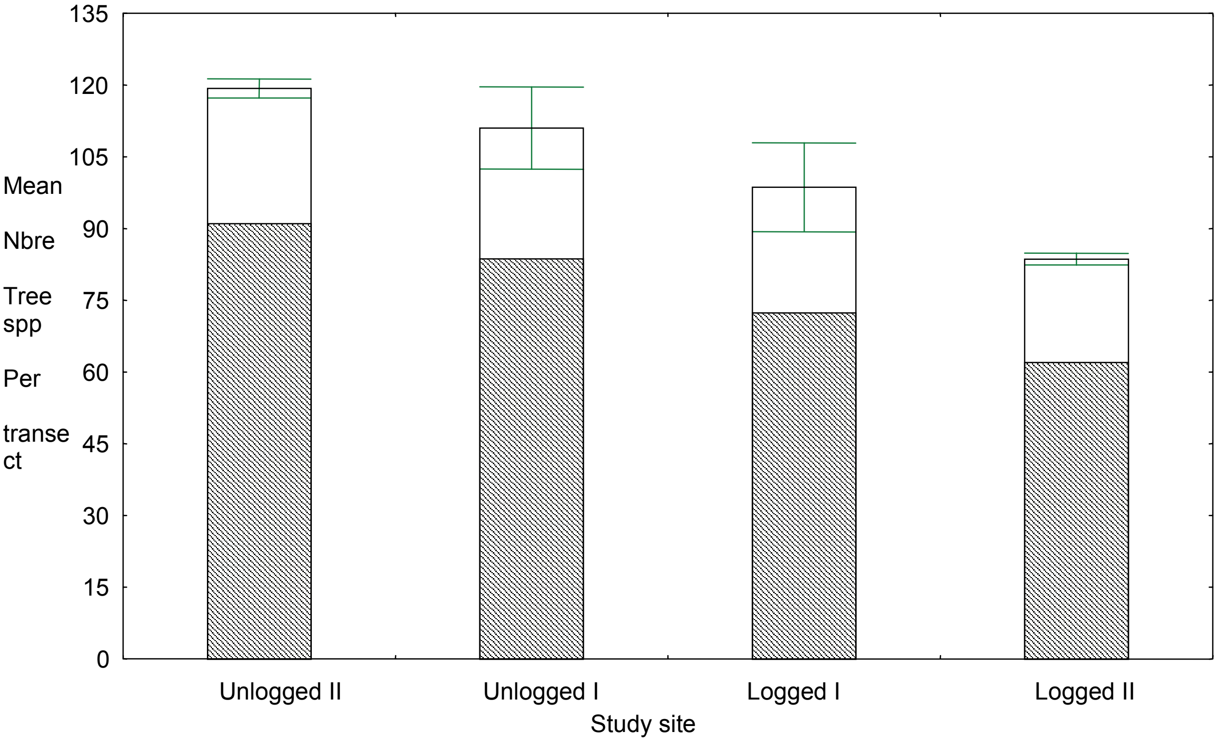

Figure 3.4: Tree species richness at transect and study site levels. The shaded part represents the mean observed species richness per transect while the unshaded bar with the standard deviation represents the mean estimated species richness per transect.

3.1.4 Species composition

The two dimensional ordination of transects based upon the correspondence analysis of tree species abundance in unlogged and logged study sites revealed two gradients in vegetation composition, one in the transects of the unlogged study sites and another in the transects of the logged study sites (Figure 3.5). The most often recorded trees, families and shrubs both in unlogged and logged study sites were *Anthonotha macrophylla* (Caesalpiniaceae), *Calpocalyx dinglagei* (Rubiaceae), *Polyalthia suaveolens* (Anonaceae), *Pycnanthus angolensis* (Myristicaceae), *Staudtia kamerunensis* (Myristicaceae), *Sorindeia grandifolia* (Anacardiaceae), *Diospyros spp* (Ebenaceae), *Homalium letestui* (Samydaceae) *Baphia nitida* (Papilionaceae), *Strombosia pustulata* (Olacaceae) and *Treculia Africana* (Moraceae). The two gradients could result from the two predominant families, the *Caesalpinaceae* which is represented by 21 species in both unlogged and logged study sites and constitutes 69.5% of the stems in unlogged forests. The family Rubiaceae is represented by 11 species and constitutes 70% of the stems in unlogged forests.

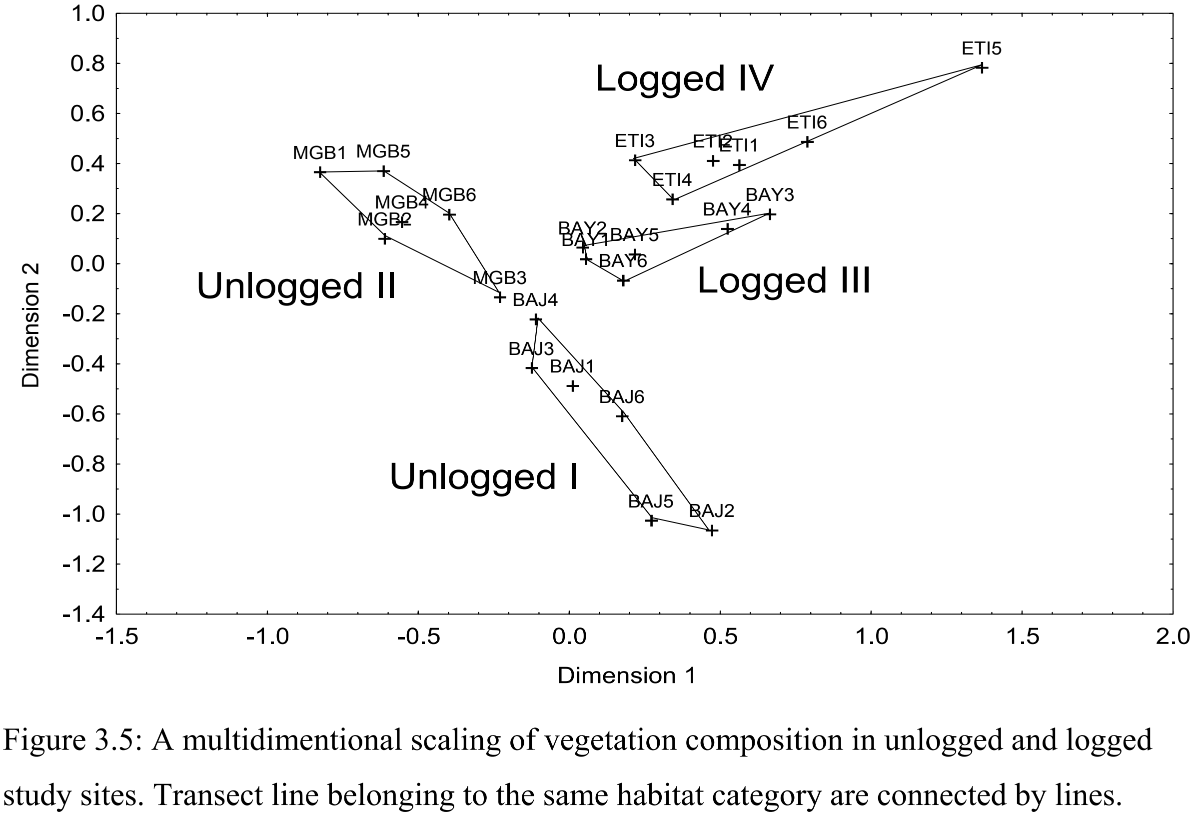

Figure 3.5: A multidimentional scaling of vegetation composition in unlogged and logged study sites. Transect line belonging to the same habitat category are connected by lines.

3.1.5 Tree family distribution and basal area

A total of 55 families were enumerated in logged and unlogged study sites. At both transect and plot levels, family distribution did not show any significant difference between unlogged and logged study sites. The analysis of family distribution revealed no significant differences in the family importance value (FIV) nor in the family density, family relative and dominance among the study sites. The most predominant families in both unlogged and logged study sites were the *Caesalpiniaceae*, *Rubiaceae*, *Euphorbiaceae*, Sterculiaceae, *Papilionaceae* and *Olacaceae*. These families were also the most diverse families of the four study sites.

The basal area changed from one study site to another when all families are lumped (Table 3.4).

At study site level, we recorded a higher basal area in unlogged forests (371.9 m ^{2}/ha) compared to logged forests (238.2 m^{2}/ha) representing a reduction of 36%.

At transect level (7 plots à 0.25 ha), the mean basal area was significantly different between unlogged I and logged forest areas, but also between unlogged II and logged I (One way ANOVA $F_{3.20} = 4.94$, $P< 0.001$). There were no significant differences observed between the same vegetation type (Tukey's HSD test $P < 0.01$).

Table 3.4: The 21 most important families (dbh ≥ 8 cm) distribution in unlogged and logged forests study areas of the Korup region.

Unlogged I		**Family indices**						
Nr	**Families**	**Ni**	**Ns**	**Ba**	**Frd**	**Frdi**	**Frdo**	**FIV**
1	*Caesalpiniaceae*	46,24	25	496,97	19,04	11,57	21,13	51,74
2	*Rubiaceae*	34,92	9	139,46	14,38	4,17	5,93	24,47
3	*Euphorbiaceae*	13,07	11	54,17	5,38	5,09	2,30	12,78
4	*Sterculiaceae*	10,34	10	88,18	4,26	4,63	3,75	12,64
5	*Papilionaceae*	9,36	4	29,86	3,85	1,85	1,27	6,97
6	*Olacaceae*	8,87	4	45,04	3,65	1,85	1,92	7,42
7	*Apocynaceae*	8,19	6	73,72	3,37	2,78	3,14	9,28
8	*Annonaceae*	8	4	31,46	3,29	1,85	1,34	6,48
9	*Mimosaceae*	7,8	6	288,89	3,21	2,78	12,29	18,27
10	*Ebenaceae*	7,51	2	16,18	3,09	0,93	0,69	4,71
11	*Meliaceae*	7,31	10	117,29	3,01	4,63	4,99	12,63
12	*Myristicaceae*	6,82	4	99,28	2,81	1,85	4,22	8,88
13	*Flacourtiaceae*	6,42	4	33,8	2,64	1,85	1,44	5,93
14	*Guttiferae*	6,24	4	17,75	2,57	1,85	0,75	5,18
15	*Amaranthaceae*	5,75	5	12,4	2,37	2,31	0,53	5,21
16	*Irvingiaceae*	5,36	4	44,64	2,21	1,85	1,90	5,96
17	*Samydaceae*	5,26	1	37	2,17	0,46	1,57	4,20
18	*Violaceae*	5,17	2	7,45	2,13	0,93	0,32	3,37

19	*Anacardiaceae*	4,48	3	20.56	1,84	1,39	0,87	4,10
20	*Burseraceae*	4,09	4	96,86	1,68	1,85	4,12	7,65
21	*Moraceae*	4,09	4	26,16	1,68	1,85	1,11	4,65
	Sum	215,41	126	1777,12	88,68	58,33	75,57	222,58
	Remaining families	27,51	90	574,39	11,32	41,67	24,43	77,42
	Total	242,92	216	2351,51	100	100,00	100,00	300,00

Unlogged II

1	*Caesalpiniaceae*	40,19	24	420,54	13,39	11,27	15,31	39,97
2	*Euphorbiaceae*	34,53	14	268,2	11,50	6,57	9,77	27,84
3	*Rubiaceae*	33,46	10	141,32	11,15	4,69	5,15	20,99
4	*Scytopetalaceae*	15,02	1	53,18	5,00	0,47	1,94	7,41
5	*Myristicaceae*	14,92	5	382,21	4,97	2,35	13,92	21,23
6	*Tiliaceae*	14,73	2	165,68	4,91	0,94	6,03	11,88
7	*Olacaceae*	13,46	3	43,35	4,48	1,41	1,58	7,47
8	*Guttiferae*	11,7	5	26,19	3,90	2,35	0,95	7,20
9	*Ebenaceae*	11,21	1	29,9	3,73	0,47	1,09	5,29
10	*Moraceae*	10,92	4	75,8	3,64	1,88	2,76	8,28
11	*Mimosaceae*	9,17	7	171	3,05	3,29	6,23	12,57
12	*Papilionaceae*	7,9	3	48,97	2,63	1,41	1,78	5,82
13	*Sterculiaceae*	6,43	8	27,55	2,14	3,76	1,00	6,90
14	*Meliaceae*	6,34	6	44,04	2,11	2,82	1,60	6,53
15	*Violaceae*	6,24	1	10,99	2,08	0,47	0,40	2,95
16	*Annonnaceae*	6,14	6	22,49	2,05	2,82	0,82	5,68
17	*Burseraceae*	5,75	4	53,52	1,92	1,88	1,95	5,74
18	*Anacardiaceae*	5,46	5	46,26	1,82	2,35	1,68	5,85
19	*Samydaceae*	5,36	1	40,89	1,79	0,47	1,49	3,74
20	*Apocynaceae*	4,29	5	28,53	1,43	2,35	1,04	4,82
21	*Sapotaceae*	4,09	2	27,92	1,36	0,94	1,02	3,32
	Sum	267,41	117	2128,53	89,08	54,93	77,50	221,51
	Remaining families	32,78	93	617,96	10,92	43,66	22,50	77,08
	Total	300,19	213	2746,49	100,00	100,00	100,00	300,00

Logged I

1	*Caesalpiniaceae*	23,8	15	484,14	12,61	7,14	29,63	49,38
2	*Rubiaceae*	19,9	6	77,11	10,54	2,86	4,72	18,12
3	*Papilionaceae*	12,78	5	57,47	6,77	2,38	3,52	12,67
4	*Euphorbiaceae*	12,68	15	78,52	6,72	7,14	4,81	18,67
5	*Sterculiaceae*	9,85	9	31,71	5,22	4,29	1,94	11,44
6	*Ebenaceae*	8,78	1	27,6	4,65	0,48	1,69	6,82
7	*Myristicaceae*	8,58	4	85,34	4,55	1,90	5,22	11,67
8	*Violaceae*	8,39	1	24,44	4,44	0,48	1,50	6,42
9	*Olacaceae*	8,19	4	43,29	4,34	1,90	2,65	8,89
10	*Moraceae*	8,6	3	59,3	4,56	1,43	3,63	9,61
11	*Burseraceae*	6,43	4	64,64	3,41	1,90	3,96	9,27
12	*Irvingiaceae*	5,85	3	55,72	3,10	1,43	3,41	7,94
13	*Annonaceae*	5,26	4	26,15	2,79	1,90	1,60	6,29
14	*Mimosaceae*	5,07	6	78,81	2,69	2,86	4,82	10,37
15	*Guttiferae*	4,78	4	18,82	2,53	1,90	1,15	5,59
16	*Amaranthaceae*	4,19	3	14,34	2,22	1,43	0,88	4,53
17	*Meliaceae*	4,5	8	42,64	2,38	3,81	2,61	8,80
18	*Samydaceae*	3,9	1	22,28	2,07	0,48	1,36	3,91

19	*Anacardiaceae*	3,31	4	32,29	1,75	1,90	1,98	5,63
20	*Chailetiaceae*	2,24	1	13,26	1,19	0,48	0,81	2,47
21	Sum	165,25	80	1337,87	87,54	38,10	81,88	207,52
	Remaining families	23,52	130	296,05	12,46	61,90	18,12	92,48
	Total	188,77	210	1633,92	100,00	100,00	100,00	300,00
Logged II								
1	*Olacaceae*	14,92	4	115,82	9,69	2,05	7,94	19,68
2	*Caesalpiniaceae*	14,63	15	201,36	9,50	7,69	13,80	30,99
3	*Sterculiaceae*	11,9	7	52,68	7,73	3,59	3,61	14,93
4	*Euphorbiaceae*	11,51	15	85,38	7,48	7,69	5,85	21,02
5	*Rubiaceae*	10,53	4	74	6,84	2,05	5,07	13,96
6	*Mimosaceae*	7,12	4	83,2	4,63	2,05	5,70	12,38
7	*Irvingiaceae*	6,82	3	127,18	4,43	1,54	8,71	14,68
8	*Ebenaceae*	6,43	3	45,92	4,18	1,54	3,15	8,86
9	*Moraceae*	5,95	3	39,49	3,87	1,54	2,71	8,11
10	*Burseraceae*	5,75	4	61,36	3,74	2,05	4,20	9,99
11	*Papilionaceae*	5,44	4	24,66	3,53	2,05	1,69	7,27
12	*Samydaceae*	4,78	1	42,7	3,11	0,51	2,93	6,54
13	*Violaceae*	4,68	2	18,75	3,04	1,03	1,28	5,35
14	*Meliaceae*	4	6	47,02	2,60	3,08	3,22	8,90
15	*Guttiferae*	3,6	2	17,33	2,34	1,03	1,19	4,55
16	*Anacardiaceae*	3,51	1	19,52	2,28	0,51	1,34	4,13
17	*Flacourtiaceae*	3,21	3	23,16	2,09	1,54	1,59	5,21
18	*Tiliaceae*	3,82	2	23,04	2,48	1,03	1,58	5,09
19	*Chailetiaceae*	3,82	1	18,32	2,48	0,51	1,26	4,25
20	*Annonaceae*	2,63	5	25,3	1,71	2,56	1,73	6,01
21	*Amaranthaceae*	2,63	2	17,88	1,71	1,03	1,23	3,96
	Sum	135,79	91	1164,07	88,21	46,67	79,76	214,64
	Remaining families	18,15	104	295,38	11,79	53,33	20,24	85,36
	Total	153,94	195	1459,45	100,00	100,00	100,00	300,00

Ni= number of individual per hectare; Ns= number of species; Ba= basal area (m²/ha); Frd=family relative density; Frdi=family relative diversity; Frdo=family relative dominance and FIV=family importance value

3.1.6 Diameter distribution

The analysis of the forest structural composition denotes similarities in diameter distribution between unlogged and logged study sites (Tables 3.5 and Figure 3.6). At study site levels, trees with a dbh ranging between 8 and 40 cm were 2/3 times more abundant in unlogged and logged forests than trees above 40 cm dbh in both.

At transect levels, unlogged forests differed from logged forests in the lower interval of 8 – 20 cm dbh size class, while the interval class of the intermediate 40 – 90 cm dbh did not differ from unlogged to logged forests. But the main differences noted at transect levels between unlogged study sites were found at the upper interval class of ≥120 cm dbh with larger dbh in unlogged forests. Tree ≥120 cm dbh were more abundant in unlogged forests than in logged forests. The most remarkable feature was the inexistence of trees within the interval class of 110 -120 cm dbh in both unlogged and logged study sites (Appendix 3.7 a,b,c,d).

Table 3.5: Tree diameter distribution of the lower and upper classes in unlogged and logged study sites.

Diameter classes	**Unlogged I**		**Unlogged II**		**Logged I**		**Logged II**	
	M.n.o.i*	S.d**	M.n.o.i	S.d	M.n.o.i	S.d	M.n.o.i	S.d
8 - 20	272.5	90.1	331.0	34.1	180.8	54.0	127.2	18.5
20 - 30	75.1	16.8	96.2	11.1	79.6	11.6	63.8	12.9
110 - 120	-	-	-	0.5	-	-	-	-
≥120	6.6	2.3	9.5	6.3	1.9	1.8	1.1	1.1

* Mean number of individual; ** Standard deviation

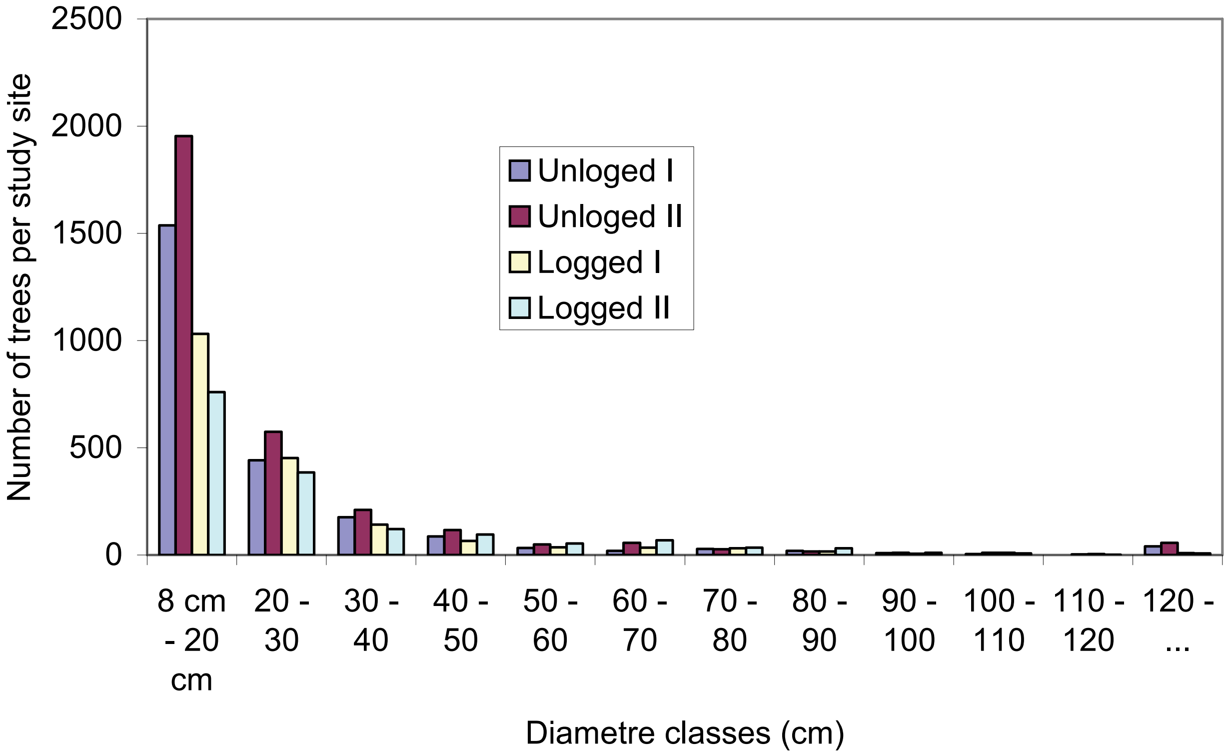

Figure 3.6: Diameter distribution in unlogged and logged study sites.

3.2 Primates results

3.2.1 Abundance

Data from unlogged to logged study sites were analysed separately for each year (Table 3.6). Located at the same ecological zones, the two unlogged and the two logged study sites were respectively pooled together to form two study sites instead of four. The number of observations, number of individuals, encounter rates, group density, individual density, standard error for each individual primate and hornbill species were estimated.

At study site levels, the number of observations (n) and number of each individual primate species (N) differed from one year to another and also between logged and unlogged areas (Table 3.6).

In logged I, The mona monkeys (*C. mona*) were more observed in 1999-2000 (n= 42) than in 2000-2001 (n= 27) and 2001-2002 (n= 21). This pattern was also similar in logged II. In contrast, observations of mona monkeys in unlogged I increased over years from 27 (1999-2000), 41 (2000-2001) and 54 (2001-2002).

The putty-nosed monkey (*C. nictitans nictitans*) observations in logged I decreased from n= 5 2 observations (1999-2000) to n= 21 observations (2001-2002) and also in unlogged II from n= 35 observations (1999-2002; Table 3.7) to n= 5 observations (2001-2002).

Both the mona and the putty-nosed monkeys were more observed in logged than in unlogged study sites.

The red-eared monkey (*C. erythrotis*) was 50% more observed in unlogged (n=60) than in logged (n= 28) study sites.

In the year 1999-2000, the crowned monkey (*Cercopithecus pogonias*) was not observed in logged I. In logged II, observations of the crowned monkey decreased from n= 4 (2000-2001) to n= 1 (2001-2002). There was a slight increase in the number of observations of this species in unlogged I compared to unlogged II. In general, this species was less abundant both in logged and unlogged study sites.

The red-capped mangabey (*Cercocebus torquatus*) was more observed in the first year (1999-2000) in logged I but rapidly decreased by more than 65% in the second year and 100% in 2001-2002. This pattern was also observed in logged II. Though less abundant in unlogged I, this species has increased from n= 3 observations in 1999-2000 to n=6 observations in 2001-2002 while the number of observations remained stable in unlogged II with n= 1 observation throughout the study period.

The preuss's red colobus (*Procolobus pennantii preussi*) was not observed both in logged and unlogged study sites in the first and second year (2000-2001) but was once observed in 2001-2002 in unlogged I.

The Chimpanzee observations in logged I decreased from n= 14 in the first year to n= 4 in the second and third year while observations were stable in logged II between the second and the third year. Meanwhile, this species was totally absent in unlogged I and less observed in unlogged II compared to logged study sites.

The Drill (*Mandrillus leucophaeus*) was hard to find both in logged (one observation in logged I in the first year) and unlogged (one observation in unlogged I in the first year) study sites.

Table 3.6: Number of observations and individual primates in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

		Logged I		**Logged II**		**Ulnlogged I**		**Unlogged II**	
Year	**Primates**	n	N	n	N	n	N	n	N
1999	*Cercopithecus mona*	32	423	-	-	37	300	16	264
- 2000	*C. nictitans nictitans*	52	379	-	-	78	256	35	97
	C. erythrotis	5	133	-	-	16	406	5	127
	C. pogonias	0	0	-	-	0	0	3	12
	Cercocebus torquatus	15	148	-	-	0	09	1	1
	Procolobus pennantii p.	0	0	0	0	0	0	0	0
	Pan troglodytes	12	8	-	-	0	0	0	0
	Mandrillus leucophaeus	1	14	-	-	1	27	0	0
2000	*Cercopithecus mona*	24	364	31	515	25	104	7	158
-	*C. nictitans nictitans*	30	558	29	344	36	196	20	461
2001	*C. erythrotis*	3	118	9	323	16	423	8	384
	C. pogonias	1	1	3	43	1	1	4	12
	Cercocebus torquatus	4	4	5	60	1	1	1	1
	Procolobus pennantii p.	0	0	0	0	0	0	0	0
	Pan troglodytes	2	2	2	19	0	0	2	2
	Mandrillus leucophaeus	0	0	0	0	1	27	0	0
2001	*Cercopithecus mona*	17	647	11	377	23	541	4	172
–	*C. nictitans nictitans*	7	190	14	301	15	237	3	76
2002	*C. erythrotis*	0	0	11	417	12	374	3	149
	C. pogonias	0	0	1	2	3	5	0	0
	Cercocebus torquatus	0	0	3	122	5	7	1	20
	Procolobus pennantii p.	0	0	0	0	1	1	0	0
	Pan troglodytes	1	2	0	0	0	0	0	0
	Mandrillus leucophaeus	0	0	0	0	0	0	0	0

n= number of observations; N= estimate number of primates

Table 3.7: Number of observations and individual primates in logged (I+II) and unlogged (I+II) study sites from 1999-2002.

		Pooled logged		**Pooled unlogged**	
Year	**Primates**	n	N	n	N
1999	*Cercopithecus mona*	118	919	86	488
	C. nictitans nictitans	112	747	128	573
2002	*C. erythrotis*	28	350	62	555
	C. pogonias	5	33	11	10
	Cercocebus torquatus	28	213	9	32
	Procolobus pennantii p.	1	27	1	1
	Pan troglodytes	18	65	2	1
	Mandrillus leucophaeus	1	14	1	27

n= number of observations; N= estimate number of primates

3.2.2 Primate densities

Individual and group densities of each selected primate and hornbill species were also analysed for each year and each study site and variations (standard error) in species densities between study sites and year were sorted out. Data were thereafter pooled per logged (I+II) and unlogged (I+II) and per year (1999-2000; 2000-2001; 2001-2002 and 1999-2002) to have large study blocks (large spatial scale) with more observations thus increasing statistical reliability, precision and accuracy of the known true population mean (Appendix 3.8).

3.2.2.1 Mona monkey (*C. mona*)

At the study site levels (Table 3.8), the density of mona monkeys in logged I decreased from 30.36 ind/km^2 in the first year (1999-2000; appendix 3.10) to 22.75 ind/km^2 in the second (2000-2001: appendix 3.11), a decrease of 25%. However in 2001-2002 (third year, appendix 3.12) the density of the mona monkeys (40.46 ind/km^2) in logged I increased by 44% (year two) and 35% (year one). The same pattern was observed in logged II with a decrease of 27% between year two (32.18 ind/km^2) and year three (23.54 ind/km^2). There was no overlap of the standard error bars for the two means in logged I between year one and year two, meanwhile, there was a large variation between year three and the two previous years.

In unlogged I, a decrease of 44% in mona's density was observed between year one (11.55 ind/km^2) and year two (6.48 ind/km^2) but with very high density in year three (33.81 ind/km^2) with a rather high variations. Compared to unlogged I, mona monkeys' densities in unlogged

II were higher in year one (18.08 ind/km²) with a rapid decrease in year two (9.87 ind/km²) and in year three (10.77 ind/km²). High variations were noted in unlogged I and between year three, year one and year two meanwhile variations in unlogged II were more or less the same (Figure 3.7).

At large spatial scale (logged I+II and unlogged I+II), the difference in mona monkeys densities between logged (28.73 ind/km²) and unlogged (15.24 ind/km²) study sites was estimated to be 47 %. There was no difference in variations between logged and unlogged study sites (Figure 3.8 and appendix 3.13).

Table 3.8: Mean group density (gp/km²), mean density (ind/km²) and standard error for the *C. mona* in unlogged and logged study sites from 1999 to 2002.

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	2.00	30.36	4.34	0	0	0	0.82	11.55	4.65	8.85	18.08	6.53
00-01	1.25	22.75	5.64	1.80	32.18	8.56	1.40	6.48	2.28	0.50	9.87	3.71
01-02	1.61	40.46	10.08	1.07	23.54	8.08	2.25	33.81	10.90	0.44	10.77	5.93
99-02	DS=1.60; D= 28.73; SE= 3.00						DS=0.90; D=15.24 ; SE=3.37					

DS: group density (gp/km²); D: individual density (Ind/km²); SE: Standard error

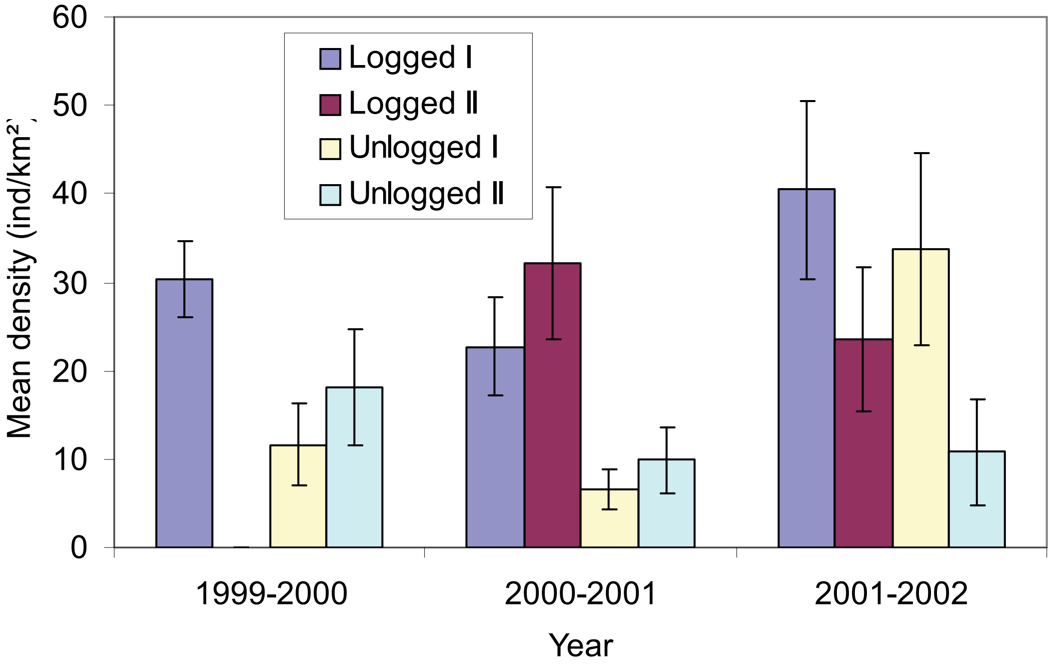

Figure 3.7: Mean density of *C. mona* in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

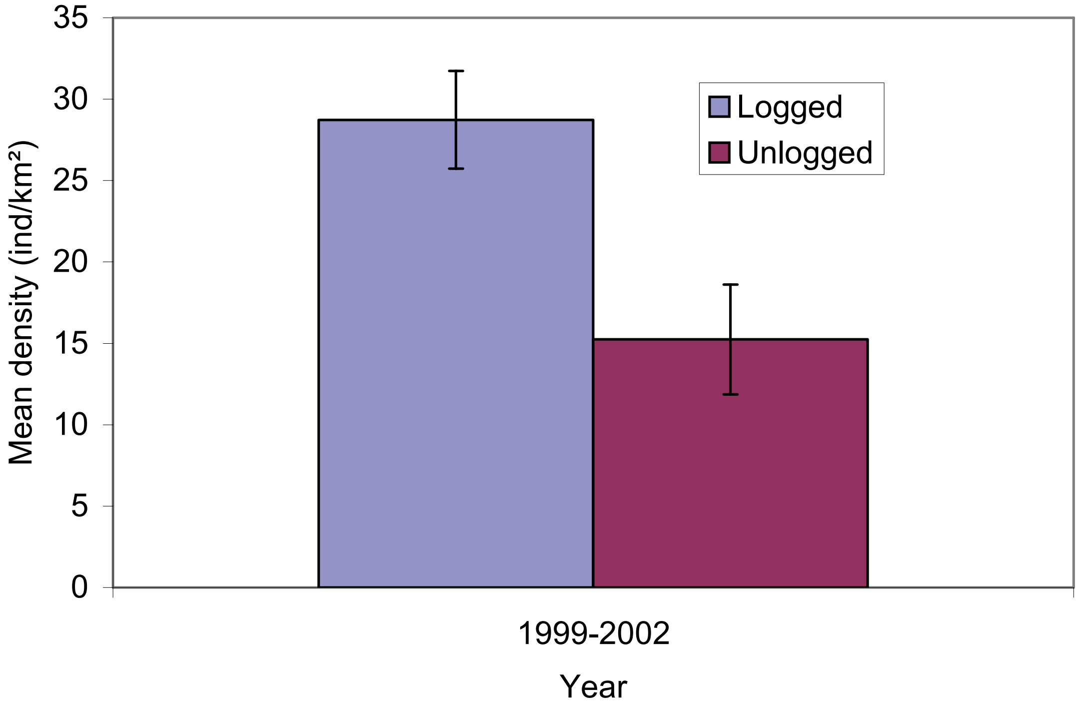

Figure 3.8: Mean density of *C. mona* in unlogged (I + II) and logged (I + II) study sites from 1999-2002.

3.2.2.2 Putty-nosed monkey (*C. nictitans nictitans*)

At study site levels (Table 3.9), we observed a decrease in density of the putty nosed monkey from year one (26.44 ind/km²; appendix 3.14) to year two (22.75 ind/km²; appendix 3.15) and year three (12.00 ind/km²). This pattern was again observed in logged II with a decrease of 41% between year two (32.18 ind/km²) and year three (18.83 ind/km²), but also in unlogged II with a decrease of 40% in year two (9.87 ind/km²) and 71% in year three (4.73 ind/km²) compared to year one (16.51 ind/km²; appendix 3.16). However a decrease of 65% in density of the putty nosed monkey between year one (18.74 ind/km²) and year two (6.48 ind/km²) was compensated by an increase of 56% between year three (14.81 ind/km²) and year two, but with a decrease of 21% between year one and year three. Variations in logged study sites could not differ between years. However in year two, we observed high variations between unlogged II and unlogged I (Figure 3.9)

At large spatial scale, we observed a decrease in density of the putty-nosed monkey of about 25% between logged (23.35 ind/km²) and unlogged (17.90 ind/km²). Variations of the population mean density of the Putty-nosed monkey were high in logged study sites as compared to unlogged study sites (Figure 3.10 and appendix 3.17).

Table 3.9: Mean group density (gp/km²), mean density (ind/km²) and standard error for the *C. nictitans nictitans* in unlogged and logged study sites from 1999 to 2002.

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	1.41	26.44	10.08	0	0	0	1.69	18.74	5.73	0.81	16.51	6.55
00-01	1.25	22.75	5.64	1.80	32.18	8.56	1.40	6.48	2.28	0.50	9.87	3.71
01-02	0.51	12.00	4.15	1.06	18.83	6.18	1.13	14.81	6.10	0.25	4.73	3.35
99-02	DS= 1.26; D= 23.35 ; SE= 3.41						DS= 1.19; D=17.90 ; SE=3.34					

DS: group density (gp/km²); D: individual density (Ind/km²); SE: Standard error

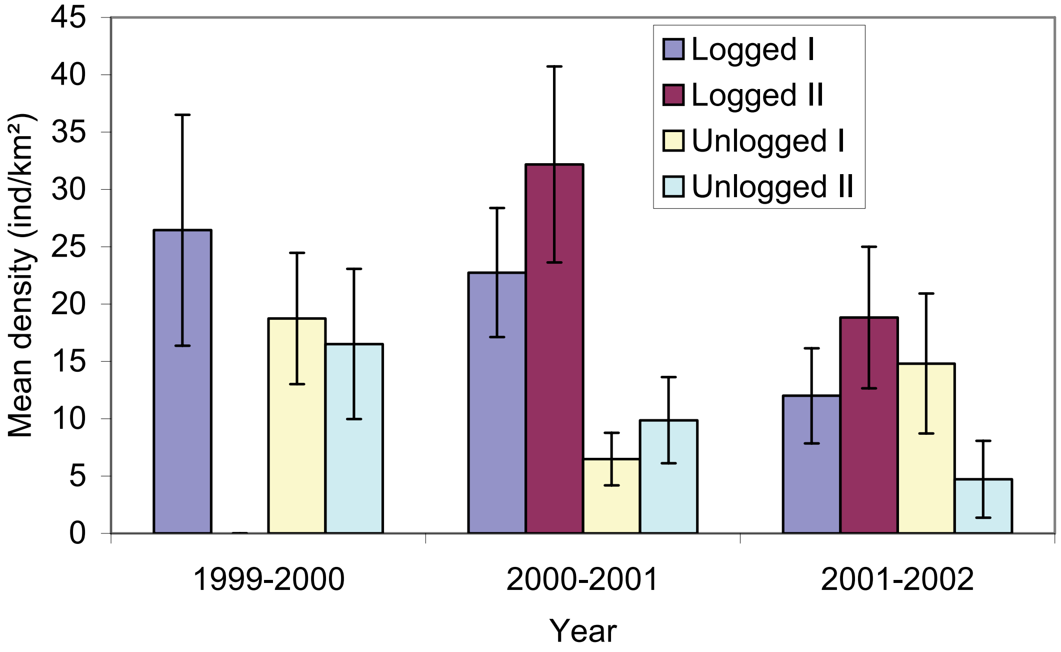

Figure 3.9: Mean density of *C. nictitans nictitans* in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

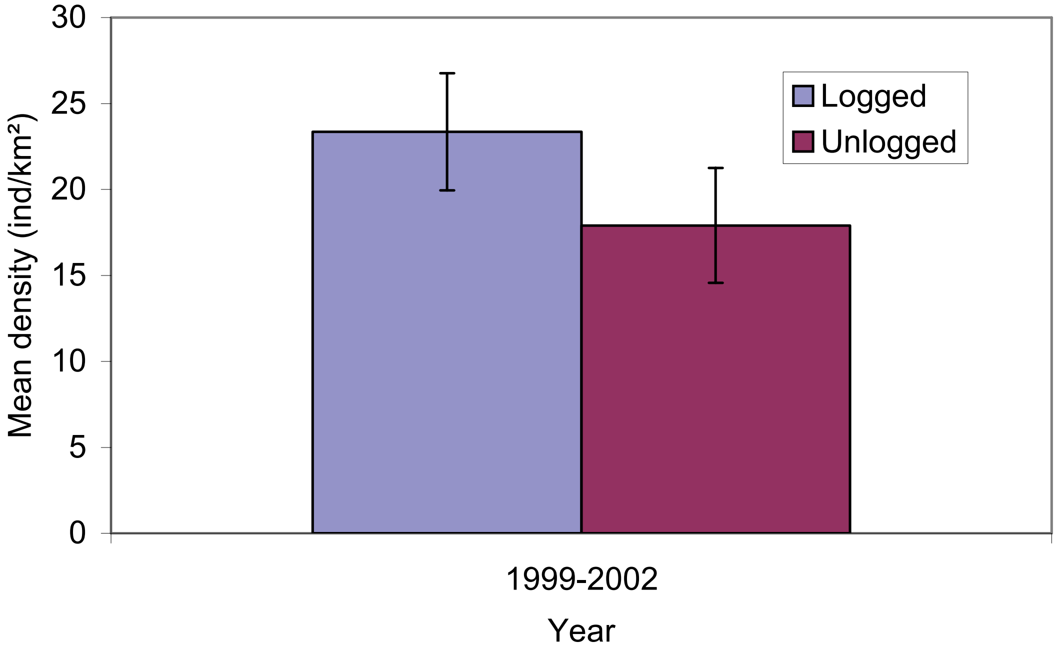

Figure 3.10: Mean density of *C. nictitans nictitans* in unlogged (I + II) and logged (I + II) study sites from 1999-2002.

3.2.2.3 Red-eared monkey (*C. erythrotis*)

At study site level (Table 3.10), the mean densities of the Cameroon red-eared monkeys differed from one study site to another, but also from one year to another. At logged I, we observed low densities with a decrease of about 11% between year one (8.29 ind/km²) and year two (7.34 ind/km²; appendix 3.18) while in year three this species was completely absent in logged I. Compared to logged I, a different pattern was observed in logged II with an increase of about 33% between year two (20.19 ind/km²; appendix 3.19) and year three (26.06 ind/km²). Variability in logged II were larger than in logged I (Figure 3.11).

Mean densities in unlogged I were more or less stable, but with high variations throughout year one (25.40 ind/km²), year two (26.44 ind/km²) and year three (23.38 ind/km²). However unlogged II shows high mean density in year two (24.03 ind/km²) compared to year one (7.90 ind/km²) and year three (9.30 ind/km²; appendix 3.20).

At large spatial scale, the mean density in unlogged study site (17.35 ind/km²) was higher by ca. 37% compared to the mean density in logged study sites (10.93 ind/km²) but with similar variations (Figure 3.12; appendix 3.21).

Table 3.10 Mean group density (gp/km²), mean density (ind/km²) and standard error for the *C. erythrotis* in unlogged and logged study sites from 1999 to 2002.

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	0.50	8.29	3.00	0	0	0	1.65	25.40	12.94	0.60	7.90	3.00
00-01	0.37	7.34	3.97	1.26	20.19	9.44	2.14	26.44	9.86	1.23	24.03	9.92
01-02	0	0	0	1.55	26.06	9.00	1.70	23.38	10.37	0.48	9.30	4.47
99-02	DS= 0.65; D= 10.93 ; SE= 3.36						DS= 1.19; D= 17.35 ; SE= 3.84					

DS: group density (gp/km²); D: individual density (Ind/km²); SE: Standard error

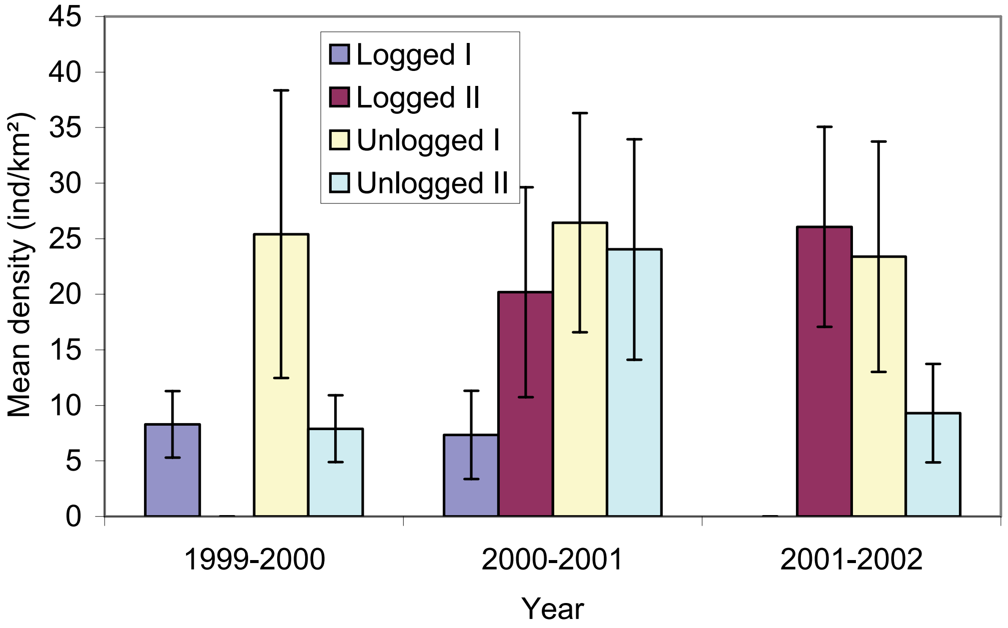

Figure 3.11: Mean density of *C. erythrotis* in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

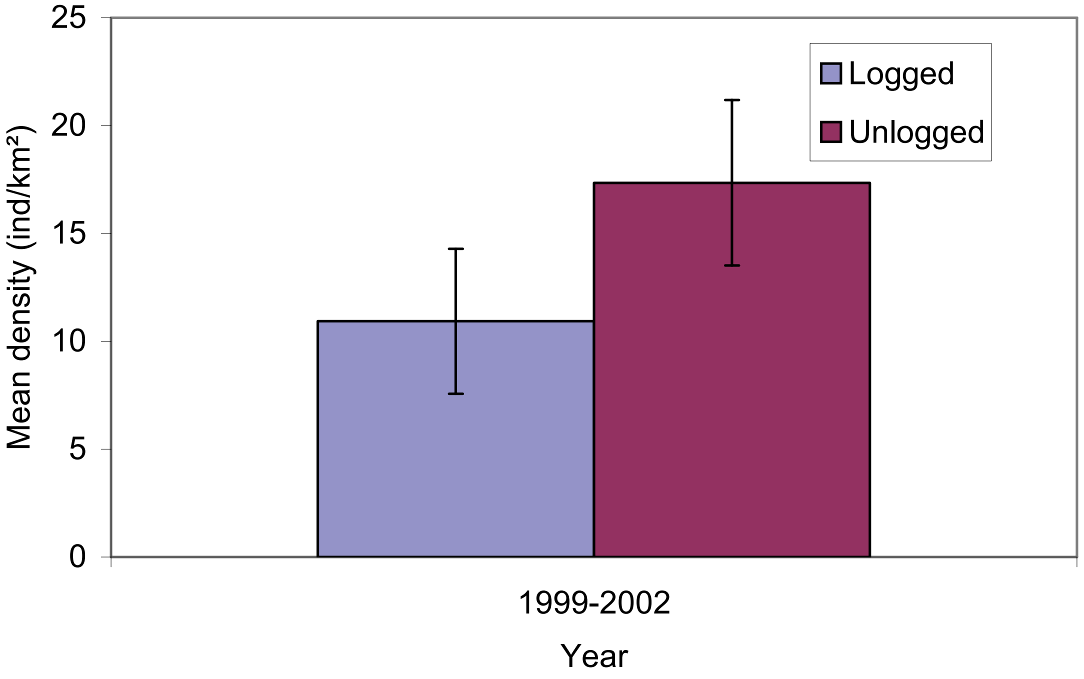

Figure 3.12: Mean density of *C. erythrotis* in unlogged (I+II) and logged (I+II) study sites from 1999-2002.

3.2.2.4 Crowned monkey (*C. pogonias*)

This species was almost absent in both logged and unlogged study sites at the beginning of the survey in 1999-2000, where it was observed at unlogged II at very low density of (0.75 ind/km²; appendix 3.22). In year two, the crowned monkey was observed all round the study area, but still with very low densities as shown in Table 3.11 and appendix 3.23. The density estimated in year 1 and year 2 dropped to zero in year three at logged I, II and unlogged II (Figure 3.13; appendix 3.24).

At large spatial scale, the density of the crowned monkey was high by 70% in logged study sites (1.03 ind/km²) compared to unlogged study sites (0.31 ind/km²; Figure 3.14; appendix 3.25).

Table 3.11: Mean group density (gp/km²), mean density (ind/km²) and standard error for the *C. pogonias* in unlogged and logged study sites from 1999 to 2002.

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	0	0	0	-	-	-	0	0	0	0.50	0.75	0.57
00-01	0.06	0.06	0.05	0.20	2.70	1.92	0.06	0.06	0.05	0.30	0.75	0.44
01-02	0	0	0	0.1	0.1	0.1	0.28	0.28	0.24	0	0	0
99-02	DS= 0.08; D= 1.03 ; SE= 0.59						DS= 0.14 ; D= 0.31 ; SE= 0.15					

DS: group density (gp/km²); D: individual density (Ind/km²); SE: Standard error

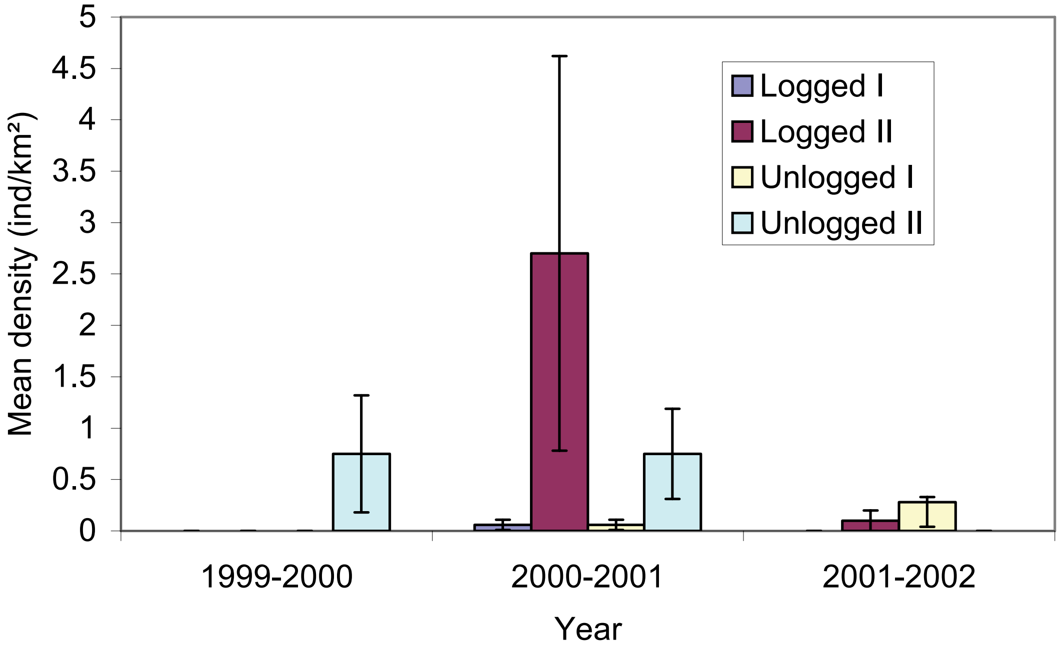

Figure 3.13: Mean density of *C. pogonias* in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

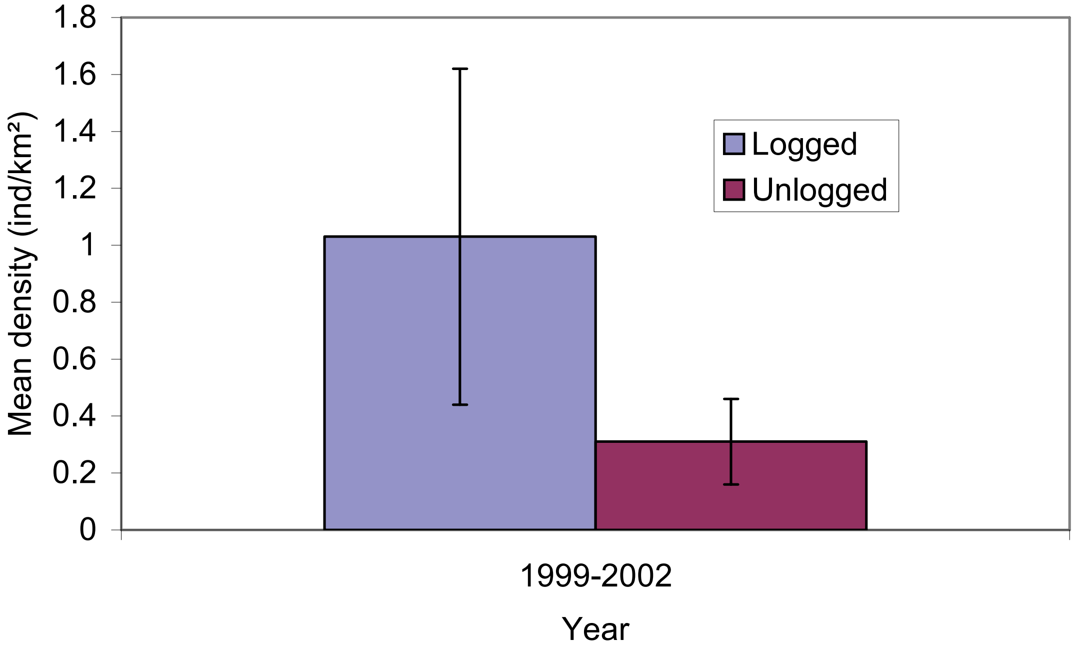

Figure 3.14: Mean density of *C. pogonias* in unlogged (I+II) and logged (I+II) study sites from 1999-2002.

3.2.2.5 Red-capped mangabey (*Cercocebus torquatus*)

At study site levels (Table 3.12), densities of the red-capped mangabey remained very low both in logged and unlogged study sites. At the first year, densities in logged I (9.22 ind/km^2) were high by about 100% compared to year two (0.26 ind/km^2) and year three (0 ind/km^2). A different pattern was observed in logged II with an increase of about 50% (7.65 ind/km^2) in year three compared to year two (3.80 ind/km^2), but with high variations between the two years. Densities in unlogged study sites were very low compared to logged study sites with the highest estimated density in year three at unlogged II (1.12 ind/km^2; Figure 3.15 and appendices 3.26-3.28).

At large scale, we estimated a high density in logged study sites (6.65 ind/km^2) compared to unlogged study sites (1.01 ind/km^2; Figure 3.16; appendix 3.29).

Table 3.12: Mean group density (gp/km^2), mean density (ind/km^2) and standard error for the *Cercocebus torquatus* in unlogged and logged study sites from 1999 to 2002.

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	0.61	9.22	7.10	-	-	-	0	0	0	0.05	0.05	0.05
00-01	0.26	0.26	0.14	0.29	3.80	1.54	0.06	0.06	0.02	0.06	0.06	0.02
01-02	0	0	0	0.27	7.65	5.04	0.45	0.45	0.23	0.10	1.12	1.03
99-02	DS= 0.31; D= 6.65; SE= 2.75						DS= 0.08; D= 1.01 ; SE= 0.63					

DS: group density (gp/km^2); D: individual density (Ind/km^2); SE: Standard error

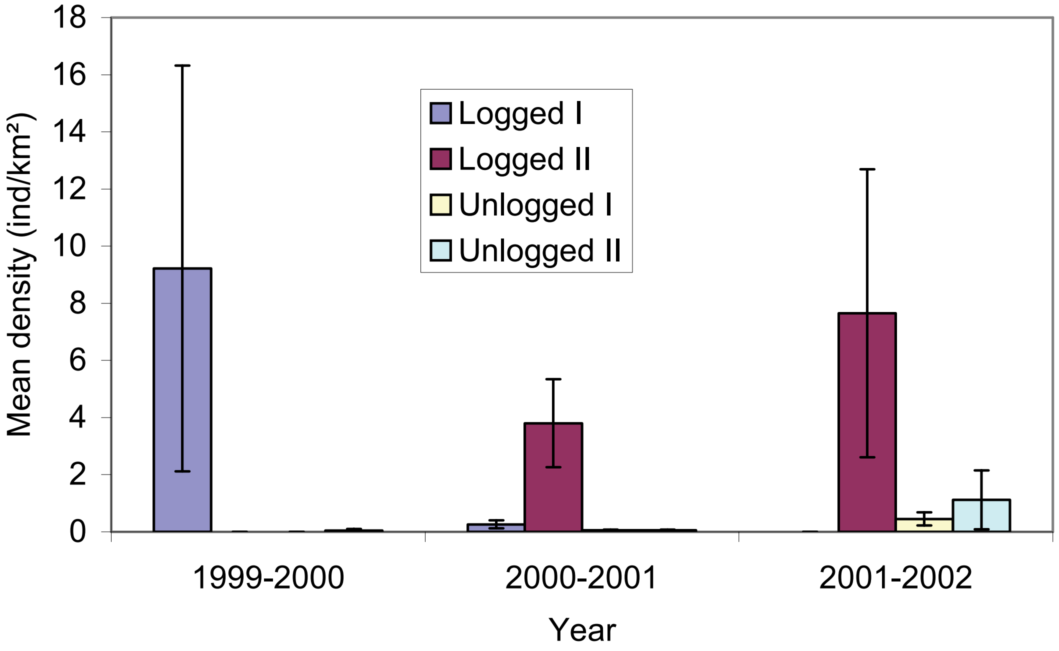

Figure 3.15: Mean density of *Cercocebus torquatus* in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

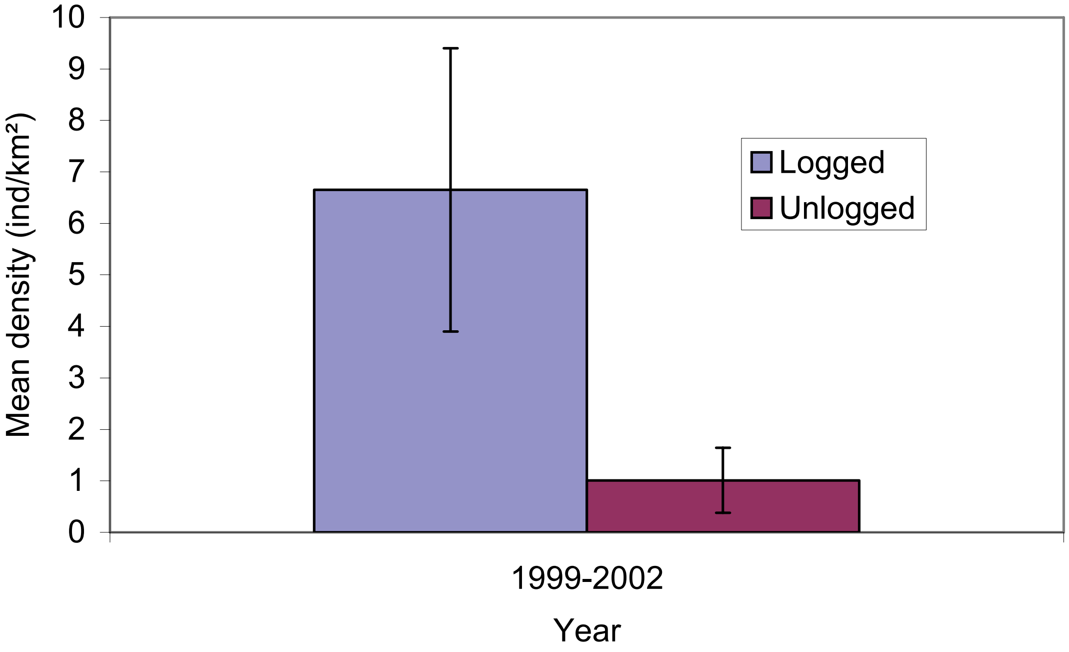

Figure 3.16: Mean density of *Cercocebus torquatus* in unlogged (I+II) and logged (I+II) study sites from 1999-2002.

3.2.2.6 Preuss's red colobus (*Procolobus pennantii preussi*)

Both at study site levels as at large spatial scale, the Preuss's red colobus was almost absent throughout the study period apart from year three where it was estimated at 0.07 ind/km² in unlogged I.

The mean density at study site levels was almost similar with the estimated mean density at large spatial scale (Table 3.13; appendices 3.30 and 3.31).

Table 3.13: Mean group density (gp/km²), mean density (ind/km²) and standard error for the *Procolobus pennantii preussi.* In logged and unlogged study sites from 1999 to 2002.

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	0	0	0	0	0	0	0	0	0	0	0	0
00-01	0	0	0	0	0	0	0	0	0	0	0	0
01-02	0	0	0	0	0	0	0.07	0.07	0.05	0	0	0
99-02	DS= 0.00 D= 0.00 ; SE= 0.00						DS= 0.02; D= 0.02 ; SE= 0.01					

DS: group density (gp/km²); D: individual density (Ind/km²); SE: Standard error

3.2.2.7 Chimpanzee (*Pan troglogytes*)

Chimpanzees in our study sites (Table 3.14) were more estimated in logged than in unlogged areas. In 1999-2000, the density of chimpanzee in logged I was estimated at 0.50 ind/km² with high variations (appendix 3.32) which rapidly dropped in year 2000-2001 (0.10 ind/km²; appendix 3.33) and 2001-2002 (0.14 ind/km²; appendix 3.34). This species was only found in logged II (year two) at 1.16 ind/km² and in unlogged II at 0.12 ind/km² (Figure 3.17).

At large spatial scale, the density of the chimpanzee was about 100% high in logged study sites (2.03 ind/km²) than in unlogged study sites (0.02 ind/km²; Figure 3.18 and appendix 3.35).

Table 3.14: Mean group density (gp/km²), mean density (ind/km²) and standard error for the *Pan troglodytes* in unlogged and logged study sites from 1999 to 2002.

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	0.50	0.50	0.42	-	-	-	0	0	0	0	0	0
00-01	0.10	0.10	0.05	0.11	1.16	0.95	0	0	0	0.12	0.12	0.12
01-02	0.14	0.14	0.11	0	0	0	0	0	0	0	0	0
99-02	DS= 0.20; D= 2.03 ; SE= 0.90						DS= 0.01; D= 0.02 ; SE= 0.01					

DS: group density (gp/km²); D: individual density (Ind/km²); SE: Standard error.

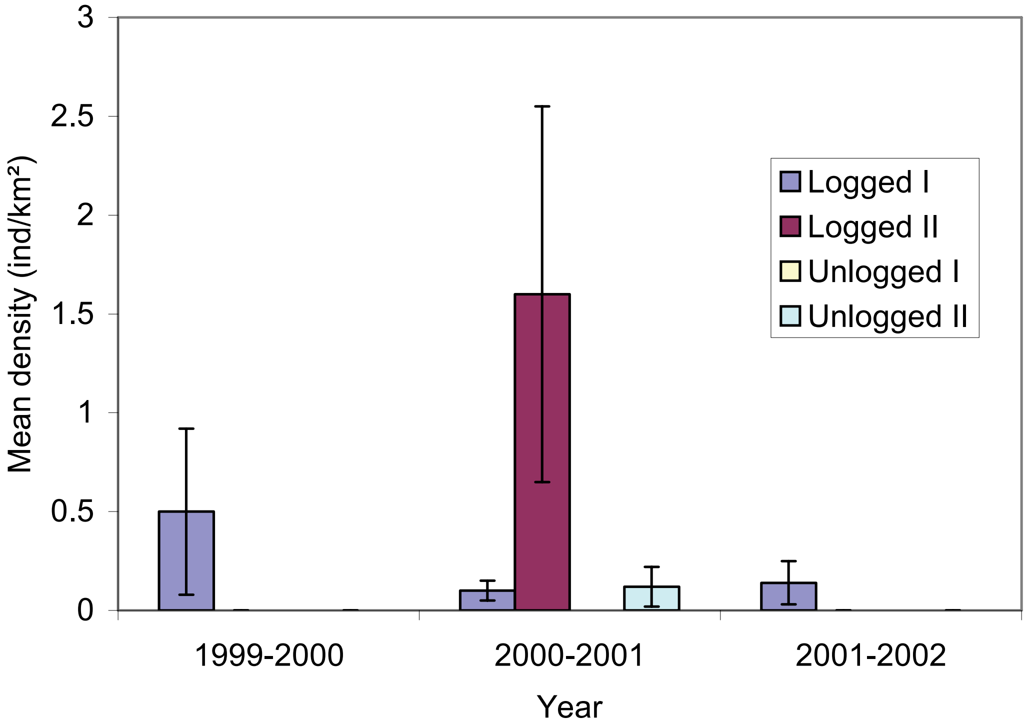

Figure 3.17: Mean density of *Pan troglodytes* in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

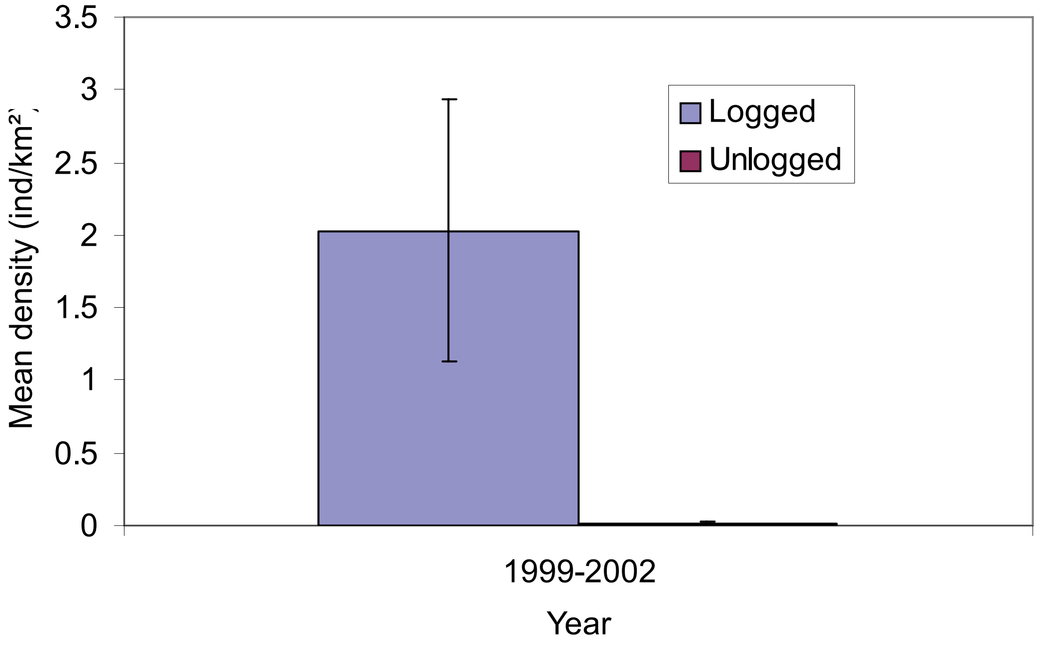

Figure 3.18: Mean density of *Pan troglodytes* in unlogged (I+II) and logged (I+II) study sites from 1999-2002.

3.2.2.8 Drill (*Mandrillus leucophaeus*)

The Drill was only observed in logged I (first year) with a density of 0.90 ind/km² and in unlogged I (second year) with a density of 1.67 ind/km² with rather large variability (Table 3.15; Figure 3.19 and appendices 3.36 and 3.37).

At large spatial scale, the difference in density was reduced to about 12% between unlogged study sites (1.03 ind/km²) and logged study sites (0.95 ind/km²; Figure 3.20; appendix 3.38).

Table 3.15: Mean group density (gp/km²), mean density (ind/km²) and standard error for the *Mandrillus leucophaeus* in unlogged and logged study sites from 1999 to 2002.

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	0.05	0.90	0.02	-	-	-	0	0	0	0	0	0
00-01	0	0	0	0	0	0	0.22	1.67	0.98	0	0	0
01-02	0	0	0	0	0	0	0	0	0	0	0	0
99-02	DS= 0.04; D= 0.91 ; SE= 0.1						DS= 0.03; D= 1.03 ; SE= 0.1					

DS: group density (gp/km²); D: individual density (Ind/km²); SE: Standard error.

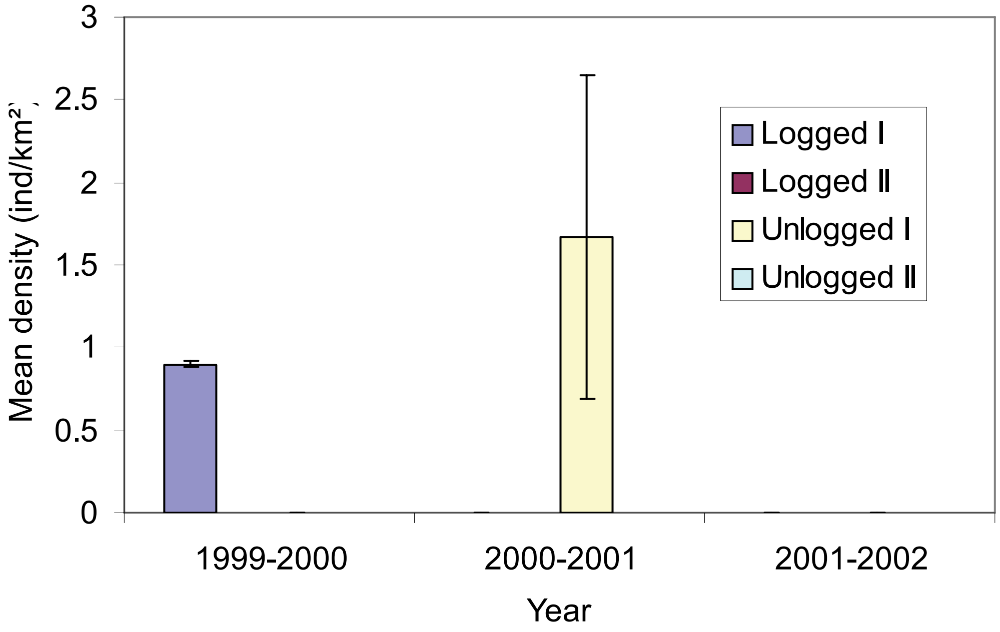

Figure 3.19: Mean density of *Mandrillus leucophaeus* in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

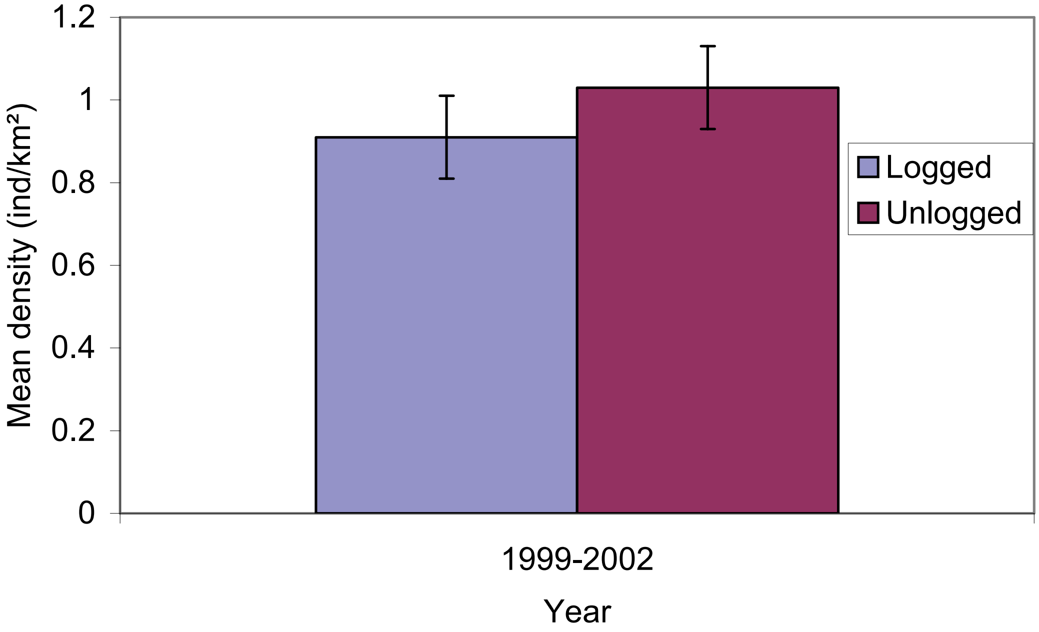

Figure 3.20: Mean density of *Mandrillus leucophaeus* in unlogged (I+II) and logged (I+II) study sites from 1999-2002.

3.3 Hornbills

3.3.1 Abundance

Hornbill abundance differed from one study site to another and from one year to another. In logged I, the black-casqued hornbill (*C. atrata*) was more abundant (n= 114) in the first year than in unlogged I (n= 85) and unlogged II (n= 67). The brown-checked hornbill (*C. cylindricus*) was more abundant in logged I (n= 99) compared to unlogged I (n= 92) and unlogged II (n= 72 and Table 3.17).

In the second year, the abundance of the black-casqued hornbill decreased from n= 114 observations in the first year to n= 99 observations in logged I. This species was more observed in logged II (n= 105) compared to unlogged I (n= 95) but rather with more observations in unlogged II (n= 153). The brown-checked hornbill was more observed in both logged I (n= 104) and unlogged I (n= 146). However, the species was less observed in logged II (88 observations) and in unlogged II (n= 62).

In the third year, both black-casqued and brown-checked hornbills were less observed in logged I (n = 49 and n= 47 respectively), logged II (n= 30 and n= 38 respectively), in unlogged I (n= 46 and n= 109 respectively) and in unlogged II.

From 1999-2002, the black-casqued hornbill was less abundant in logged study sites (n= 392) compared to unlogged study sites (n= 482). A similar result was found for the brown-checked hornbill with n= 548 observations in unlogged study sites compared to n= 376 observations in logged study sites (Table 3.16).

Table 3.16: Number of observations of hornbills in unlogged (I + II) and logged (I + II) study sites from 1999-2002.

		Pooled logged		**Pooled unlogged**	
Year	**Hornbills**	n	N	n	N
1999	*Ceratogymna atrata*	392	741	482	692
2002	*Ceratogymna cylindricus*	376	718	548	803

n= number of observations; N= estimate number of hornbills

Table 3.17: Number of observations of hornbills in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

		Logged I		**Logged II**		**Ulnlogged I**		**Unlogged II**	
Year	**Hornbill species**	n	N	n	N	n	N	n	N
1999	*Ceratogymna atrata*	114	423	n.a	n.a	85	173	67	251
2000	*Ceratogymna cylindricus*	99	348	n.a	n.a	92	172	72	232
2000	*Ceratogymna atrata*	94	433	105	331	95	282	153	795
2001	*Ceratogymna cylindricus*	104	442	88	351	146	476	62	371
2001	*Ceratogymna atrata*	49	315	30	129	46	271	36	206
2002	*Ceratogymna cylindricus*	47	290	38	291	109	376	67	670

N=estimates number of hornbills; n=number of observations; n.a= non available

3.3.2 Densities

3.3.2.1 The black-casqued hornbill (*Ceratogymna atrata*)

In year one and at study site level (Table 3.18), the density of the black-casqued hornbill was higher in logged I (26.42 ind/km²) compared to unlogged I (10.80 ind/km²) and unlogged II (15.69 ind/km²; appendix 3.39). In year two, the density of the black-casqued hornbill remained stable in logged I (27.09 ind/km²) compared to year one. At the same time, we estimated rather higher densities in unlogged I (17.60 ind/km²) and unlogged II (49.71 ind/km²) compared to unlogged I and II in year one (Appendix 3.40).

Densities in year three of the black-casqued hornbill rapidly dropped from logged I (19.69 ind/km²), logged II (8.08 ind/km²), unlogged I (16.91 ind/km²) to unlogged II (12.85 ind/km² ± 2.32) compared to year one and two (Figure 3.21 and appendix 3.41)

Overall, from 1999-2002 density of the black-casqued hornbill in logged study sites was higher at about 17% (23.15 ind/km²) compared to unlogged study sites (21.61 ind/km²; Figure 3.22) with rather low variations (Appendix 3.45).

Table 3.18: Mean group density (gp/km²), mean density (ind/km²) and standard error for the *Ceratogymna atrata.* In unlogged and logged study sites from 1999 to 2002.

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	9.34	26.42	6.03	-	-	-	7.20	10.80	2.54	6.32	15.69	2.23
00-01	9.80	27.09	3.85	12.21	20.66	3.59	10.55	17.60	4.76	19.61	49.71	10.10
01-02	7.00	19.69	3.90	4.41	8.08	3.57	6.76	16.91	3.66	6.00	12.85	2.32
99-02	DS= 9.07; D= 23.15; SE= 2.74						DS= 9.27; D= 21.61; SE= 1.96					

DS: group density (gp/km²); D: individual density (Ind/km²); SE: Standard error

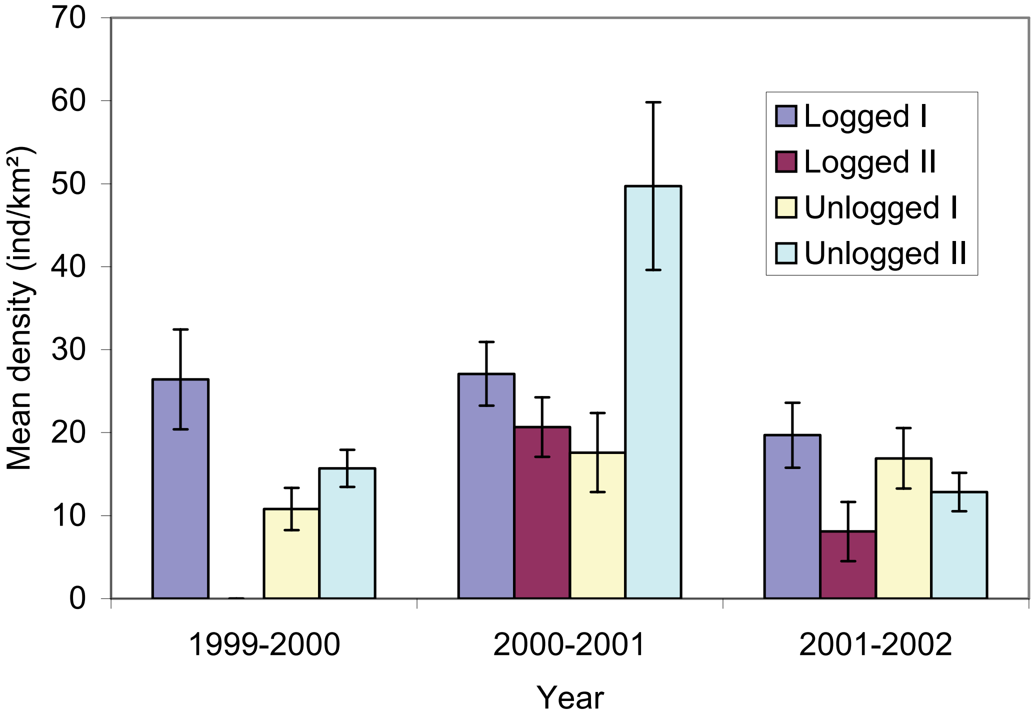

Figure 3.21: Mean density of *Ceratogymna atrata.* in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

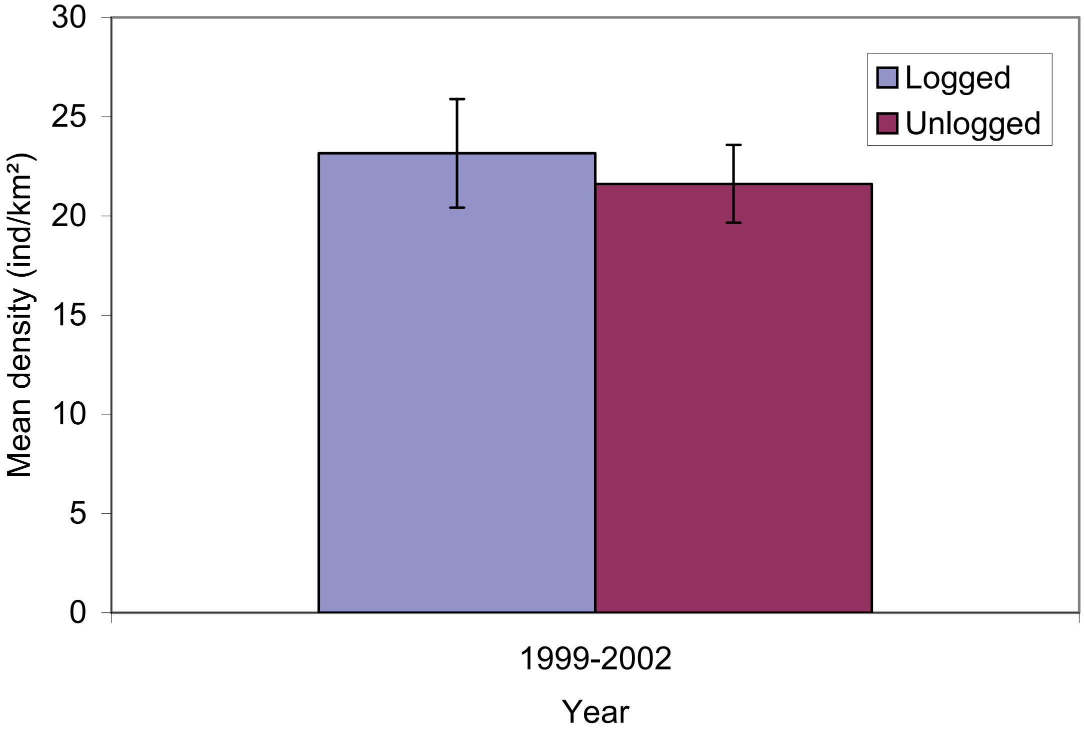

Figure 3.22: Mean density of *Ceratogymna atrata.* in unlogged (I and II) and logged (I+II) study sites from 1999-2002.

3.3.2.2 The brown-checked hornbill (*Ceratogymna cylindricus*)

At study site levels (Table 3.19), densities of the *Ceratogymna cylindricus* in the first year were higher in logged I (21.72 ind/km²) compared to unlogged I (10.72 ind/km²) and unlogged II (14.79 ind/km² and appendix 3.42). We estimated rather higher densities in the second year in logged I (27.60 ind/km²), logged II (21.92 ind/km²), unlogged I (29.74 ind/km²) and unlogged II (23.19 ind/km² and appendix 3.43). However, apart from an increase in density of about 47% in unlogged I (41.88 ind/km²), densities in logged I (18.13 ind/km²), logged II (18.16 ind/km²) and unlogged I (23.51 ind/km²) were rather low compared with densities in year two (Figure 3.23 and appendix 3.44).

At large spatial scale, the brown-checked hornbill densities were at about 11% higher in unlogged study sites (25.05 ind/km²) compared to logged study sites (22.43 ind/km²; Figure 3.24 and appendix 3.45).

Table 3.19: Mean group density (gp/km²), mean density (ind/km²) and standard error for the *Ceratogymna cylindricus* in unlogged and logged study sites from 1999 to 2002:

Year	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	DS	D	SE	DS	D	SE	DS	D	SE	DS	D	SE
99-00	8.11	21.72	2.81	-	-	-	8.00	10.72	2.21	7.00	14.79	1.66
00-01	10.83	27.60	3.19	10.23	21.92	4.25	16.22	29.74	4.86	7.95	23.19	5.66
01-02	6.71	18.13	3.38	5.58	18.16	5.17	16.03	23.51	4.83	11.17	41.88	6.11
99-02	DS= 8.70 ; D= 22.43 ; SE= 1.83						DS= 10.53 ; D= 25.08 ; SE= 2.85					

DS: group density (gp/km²); D: individual density (Ind/km²); SE: Standard error

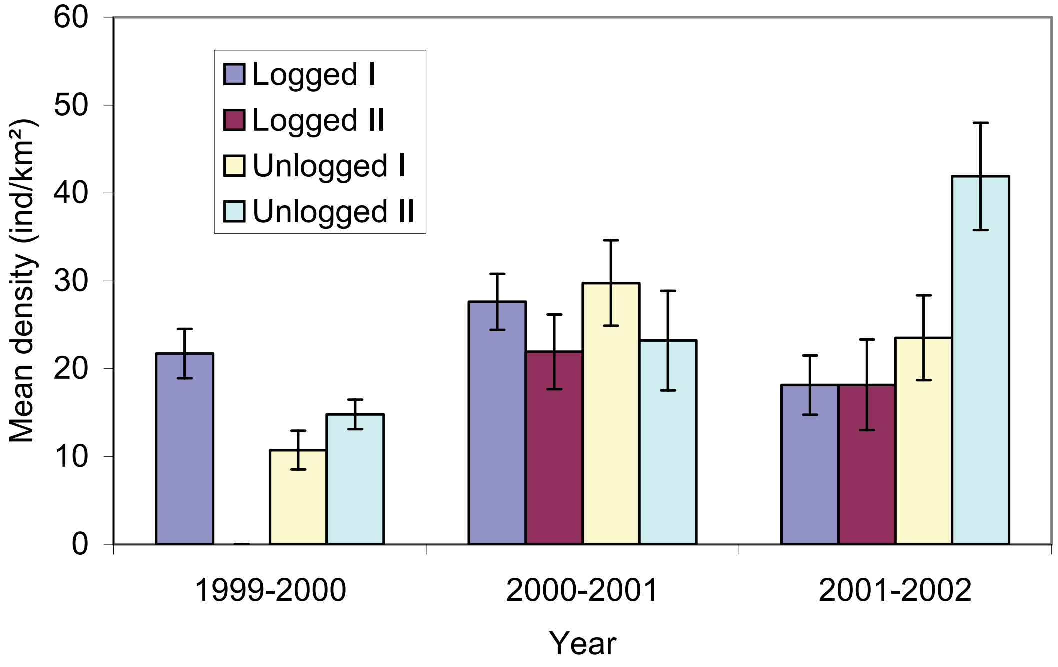

Figure 3.23: Mean density of *Ceratogymna cylindricus.* in unlogged (I and II) and logged (I and II) study sites from 1999-2002.

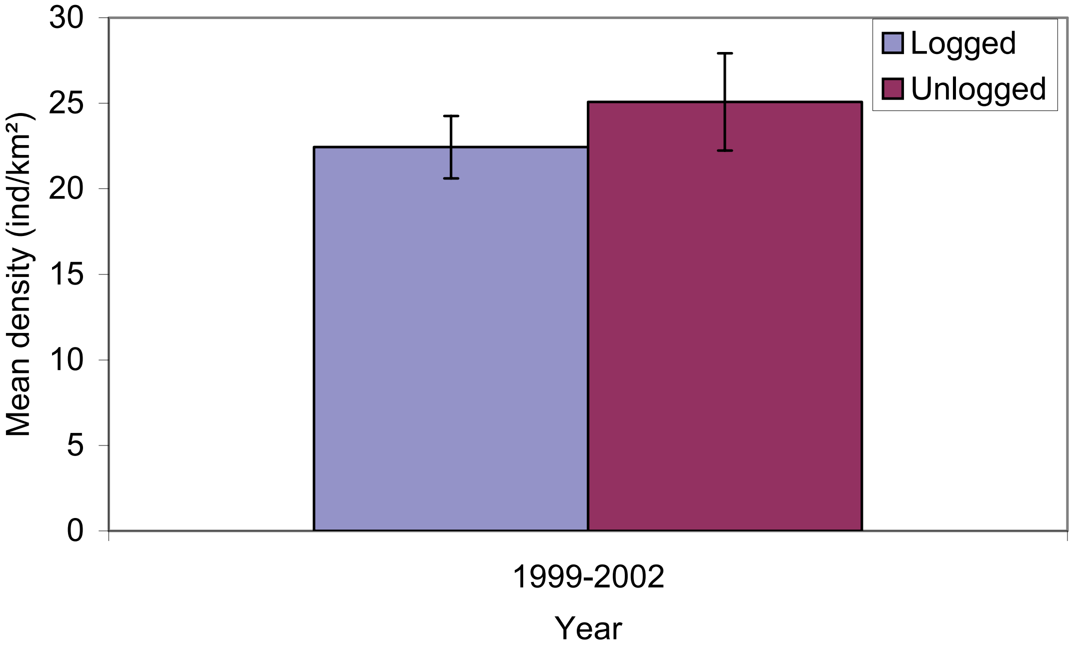

Figure 3.24: Mean density of *Ceratogymna cylindricus.* in unlogged (I+II) and logged (I+II) study sites from 1999-2002.

3.4 Relationship between primate encounter rates and their potential food tree resources in unlogged and logged study sites

3.4.1 *C. mona* encounter rates and their potential food trees resources

At transect level (n= 6), we did not find any correlation between mona monkey and the overall potential food abundance (Table 3.20). However, at selected key individual food resource level (n=6), we found a negative, strong and significant correlation between the mona monkey and the *Pycnanthus angolensis* (R= -0.70; P= 0.0001; Figure 3.25) but no correlation was found between the mona monkey and the Cola spp, *Irvingia gabonensis* and *Musanga cecropioides* (Table 3.21).

At large scale level (n= 12) and in logged areas, we did not find any correlation between the mona monkey and the overall potential food tree resources. However we found a negative, modest and significant correlation (R= -0.64 and P= 0.02) in unlogged areas between the two variables (Figure 3.26; Table 3.22).

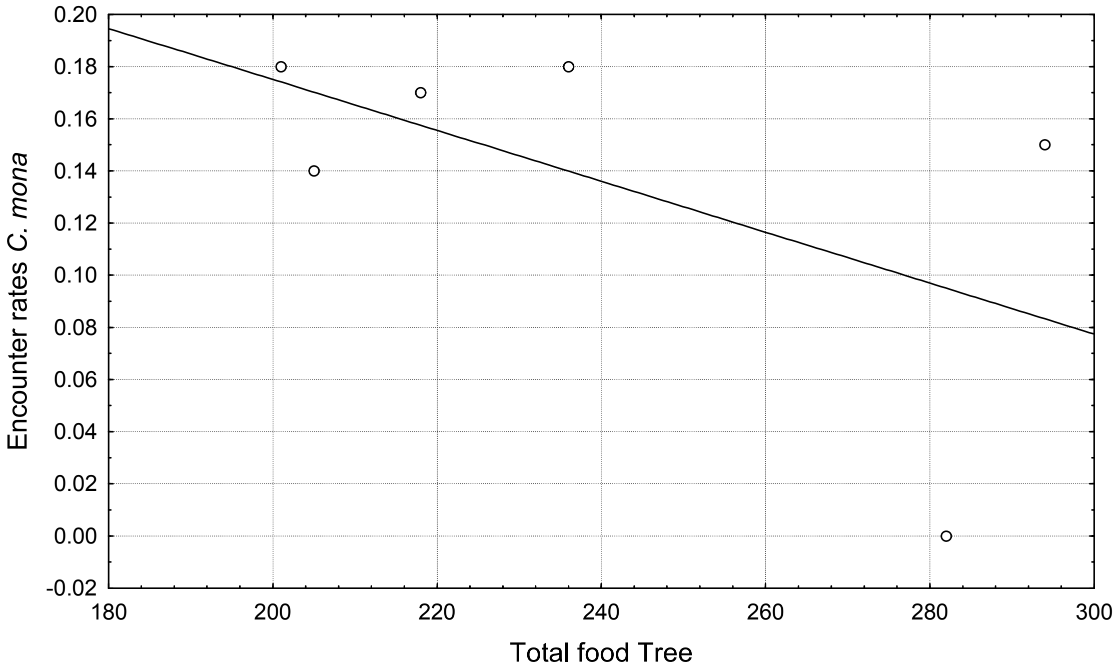

Figure 3.25: Correlation between encounter rates of *C. mona* and *Pycnanthus angolensis* in unlogged II (n= 6). Spermann Rank correlation values: R= -0.70 and P= 0.0001.

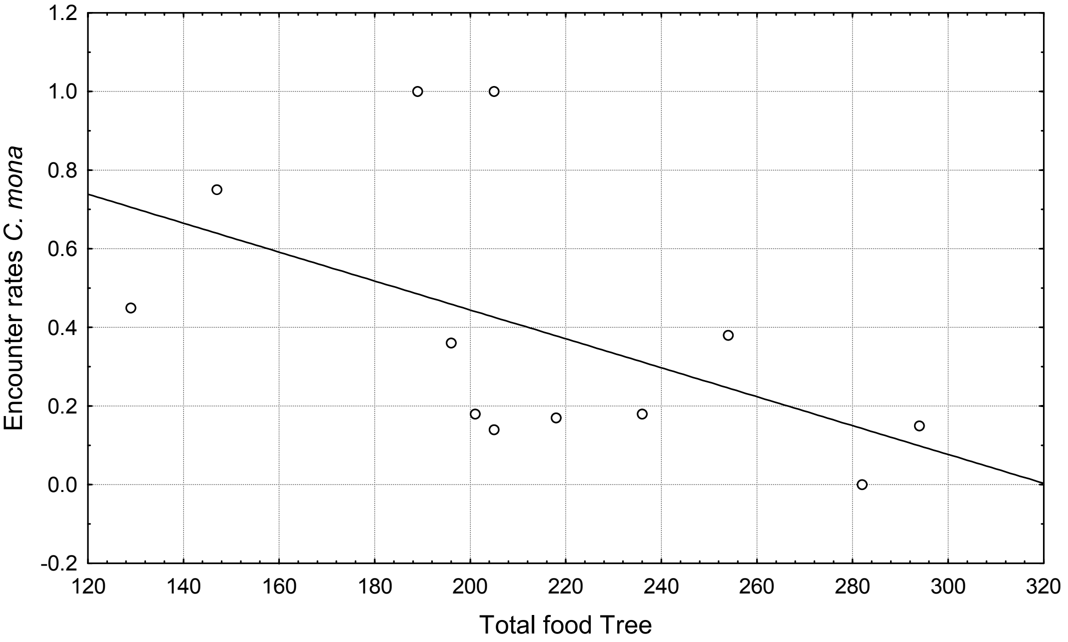

Figure 3.26: Correlation between encounter rates of *C. mona* and potential total food resources in unlogged forest study sites (n= 12). Spermann Rank correlation values: R= -0.64 and P= 0.02.

3.4.2 *C. nictitans nictitans* encounter rates and their potential food tree resources

At transect level (n= 6), we observed no correlation between the putty-nosed monkey and its potential food tree resources (Table 3.20).

At selected key individual food resource level (n= 6), we found a negative, modest but significant correlation between the putty-nosed and *Pycnanthus angolensis* (R= -0.51; P= 0.01 Figure 3.27). However, the Putty-nosed monkey did not correlate with other selected food tree resources (Table 3.21).

At large scale level (n= 12), no correlation was found in unlogged forest areas however, we found a negative, modest and significant correlation (R= -0.60 and P= 0.04) between the putty-nosed monkey and its potential food tree resources in logged forest study sites (Table 3.22; Figure 3.28).

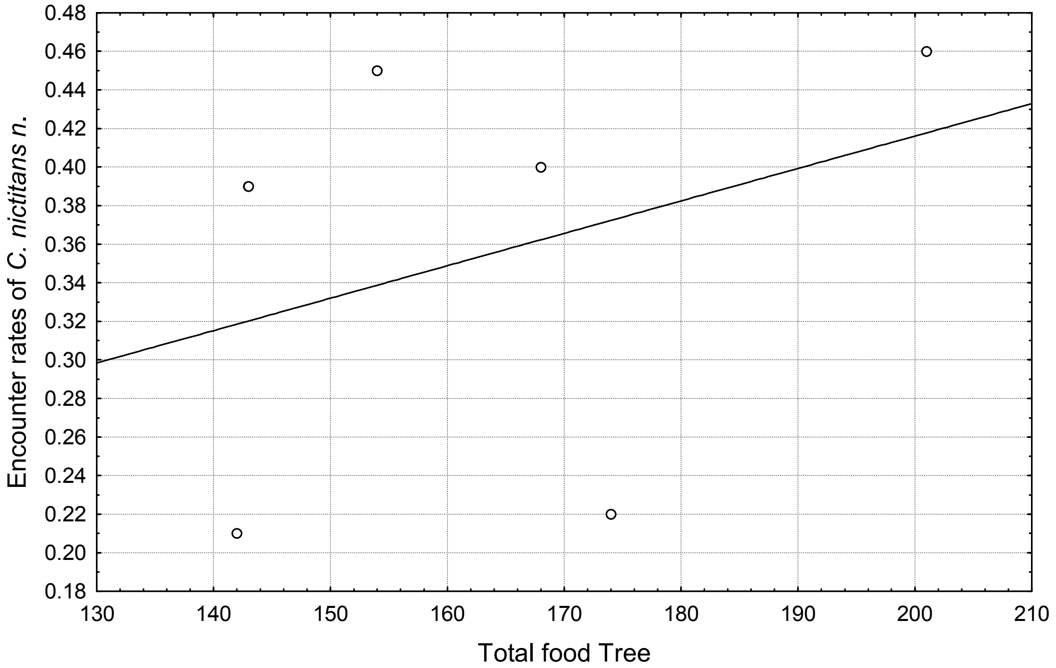

Figure 3.27: Correlation between encounter rates of *C. nictitans nictitans* and *Pycnanthus angolensis* resources in logged I (n= 6). Spermann Rank correlation values: R= -0.51; P= 0.01.

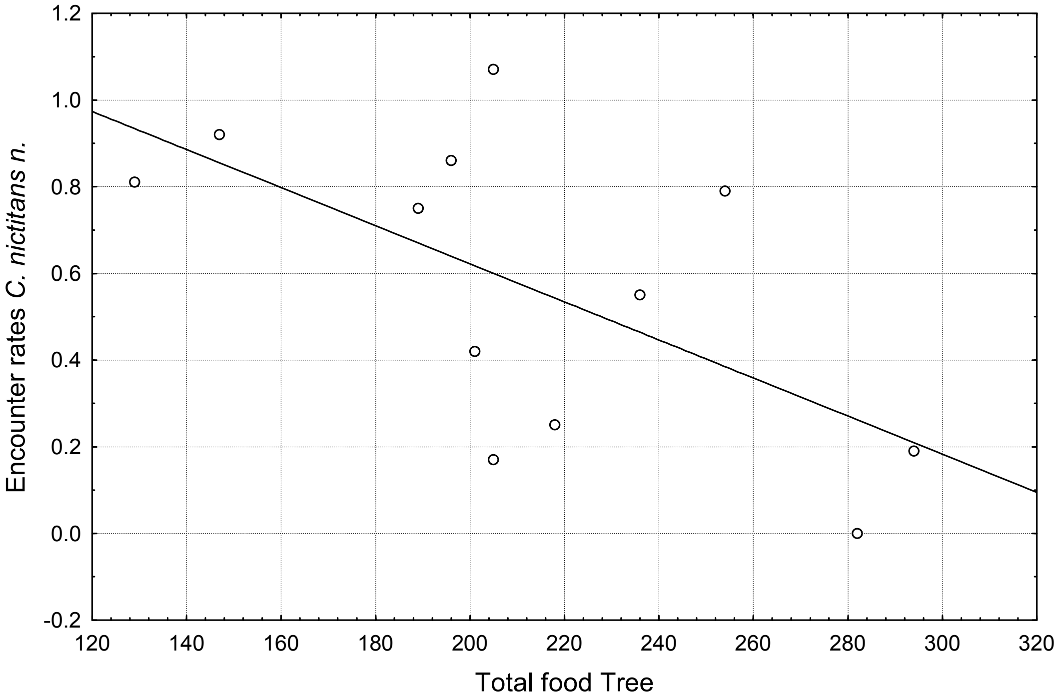

Figure 3.28: Correlation between encounter rates of *C. nictitans nictitans* and potential total food tree resources in logged forest study sites (n= 12). Spermann Rank correlation values: R= -0.60 and P= 0.04

3.4.3 *C. erythrotis* encounter rates and their potential food tree resources

At transect level (n= 6), no correlation was observed between the red-eared monkey and its potential food tree resources (Table 3.20).

At selected key individual food tree species level (n= 6), no correlation was found between the red-eared monkey and the *Pycnanthus angolensis, Cola sp, Irvingia gabonensis* and *Musanga cecropioides* (Table 3.21).

At large scale level (n= 12), we also did not find any correlation both in logged and unlogged forest study sites between the studied primates and their potential food tree resources (Table 3.22).

3.4.4 *C. pogonias* encounter rates and their potential food tree resources

At transect level (n= 6) and in logged I, unlogged I and II, we found no correlation between the crowned monkey and its potential food tree resources. However, in logged II, we found a negative, strong and significant correlation (R= -0.88; P= 0.019) between the crowned monkey and its potential food tree resources (Table 3.20; Figure 3.29)

At selected key food tree species level (n= 6), we observed no correlations between the crowned monkey and the presumed key food tree resources. This pattern was also observed at large spatial scale (n= 12; Table 3.21).

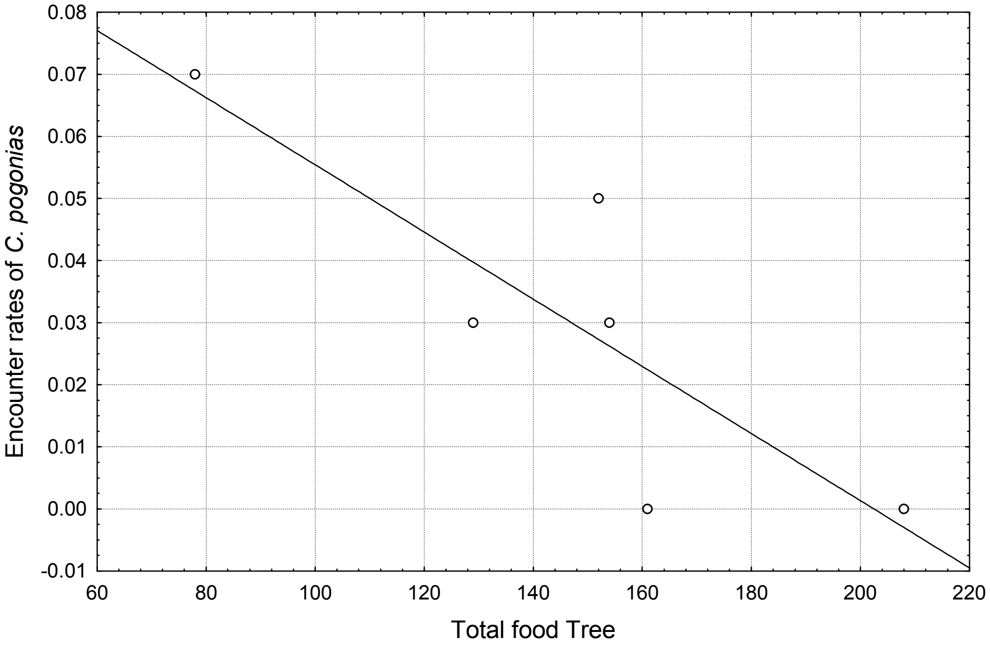

Figure 3.29: Correlation between encounter rates of *C. pogonias* and potential total food tree resources in logged II, n= 6. Spermann Rank correlation values: R= -0.88; P= 0.019.

3.4.5 *C. torquatus* encounter rates and their potential food tree resources

At transect level (n= 6) and in logged I, unlogged I and II, we observed no correlation between the red-capped mangabey and its potential food tree resources (Table 3.20). However, we found in logged II, a negative, very strong and significant correlation between the red-capped mangabey and its potential food tree resources (R= -0.94, P= 0.005 Table 3.21; Figure 3.30).

At transect level and with the selected key food tree resources but as well as at large spatial scale level (n= 12) we did not find any correlation between the red-capped mangabey and the *Pycnanthus angolensis, Irvingia gabonensis* and *Musanga cecropioides* (Table 3.22).

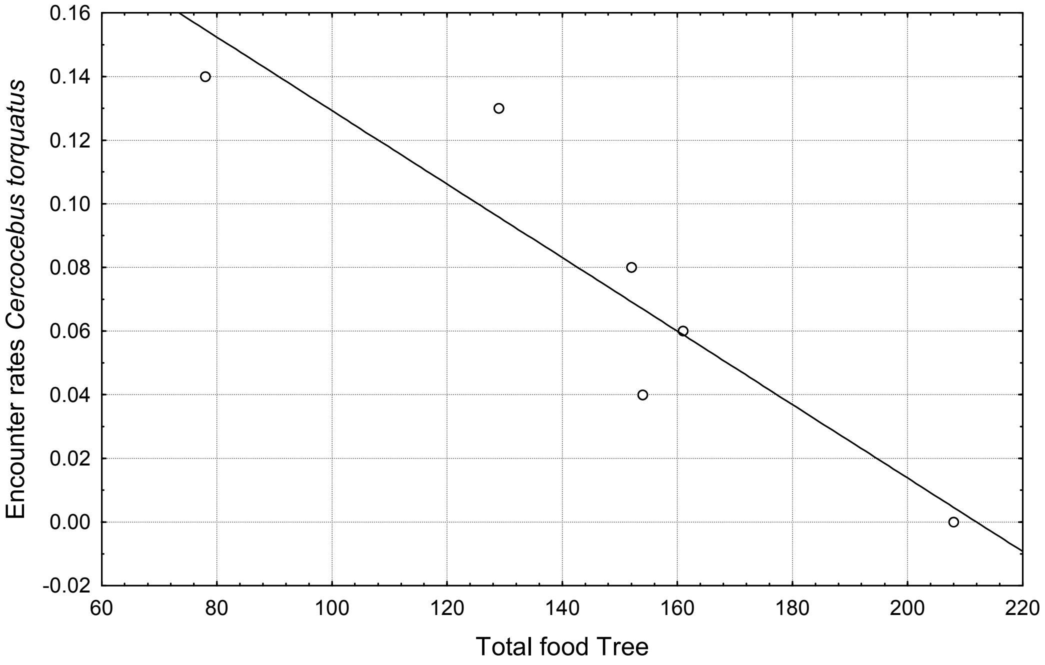

Figure 3.30: Correlation between encounter rates of *Cercocebus torquatus* and potential total food tree resources in logged II, n= 6. Spermann Rank correlation values: R= -0.94, P= 0.005.

3.4.6 *P. pennantii preussi* encounter rates and their potential food tree resources

Both at transect (n= 6) and at large spatial scale (n= 12) levels, no correlation was observed between the preuss' red colobus and its potential food tree resources (Table 3.20). We also found no correlation between the two variables (preuss' red colobus and key selected food tree resource level (Table 3.21).

3.4.7 *P. troglodytes* encounter rates and their potential food tree resources

Neither did we find at transect (n= 6) nor at large scale (n= 12) levels any correlation between the chimpanzee and its potential food tree resources (Table 3.20 and Table 3.21)
The same pattern was observed between this great Apes and the four selected key food tree resources (Table 3.22).

3.4.8 *M. leucophaeus* ecounter rates and their potential food tree resources

At transect level (n= 6), we found no correlation between the drill and its potential food tree resources (Table 3.20) and as well as at large spatial scale level (n= 12; Table 3.21) and also with the selected key food tree resources (Table 3.22).

3.4.9 *C. atrata* encounter rates and their potential food tree resources

At transect level (n= 6), we found no correlation between the black-casqued hornbill and its potential food tree resources (Table 3.20) as well as with the selected key food tree resources (Table 3.21). The same pattern was observed between the two variables at large spatial scale level (n= 12).

3.4.10 *C. cylindricus* encounter rates and their potential food tree resources

At transect level (n= 6) and in logged I and unlogged II, we did not find any correlation between the brown-casqued hornbill and its potential food tree resources while in unlogged I we obtained a positive, modest and significant correlation (R= 0.82 and P= 0.04) of the two variables (Figure 3.31 Table 3.20).
At transect level and with the selected key food tree resources, we found a negative, strong and significant correlation (R= -0.82 and P= 0.04; Table 3.21) between the *C. cylindricus* and the *Pycnanthus angolensis*.
At large spatial scale level (n= 12), we did not find any correlation between the two studied variables (Table 3.22).

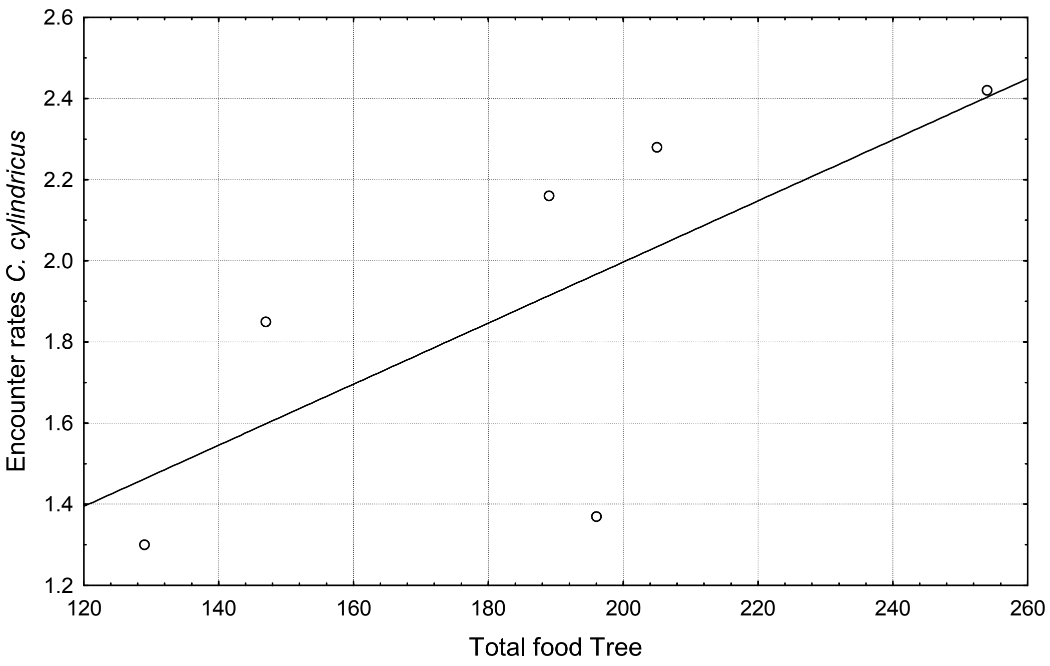

Figure 3.31: Correlation between encounter rates of *Ceratogymna cylindricus* and potential total food tree resources in unlogged I, n= 6. Spermann Rank correlation values: R= 0.82 and P= 0.04.

Table 3.20: Correlations between primate, hornbill encounter rates and their potential food tree resources per transect (n= 12) in unlogged (I+II), logged (I+II) study sites.

Primate and hornbill species	**Logged**			**Unlogged**		
	R	t(N-2)	P	R	t(N-2)	P
Cercopithecus mona	-0.07	-0.23	0.82	-0.64	-2.70	0.02
Cercopithecus nictitans n.	0.07	0.22	0.82	-0.60	-2.38	0.04
Cercopithecus erythrotis	-0.05	-0.15	0.88	-0.50	-1.81	0.10
Cecopithecus pogonias	-0.5	-1.72	0.11	-0.09	-0.31	0.76
Cercocebus torquatus	-0.33	-1.11	0.29	-0.47	-1.68	0.76
Procolobus pennantii preussi	-0.47	-1.70	0.11	-0.48	-1.73	0.11
Pan troglodytes	-0.45	-1.62	0.13	0.08	0.27	0.79
Mandrillus leucophaeus	0	0	1	-0.21	-0.71	0.49
Ceratogymnna atrata	-0.21	-0.69	0.50	-0.25	-0.83	0.49
Ceratogymna cylindricus	0.08	0.26	0.80	0.08	0.25	0.80

Table 3.21: Correlations between primate and hornbill encounter rates and their potential food tree resources per transect (n=6) in logged I, logged II, unlogged I and unlogged II.

Primate and hornbill species	**Logged I**			**Logged II**			**Unlogged I**			**Unlogged II**		
	R	**t(N-2)**	**P**	**R**	**t(N-2)**	**P**	**R**	**t(N-2)**	**P**	**R**	**t(N-2)**	**P**
Cercopithecus mona	-0.11	-0.23	0.82	-0.08	-0.17	0.87	-0.14	-0.29	0.78	-0.41	-0.89	0.42
Cercopithecus nictitans n.	0.60	1.50	0.20	0.41	0.90	0.42	0.28	0.05	0.96	-0.31	-0.66	0.54
Cercopithecus erythrotis	0.12	0.23	0.82	0.52	1.22	0.29	0.33	0.71	0.52	-0.48	-1.11	0.33
Cecopithecus pogonias	0.60	1.73	0.16	-0.88	-3.75	0.019	-0.06	-0.12	0.91	-0.12	-0.25	0.82
Cercocebus torquatus	0.39	0.86	0.44	-0.94	-5.65	0.005	0.20	0.40	0.70	-0.65	-1.73	0.15
Procolobus pennantii preussi	-0.70	-1.83	0.14	-0.40	-0.85	0.44	-0.65	-1.73	0.16	n.a	n.a	n.a
Pan troglodytes	0.24	0.51	0.64	-0.71	-2.04	0.11	n.a	n.a	n.a	-0.30	-0.64	0.56
Mandrillus leucophaeus	-0.13	-0.26	0.80	n.a	n.a	n.a	0.13	0.26	0.80	n.a	n.a	n.a
Ceratogymnna atrata	0.25	0.53	0.62	-0.25	-0.53	0.62	0.60	1.50	0.21	-0.65	-1.74	0.15
Ceratogymna cylindricus	-0.23	-0.48	0.65	0.65	1.74	0.15	0.82	2.96	0.04	0.25	0.53	0.62

Table 3.22: Correlations between primate and hornbill encounter rates and their potential food tree resources per transect(n=6) in logged I, logged II, unlogged I and unlogged II.

Primate and hornbill species	***Pycnanthus angolensis***			***Cola sp***			***Irvingia gabonensis***			***Musanga cecropioides***		
	R	**t(N-2)**	**P**	**R**	**t(N-2)**	**P**	**R**	**t(N-2)**	**P**	**R**	**t(N-2)**	**P**
Cercopithecus mona	-0.70	-4.55	0.0001	0.08	0.41	0.68	0.08	0.39	0.69	-0.04	-0.02	0.84
Cercopithecus nictitans n.	-0.51	-2.80	0.01	0.04	0.20	0.84	-0.04	-0.19	0.85	-0.03	-0.15	0.88
Cercopithecus erythrotis	-0.35	-1.74	0.09	-0.11	-0.51	0.62	0.17	0.84	0.41	0.01	0.05	0.95
Cecopithecus pogonias	-0.20	-0.98	0.33	0.27	1.33	0.19	0	0	1	0.29	1.44	0.16
Cercocebus torquatus	-0.51	-2.78	0.01	0.01	0.05	0.95	0.12	0.58	0.56	-0.14	-0.67	0.51
Procolobus pennantii preussi	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a	n.a
Pan troglodytes	-0.04	-0.21	-0.83	-0.22	-1.05	0.30	-0.19	-0.94	0.35	0.05	0.26	0.79
Mandrillus leucophaeus	-0.21	-0.99	0.33	0.10	0.50	0.62	0.29	1.41	0.17	-0.25	-1.19	0.24
Ceratogymnna atrata	-0.33	-0.71	0.51	-	-	-	-0.35	-0.74	0.49	0.14	0.29	0.78
Ceratogymna cylindricus	-0.82	-2.90	0.04	-	-	-	0.30	0.65	0.55	-0.44	-0.98	0.38

4 DISCUSION

4.1 Effects of selective logging on the vegetation in unlogged and logged areas

4.1.1 Tree abundance

Tropical rainforests are an association of many different types of vegetation and wildlife. Depending on the intensity, selective logging has an impact on the vegetation and wildlife abundance. We found a significant difference in tree abundance between unlogged and logged study sites. Tree abundance was at 38% higher in unlogged study sites compared to logged study sites. In Kibale forest, Uganda, commercially mechanised logging resulted in the destruction of about 50% of the original stand (Kesenene, 2001). This difference could be a result of poor felling methods, non respect of exploitable diameter class and skidding road constructions which have affected trees within the studied class of ≥ 8 cm dbh. Some of our transects and plots felt on these highly disturbed areas, where almost no tree within the studied dbh was found, thus contributing to the reduction in tree abundance in logged forest study areas. Though belonging to the same ecological region, the unlogged forest study sites differed geographically from logged forest sites. Begon *et al*. (1990) observed a strong correlation between species abundance and richness with altitude and concluded that a decrease in species abundance and richness with altitude was a widespread phenomenon. The topography in logged forest study sites is dominated by high elevation rising from 200 m to 1000 m (Nkewnde hills) above sea level while in unlogged forest study sites there exist gentle hills and slopes whose level range from 250 m to 300m a.s.l.). Beside logging activities and considering that tree abundance reduce with altitude (Oliver and Larson, 1996) the higher number of trees found in unlogged forest study sites could therefore be the result of the low elevation. Compared to unlogged II forests, unlogged I forests are highly affected by large scale cash crop (palm oil and coffee) farming followed by the clear cutting of the vegetation. Some of our transects in this region were more or less affected by this phenomenon. The degree of disturbances between the logged and unlogged forest study sites could also explain the difference in tree abundance between the two sites. Logging results in an increase of large forest gaps which favour the invasion of secondary forest tree formation (Kesenene, 2001). In logged forest areas we found a high number of *Musanga cecropioides* (also known as umbrella tree) and *Pycnanthus angolensis*, species described as typical pioneer species (Struhsaker 1997) which colonise forest gaps after forest disturbances (farming, wind fall, selective logging). Many species of pioneer tree species and gap opportunists depend on forest gaps for their survival. Out of 97 stems of *M. cecropioides* recorded in our study, 89%

(86 stems) were found in logged forests sites while 56% of the *Pycnanthus angolensis* were also more abundant in logged forest than in unlogged forest areas.

Considering natural factors that could affect the abundance of trees in tropical rainforests (tree mortality, wind fall, competition and topography), we can attribute the reduction in tree abundance between unlogged and logged study forest areas to commercial logging. The physical scale is not an important factor in determining tree abundance in a given forest area rather the disturbance scale has a greater impact on tree abundance. Skorupa (1988), Struhsaker (1997), Lwanga *et al.* (2000) and Zapfack *et al.* (2002), also found similar patterns in tree abundance on the assessment of tree diversity and abundance between exploited and non exploited forest areas.

The Korup region is home to high wildlife and plant species richness, abundance and diversity (Gartlan, 1986; Thomas, 1995; 1997 and Newbery *et al.,*1998) and more than 620 species of trees and shrubs have been so far recorded in the area. This study clearly shows that despite commercial timber exploitation carried out within the vicinity of the Korup National Park, there is still a high potential of forest resources in logged forests of the Korup region.

4.1.2 Tree species richness and diversity

Species richness is one of the fundamental component of species diversity (Begon *et al.,* 1990). It represents a nonadditive variable when aggregated across scales (He *et al.,* 2002). Variations in species richness in a given forest area depend largely on gradient features such as latitude and altitude (Begon *et al*., 1990). The total number of tree species recorded at dbh ≥ 8 cm was 217, while the total species richness of the Korup forests is estimated to be at 620, which includes trees, shrubs and lianas (Gartlan 1986 and MINEF 2003). At transect level, the number of tree species in logged forest study sites was reduced by ca. 43% compared to unlogged forest study sites, while at plot level, species richness was reduced by ca. 41%. These differences can be explained through several factors, among them the degree of disturbances and spatial scale size.

The logged forest study sites are covered by a huge skidding road network and patches of exploited forests. Some of the transects (and plots) were established in these highly disturbed areas. Due to the high disturbance of the forest in these sites, we found fewer species thus less diverse forests (Skorupa, 1988). Hill and Hamer (2004) noted that disturbance reduces habitat heterogeneity at small to intermediate spatial scales, but that habitat heterogeneity increased at larger spatial scale under different disturbance intensities. They concluded that large spatial scale are expected to report increased diversity following disturbance due to elevated β diversity across disturbed sites. Struhsaker (1997) also found that even moderate logging reduces species number when comparing logged and unlogged forest areas. Johns (1983) also attributed the reduction of 82.5% in tree diversity in Malaysia to logging. Bobo *et al.,* (2005) observed a significant decrease of tree species richness with increasing level of habitat modification. Species richness is commonly measured on the basis of sample size units or scales (He *et al.,* 2002). The sample size unit is obviously one of the parameters that could determine the amount of species in a given area. Large sample units (e.g.: 1 transect à 7 plots) are more heterogeneous than small sample units. They provide a greater variety of microclimates, microhabitats, different soil types and topography which could accommodate more species than small homogeneous sample units (e.g.: 0.25 ha plot, Begon *et al*., 1990). The relative high number of species richness at transect level in unlogged forest study sites could also be explained by the heterogeneous nature of the environment in these forests.

Species accumulation curve of the unlogged and logged study sites were almost asymptomatic in shape, suggesting that most species in the study area were represented in all samples (Lwanga *et al.,* 2000). Compared to Kibale forests which are described as species-poor forests (Lwanga *et al.,* 2000) with 14 species per hectare, we found a high number of species per plot (0.25 ha plot) with an average of 22 species in logged forest areas and 32 species in unlogged forest areas suggesting a species-rich forest. At large spatial scale (study site level) the difference in species richness between unlogged and logged study sites was not significant but significant at both plot and transect levels. Contrary to Kessler *et. al.,* (2005) findings when accumulation curves are compared on an individual basis, secondary forest are less species rich than primary forests. Our study suggests that species richness is scale dependent. The smaller the scale, the larger the difference in species richness between undisturbed and disturbed forests. Species richness is more influenced by the size of the area rather than by disturbance effects (Kessler *et. al*., 2005). But the difference in species richness at different spatial scales should be considered carefully because “much of the habitat variation that is typical for tropical rainforests is more likely to be represented in many small plots scattered throughout the study area than in one large plot of an equal area” (Lwanga *et al.,* 2000).

This phenomenon can even become more pronounced for shade bearing species (slow growth) many years after logging. In fact, large gaps created through felling of large trees will favour pioneer tree species or gap opportunist tree species (*Musanga cecropioides*, *Macaranga sp.*, *Oubangia alata*, *Protomegabaria stafiana*), unable to meet light and other nutritional requirements, these tree species will be excluded by the extreme hard conditions of survival. But if this assumption is true, how can tree species with practically no visible regeneration survive in the long term? However, climatic conditions could provide a convincing explanation why despite the dominance of pioneer species after logging, the forest remain with a considerable amount of shade bearing tree species. For successful establishment of natural regeneration, tree species require specific conditions, such as sufficient quantity of viable seeds and suitable conditions in the early stage of development. To survive in the early stage under poor light conditions, shade bearing species need sufficient amount of reserve. These species are able to judiciously utilise the little amount of light that reach the forest floor and slowly gain height where light conditions are improved. Although not quantified, the population of shade tolerant tree species in both unlogged and logged study forest areas seems to be considerable beside pioneer tree species.

However, despite the fact that there was no significant difference at study site level in tree species richness between unlogged and logged forest areas, low quantity extraction of timber would favour the inherent strategy of the tropical rainforests to maintain its higher species richness and diversity**.**

4.1.3 Vegetation composition

Tree species composition differed between unlogged and logged study sites. The statistical analysis via a two dimensional ordinate of the different transects based on tree abundance showed an overlap in vegetation composition between unlogged and logged study sites. But unlogged forest study areas did not differ from one another as well as logged forest study areas. This confirms the fact that despite the extraction of timber in logged forest areas, there is a potential natural vegetation that could ensure the recolonisation of the forest. The difference in vegetation composition between unlogged and logged study sites could be explained by the level of disturbances (logging) that has affected the vegetation in logged forest areas. DeWalt *et al*., (2003) also observed changes in vegetation composition between secondary and old growth stands. Struhsaker (1997) described a significantly higher density of tree species in unlogged and lightly logged areas than in moderately and heavily logged areas. Though belonging to the same gradient, the lower and upper disposition of the unlogged and logged geometric figures (Figure 3.6) could be explained by the maturity of the stand. Vegetation composition increases with stand age (DeWalt *et al*. 2003). Unlogged II forest areas seem to be more mature than logged forest areas which are in the process of conversion into an old-growth forests. The high abundance of *Musanga cecropioides*, a pioneer/gap opportunist species in logged forest areas reveal the level of disturbances (logging) in these forests.

The vegetation composition of our study sites suggests that besides natural ecological differences between study sites, selective logging is responsible for the change in tree community composition between unlogged and logged forest areas with an abundance of secondary forest tree species in logged forests.

4.1.4 Tree structure

The structural features of forest stand (e.g.: dbh, height) are good indicators of the dynamic processes in tropical rainforest regions. The diameter frequency distribution of natural tropical rainforests looks like a German Plenterwald (forest plantations) showing the well known D'Locourt curve or inverse J curve in which tree abundance decreases as the dbh increases. In our study, we found a higher number of trees within the lower diameter class both in unlogged and logged study sites. We also observed a relatively more trees within the upper diameter frequency in unlogged forest areas than in logged forest areas. The presence of more numbers of small trees within the lower diameter class in both unlogged and logged forest areas could be explained by the higher potential of natural regeneration of shade tolerant species which got established after several succession stages.

Our results are related to those described by Bouli *et al.,* (2004) who states that diameter frequency distribution always follows a decreasing pattern with a large number of trees within the lower diameter class and a few number of trees within the higher diameter class. Diameter distribution differences were more visible in the upper diameter frequency (≥ 120 dbh m) study sites. Considering that logged study sites belong to the same ecological region, we can conclude that almost all trees with exploitable diameter were harvested thus suggesting the unsustainability of timber extraction in the region. The absence of trees within the diameter class of 110 cm dbh – 120 cm dbh in both unloggedI I and logged II study sites could be explained by natural factors (growth rate, topography) rather than logging effects. Struhsaker (1997) also found that heavy logging reduced trees that were at least 25 m tall.

Logging operations in the Korup region followed by the non respect of logging regulations have to a large extent affected the structure of the vegetation in logged forests with an increase of understorey vegetation of secondary forest tree species.

4.1.5 Tree family distribution and basal area

Tree family diversity between unlogged and logged study sites did not differ from one site to another. Families such as *Caesalpiniaceae*, *Rubiaceae*, *Meliaceae* and *Euphorbiaceae* which comprise large trees of great economic importance in the rainforest (Letouzey, 1986) were more abundant in unlogged forest than in logged forest study sites within the upper diameter class. This suggests that the majority of trees in logged forest belonging to these families were logged. However the family *Papilionaceae*, *Moraceae* and *Myristicaceae* denoting secondary forest formations in which few large rainforest trees are found (Letouzey, 1986) were more represented in logged forest than in unlogged forest study sites. Tree family distribution in the study areas is similar with earlier studies on the vegetation in Kibale National Park, Uganda (Struhsaker 1997, Lwanga *et al.,* 2000), Takamanda region, Cameroon (Sunderland *et al*., 2003), and in the Barro Colorado Nature Monument (DeWalt *et al*., 2003).

The fact that all families were represented in both unlogged and logged forest areas of the study sites, suggest that logging has no impact on tree family distribution. But other factors such as soil structure and texture, climate, topography could have an impact on tree family distribution in tropical rainforest regions (Stuhsaker, 1997, Sunderland et al., 2003).

Tree basal area measured from 21 most important tree families with dbh ≥8 cm decreased from unlogged forests to logged forests. The total basal area of all trees within the studied dbh class was greatly reduced by selective logging in Kibale forests (Skorupa, 1988 and Struhsaker, 1997), results similar to those described in our study. Selective logging in the Kibale forests followed by extraction of large forest trees has resulted in the decrease of the basal area in logged forest compartments (John, 1985; Skorupa, 1988; Struhsaker, 1997; and Plumptre, 2001) effects similar to those observed in the Korup region. The tallest trees are removed. These large trees represent half of the ground biomass of the forest. In addition, large trees have a dominant role in an ecosystem, some constitute keystone species. These keystone species enrich forest ecosystem functions in a unique and significant manner through their activities. Their removal could result in change in tree species diversity and abundance but also in change in tree community structure. Therefore, the presence and abundance of some large trees in the forest could be an indication of the presence of certain essential species of primates and birds.

4.1.6 Food tree resources for primates and hornbills

There exist many factors that could have an effect on animal population densities among these food availability (Chapman *et al.,* 2006). Several methods such as transect counts (Struhsaker, 1987), direct observations (Usongo & Amubode, 2001), the raked-trail survey method (Poulsen *et al.,* 2002) have been used to measure the availability of food for animal species in tropical rainforest regions. But none of these methods has studied the availability of food resources for primates and hornbills using logged and unlogged forests as sample to determine food abundance and its impact on primate and hornbill population densities.

At transect level and within the same vegetation type, we found a relatively small difference (ca. 2.8%) in food tree abundance between unlogged and logged forest study sites. This could be mainly attributed to habitat difference (Blom *et al.,* 2005) and human induced activities. Though located at the same ecological forest region, unlogged II is characterised by trees of the primary forest formation such as *Afzelia spp., Lophira alata*, *Berlinia spp*., *Irvingia gabonensis*, *Piptadeniastrum africanum*, *Baillonella toxisperma* which have attained maturity. Parts of these trees such as leaves (*Piptadeniastrum africanum*), flowers (*Lophira alata*), fruits (*Irvingia gabonensis*, *Baillonella toxisperma*) constitute an important diet for primates. The maturity of forest trees in unlogged II could have had a positive effect on fruits/seeds production that are important for primates and hornbills. The highest number of food trees found in unlogged II can also be explained by the higher level of seed dispersal by animals mainly frugivores (Hamilton, 1999; Hubbell *et al*., 1999). However, the fact that the difference in food tree abundance between unlogged II and unlogged I is not significant, indicates that habitat difference is not the only determining factor for food tree abundance between the two study sites.

Forests in unlogged I have undergone large scale disturbance caused by the establishment of large plantations of palm oil and coffee, activities affecting wildlife habitat quality and quantity, but also responsible of the reduction of trees that constitute an important food source for primates and hornbills (Stuhsaker, 1987).

Within logged forest study sites, there was a relatively high abundance of food trees in both logged I and logged II compared to non food trees. This high abundance of food trees in logged forests can be explained by both ecological and disturbance factors. Ecologically, logged forests are predominated with secondary vegetation of pioneer species. Some of these fast growing species belong to families such as *Amaranthaceae* (*Xylopia aethiopica*, *Uvariopsis bakiriana*), *Caesalpiniaceae* (*Anthonotha spp*), Euphorbiaceae (*Uapaca* *guineensis*), *Moraceae* (*Musanga cecropioides*), *Sterculiaceae* (*Cola spp*) and Myristicaceae (*Pycnanthus angolensis*). After the removal of shade tolerant species which constitute the main economic timber: *Lophira alata* (*Ochnaceae*), *Entandrophragma cylindricum* (*Meliaceae*), *Nauclea diderrichii* (Rubiaceae) and *Afzelia Africana* (*Caesalpiniaceae*), the forest is invaded by fast growing tree species, the majority of them fruiting at earlier stage and tree parts (fruits, seeds, leaves, flowers) constituting an important food resource for frugivores species.

At study site levels (n= 12) we found relatively more food trees in unlogged forests (ca. 28%) compared to logged forests (ca. 24.6%) and this pattern was reduced at large scale level (n= 24) with 51.6% of non food and 48.6 % of food for primates and hornbills. Rode *et al.* (2006) also reported a high abundance of food for the Redtail monkeys in the unlogged areas compared with logged areas of the Kibale National Park, Uganda. Our findings suggest that despite logging activities, logged forests of our study sites remained with a high potential of trees that could ensure a suitable habitat for the survival of many species that depend on the habitat value of disturbed forests (Weisenseel *et al.,* 1993). These forests are also predominated by pioneer tree species such as *Musanga cecropioides*, *Pycnanthus angolensis, Ficus spp*. which fruit at earlier stage. Fruits, leaves and seeds of these trees constitute an important food source for primates and hornbills, but as well as for other frugivore species.

Several authors have studied the relationship between animals and their tree food resources. Fairgrieve and Muhumuza (2003) observed a difference between the feeding and dietary composition of Blue monkey in unlogged and logged forest of Budongo forest reserve with a higher proportion of unripe fruits in logged forests while unlogged forests were predominated by young leaves, invertebrates and seeds. Colin *et al.* (2002) study on variation in the diets of *Cercopithecus* species in different forests suggested that *Cercopithecus* species depend mainly on fruits rather than seeds, flowers, leaves and insects. Furuichi *et al*. (2000) study on fruit availability and habitat used by chimpanzees in the Kalinzu forest, Uganda, observed that the number of chimpanzees did not necessarily increase with fruit abundance in the secondary forest and therefore their increase in number could not be explained by the food supply in *Musanga* predominated forest. Weisenseel *et.al* (1993) found no relationship between the use of a particular tree species by nocturnal primates and their availability in unlogged and logged forests. Some specific trees in rainforest in Asia (Borneo) and Africa (Kibale) such as fig (*Ficus spp*), umbrella tree (*M. cecropioides*) have been reported as keystone food for birds and monkeys (Terborgh, 1986; Tutin *et al.,* 1997), but also for chimpanzees (Yamkoshi, 1998).

At transect level (n=6) we observed a negative, but very strong and significant correlation between the *C. pogonias*, *Cercocebus torquatus* and their potential food resources in logged II (R= -0.88 and P= 0.019; R= -0.94 and P= 0.005 respectively) while no correlation was observed between the six other studied primates and hornbills with their related food resources in both unlogged and logged forest areas (Appendix 4.1).

At large scale level (n=12), a negative, moderate and significant correlations were observed only between the *C. mona*, *C. nictitans nictitans* and their potential food resources in unlogged forests (R= -0.64 and P= 0.02; R= -0.60 and P= 0.04 respectively). Furthermore, the selection of the *Pycnanthus angolensis*, *Cola spp*, *Irvingia gabonensis* and *Musanga cecropioides* as the most relevant food trees used by primates and hornbills in the Korup region did not show any relevant correlation. Only *P. angolensis* was negatively correlated with *C. mona* (R= -0.70 and P= 0.0001), *C. nictitans nictitans* (R= -0.51 and P= 0.01), *Cercocebus torquatus* (R= -0.51 and P= 0.01) and *Ceratogymna cylindricus* (R= -0.82 and P= 0.04). The abundance of food resources and the less primates and hornbills encountered either in unlogged or in logged study sites could be the results of other limiting factor rather than food resources (Boutin 1990, Dobson & Oli 2001). The abundance of food resources and keystone trees (e.g.: *M. cecropioides*, *Ficus spp*, *P. angolensis*), that constitute an important diet for primates and hornbills, could not be the only factors responsible for the increase, decrease or stability of frugivores species in tropical rainforest regions. Furuichi *et al.* (2000) observed no correlation between fruit availability and the number of chimpanzees in *Musanga* secondary forest. This suggests that the number of chimpanzee did not necessarily increase with fruit abundance and could not be explained only by the food supply. Other factors such as predation, habitat quality and quantity and hunting may all contribute to regulate wildlife populations in tropical rainforests (Krebs 1978). In our study we did not observe a significant difference in food abundance between unlogged and logged study sites, however population densities of primates and hornbills were very low in these forests. Furthermore, the ecological value of logged forests may vary according to the original vegetation type, the intensity of logging and time since logging (Plumptre and Reynolds, 1994). Logged forests, if properly managed, may help survival of primates, hornbills and other secondary forest wildlife generalists because they contain an important amount of food trees such as *M. cecropioides*, *P. angolensis*, *B. toxisperma*, *Cola spp.*, *Ficus spp.,* that constitute an important diet for primates and hornbills.

4.2 Primate and hornbill population densities in unlogged and logged study sites

Wildlife habitat disturbances (logging, extensive farming, hunting) by human is described by many authors as one of the major factors influencing the distribution of large mammals within protected rainforests of Central Africa (Noss, 1998; Lahm *et al.,* 1998; and Blom *et al*., 2005). In addition to human influence, ecological factors, which include vegetation composition (White, 1994), constitute limiting factors for wildlife population density in tropical rainforests.

Of the studied diurnal primates in unlogged and logged forest of the Korup region, the drill, chimpanzee, red-colobus, red-capped mangabey and the red-eared monkey are described to be of conservation concern (IUCN, 1998), while the mona, putty-nosed and the crowned monkeys are restricted to the Korup region. Encounter rates estimated by Edwards (1992) and Waltert *et al.* (2002) suggest the decline of all studied primates in both unlogged and logged studied sites (Table 4.1). We observed a large variation in primate responses to logging. Mona monkeys and chimpanzees seem to depend highly on logged forests, putty-nosed and crowned monkeys and the drills were encountered at the same number in both unlogged and logged forests, while the red-capped mangabeys and the red-eared monkeys were more encountered in unlogged forest study sites.

Mona monkeys are described to inhabit low land forests, but also degraded forests (Kingdon, 1997). Glenn (1998) reported low population density of mona monkeys (9.4 ind/km^2) on the Caribbean island protected forests of Grenada and attributed that estimate to hunting. But the mona population density in unlogged (28 ind/km^2) and logged (28.73 ind/km^2) forests of our study sites falls within the range of those described by Whitesides (1981) on Douala-Edea forest reserve (15.2 ind/km^2) and Dunn (1993) on Gashaka Gumpti national park in eastern Nigeria (49 ind/km^2).

Table 4.1: Number of encounters and encounter rates of diurnal primates groups/solitary individuals in Korup region.

Species	**Number of encounters**				**Encounter rate per km**			
	1990*	**2000****	**Ul. 99-02**	**L. 99-02**	**1990**	**2000**	**Ul. 99-02**	**L. 99-02**
C. mona	47	42	86	118	0.10	0.45	0.16	0.26
C. nictitans	75	100	128	112	0.15	1.06	0.24	0.25
C. erythrotis	16	18	62	28	0.03	0.19	0.11	0.06
C. pogonias	42	1	11	5	0.08	0.01	0.02	0.01
C. torquatus	2	4	9	28	0.00	0.04	0.01	0.06
P.troglodytes	0	0	2	18	0.00	0.00	0.004	0.04
P.pennantii	26	2	0	1	0.05	0.02	0.00	0.002
M. leucophaeus	8	1	1	1	0.02	0.01	0.002	0.002

*: Sample effort was 492 km (Edwards, 1992); **: 94 km (Waltert *et al.,* 2002); 442 km in logged (L) and 520 km in unlogged (Ul) forests (Lien, 2007). Ul: unlogged; L: logged

Besides the availability of their feeding resources (Johns, 1993), the ability of primates to survive in selectively logged concession forests depends on logging intensity (Skorupa, 1986, Plumptre and Reynolds, 1994), but also on the degree of activities such as hunting (Stuhsaker 1997) and farming that follow logging.

The population density of the four studied large guenons, *C. nictitans n.*, *C. erythrotis*, *C. pogonias* and *C. torquatus* differed from unlogged to logged study sites.

C. nictitans nictitans, a species described to inhabit primary but also secondary forests had higher abundance estimates in logged forests (23.35 ind/km) compared to unlogged forests (17.90 ind/km^2). This suggests that the *C. nictitans nictitans* of our study sites seems presently not to be affected by selective logging and this result is in line with Struhsaker (1997) who observed that it may require several years before logging to observe significant decline in primate population densities. Fimbel (1994) observed *C. campbelli* and *C. petaurista* being more common in logged forests compared to unlogged forests and concluded that the two species were apparently not affected by logging. These findings are consistent with those found in our study, but also with those described by Struhsaker (1997) on Kibale forest reserve, Uganda. However, the group density of the *C. nictitans* estimated by Matthews and Matthews (2002) were high in primary undisturbed forests than in logged concession forests around Campo Ma'an National Park and in Kibale National Park, Uganda (Table 4.2).

C. erythrotis is reported to inhabit lowland rainforests but, is also described to be negatively affected by deforestation (Kingdon, 1997). This species was more common in unlogged forests (17.55 ind/km²) than in logged forests (10.93 ind/km²) study sites. Although Usongo (1990) observed that the red eared monkey was rare around the Rumpi Hills Forest Reserve, the population density of the *C. erythrotis* in unlogged and logged study sites is higher than those estimated by Edwards (1992) and Waltert *et al.* (2002). However, the difference in population density between unlogged and logged study sites could indicate that habitat quality constitute a limiting factor for the red eared monkey (Rosenbaum *et al.*, 1998). Compared with previous studies (Usongo, 1990; Edwards, 1992 and *Waltert et al.,* 2002), the high population density of this species in our study area could be explained by the high reproduction rate and low mortality rather than low hunting pressure and food availability.

Among the eight studied primates, three (*P. troglodytes*, *M. leucophaeus* and *P. pennantii preussi*) are listed by IUCN (Hilton-Taylor, 2000) as endangered. In both unlogged and logged study sites, these species were either not found (preuss' red colobus in unlogged study sites) or had very low population density (Chimpanzee and drill). Chapmann *et al.* (2000) estimated higher group densities of the chimpanzees and preuss's red colobus in unlogged than in logged forests within and around Kibale National Park. Within the same study site, Waltert *et al*. (2002) population density estimates of the preuss' red colobus, chimpanzees and drills are far higher than those herein described (Table 4.3). McConkey and Chivers (2004) survey on primates and ungulates in the forests of Barito Ulo, Indonesia, argued that the low density primate populations was the result of poor fruit supply in the area. The preuss's red colobus, the chimpanzee and the drill are described to live in tropical dense high forest (Struhsaker, 1975; Davies and Oates, 1994). The low population densities of these three endangered species estimated in this study compared with the further decline observed by Waltert *et al*. (2002) could be the result of the combination of both hunting and habitat destruction. Usongo (1990), Edwards (1992), Infield (1998) and Tchigio (2007) reported that primates were among the most hunted wildlife species in the Korup region. Chapman *et al.* (2000) noted the incompatibility between logging and primate conservation. Richards (1996) stated that many tropical wildlife species were locally endemic, rare and patchily distributed. These factors predisposed species as primates and hornbills to an increased risk of extinction when habitat is modified. Wildlife habitat in the Korup region is highly modified either by hunting, logging or by the establishment of large plantations of cocoa, coffee and palm oil. For wildlife species of the Korup region such as primates that depend on unmodified habitat, the risk of local extinction seems therefore to be higher. Fimbel (1994) describes biological traits to be responsible for the persistence or extinction of species in disturbed habitats. Factors such as forest composition, climate and biogeography patterns could also play a determining role in primate habitat use. The rate in which population density of these three species decline is extremely higher and could in short term lead to local extinction of the preuss' red colobus, chimpanzee sand the drills, if protection measures are not implemented.

Hornbills were described by Poulsen *et al*. (2002) to be good indicators of the state of the rainforest as they required large nesting trees and large seeded lipid fruits but also large home range. Compared to the unlogged study sites (21.61 ind/km²), the logged sites show a relative high population density of *Ceratogymna atrata* (23.15 ind/km²), although the decrease in population density from year two to year three is remarkable. On the other hand, the brown-checked hornbill (*C. cylindricus*) population density was higher in unlogged study sites (25.08 ind/km²) compared to logged study sites (22.43 ind/km²). Poulsen *et al*. (2002) reported the great and large hornbill (*Buceros bicornis*) to be more susceptible to habitat disturbance than the grey and small hornbill (*Ocyceros griseus*). Whitney and Smith (1998) stated that *C. atrata* reaches its highest density in mature forest habitats while *C. cylindricus* density is higher in secondary forests associated with agriculture, results similar to the distribution of the densities of the *C. cylindricus* in unlogged and logged study sites of the Korup region. However, our data show no significant difference in population density of both species, *C. atrata* and *C. cylindricus* in unlogged and logged forest habitat of the Korup region. Our results suggest that the abundance of fruit food tree species and other large trees in logged study sites probably constitute a suitable feeding source and habitat for the hornbills. Such a diversity of food and large trees is relevant for the survival of hornbills during the breeding period (Datta, 1998).

Contrary to Brown and Lugo (1990) and Turner *et al*. (1997) who described secondary forests of having a less complex species richness of large trees compared to primary forests, our study suggests the ecological value of secondary forests of the logged study sites, forests that may contribute to maintain larger population of hornbills and primates. The conservation value of these forests therefore should be of major priority to the local government and to the relevant international organisations operating in the region.

Table 4.2: Group densities of *C. nictitans*, *C. pogonias* and *Cc. torquatus* in different habitats in Cameroon.

Primates species	**L.c**	**Cf**	**Mf**	**Mitani, 91**	**Df**	**U.l.f.**	**L.f.**
	gp./km^2	**gp./km^2**	**gp./km^2**	**gp./km^2**	**gp./km^2**	**gp./km^2**	**gp./km^2**
Cercopithecus nictitans n.	1.45 (± 0.13)	1.43 (± 0.12)	2.44 (± 0.76)	2.03	1.57	1.19 (±)	1.26
Cercopithecus pogonias	0.8 (± 0.38)	0.81 (± 0.3)	0.86 (± 0.41)	0.64	1.38	0.14	0.08
Cecocebus torquatus	0.36 (± 0.07)	0.51 (± 0.21)	-	0.65	-	0.08	0.31

L. c: Logging concession around Campo Ma'an national park forests; C. f: Campo forests; M. f: Ma'an forest; D. f: Dja reserve forest; U. l. f: Unlogged forest (Lien, 2007); L. f: Logged forest (Lien, 2007)

Table 4.3: Population density of *P. pennantii preussi*, *P. troglodytes* and *M. leucophaeus* in different forest habitats of Africa.

Primate species	**Unlogged(a)**	**Logged(a)**	**Unlogged(b)**	**Logged(b)**	**Unlogged(c)**	**Logged(c)**
	gp/km^2	**gp/km^2**	**Ind/km^2**	**Ind/km^2**	**Ind/km^2**	**Ind/km^2**
Procolobus pennantii preussi (preuss' red colobus)	5.46	3.08	0.04	0.65	0.00	0.02
Pan troglodytes (chimpanzee)	0.4	0.09	0.16	0.09	0.2	0.01
Mandrillus leucophaeus (drill)	n.a	n.a	0.21	0.29	0.03	0.04

(a) Group densities from Chapman *et al.,* 2000; Kibale National Park, Uganda

(b) Individual densities from Waltert et al., 2002. Forests around Korup National Park, Cameroon

(c) Individual densities from Lien, 2007. Forests around Korup National Park, Cameroon

4.3 A factor affecting wildlife population decline in the Korup region: Hunting

One of the main threats to conservation of biological diversity in tropical rain forests is believed to be over-exploitation of wild animals through illegal hunting (Infield, 1988; Oates *et al*., 2000; Robinson & Bennett, 2000; Fa, 2000; Auzel and Wilkie; 2000 Waltert *et al*., 2002). Hunting in the Korup region is one of the most prominent activities carried out by all local communities living in and around Korup National park and other protected forest areas (Infield, 1988, Edwards, 1992). This activity, although being the main source of protein to the people of the Korup region (Tchigio, 2007), has contributed largely in wildlife population decline in the region (Waltert *et al.,* 2002). The unsustainable off-take of wild animals through hunting affects the harvested population in several forms: stress, predation, reproduction, movement and can even threaten an entire species' persistence. Oates *et al*. (2000) attributed hunting to be the ultimate cause of the extinction of red colobus monkey in Ghana (Ashanti region) and predicted extinctions of other large mammals in the Upper Guinea rainforest region if attention is not paid to protect all forms of endangered wild species. Mittermeier (1997) reported that about one-seventh of all primate species could easily be extinct by the turn of the century and this is due to an increased demand for biological resources and facilitated by an increasing human population and economic wealth and other biological factors such as mortality, predation and competition. Small wildlife populations are more vulnerable to mortality in case of a disease than larger wildlife populations, whose mortality rates are overcompensated by an increase in density (Begon *et al.,* 1990). Though human population growth is widely recognised as one of the factors influencing the decrease of wildlife population densities, it has also been demonstrated that wildlife can be overhunted in areas with low human population density (Fimbel *et al*., 2000 and Wilkie *et al*., 1998).

Fimbel *et al*. (2000) acknowledged an increasing evidence of over-hunting of mammals in forested areas of Central, East and West Africa where the human population is relatively low (< 2 ind/km^2). In Central Africa, large forested areas such as Lobeké, South-eastern Cameroon (> 5000 km^2) and Okapi Reserve (13,000 km^2) in the Ituri region, North-eastern Democratic Republic of Congo, all areas supporting low human population densities (< 2 ind/km^2), show signs of over-hunting (Wilkie *et al*.,1998)

The main animals targeted for hunting in tropical forests are mammals, from the size of a small duiker upwards (White, 1983; Usongo, 1995; Oates, 1996; Infield, 1998; and Koulagna, 2001). Compared to small mammals, they are the main target group because of their economic value and for practical reasons (easy to hunt). But in the Korup region all animals from rodents to large mammals are hunted. Besides the human factor, other biological features, which could contribute to the extinction of large mammals or making them more vulnerable, remain their low population density, low fecundity, low generation time, and dependency on the forest-interior (Begon *et al.*, 1990 and Mühlenberg, 2001).

Most tropical forest wildlife are either locally extinct, endangered, vulnerable or found with a population below carrying capacity (IUCN, 1998), it is rather questionable if populations of large mammals in tropical rainforests can sustain the harvest yields which meet the socio-economic need of local communities. And, indeed, current levels of wildlife exploitation in many parts of tropical West and Central Africa now pose serious threats to wildlife populations and are reducing income and protein provision for forest people (Fa, 2000).

FitzGibbon's *et al.*, (1996) study on the threatened mammals of Arabuku-Sokoke Forest, Kenya, considers wild-meat harvesting as one of the ways local communities could benefit from forest conservation. They argue that sustainable harvesting levels of prey species are substantial and have rarely been tackled in tropical forest habitats. Their results suggest that the current harvesting levels did not affect duikers, but primate harvesting has to be controlled, however, densities of large mammals (bushbuck and buffalo) were low, resulting from over-harvesting.

Fa (2000) stated that a large majority of the local population of the Bioko Island in Equatorial Guinea depends on wild animals for their protein provision and as a source of income. This has resulted in an uncontrolled harvest of wildlife in the Bioko forest which is known as a refuge for large mammals, including several rare and endemic forms (Fa, 2000). He concluded that survival of wildlife would depend on measures to establish and safeguard protected areas, but also through the promotion of native cooperation or involvement/commitment of rural populations.

Extraction rates of wild meat in the Korup region, Cameroon, were estimated to be 271,000 kg per year (217 kg/km²) between 1987 and 1989 (Infield 1988) whereas the figure for subsistence hunters in the Arabuko-Sokoke forest, East Africa (FitzGibbon *et al.*, 1996) was around 130,000 kg of game meat per year (a harvest rate of 350 kg/km²). Comparing these figures with wildlife population densities in the Korup region (Edwards 1992; Waltert *et al.*, 2002 and Dunn & Okon 2002), we come to the conclusion that wildlife harvesting in the area is not sustainable and that there is an urgent need to save the "remaining" wildlife populations in the region.

While the "bushmeat problem" is one of the major problems in conservation science and management of tropical forests, there are few experiences with wildlife management in tropical rainforests (Infield, 1988; FitzGibbon *et al.,* 1996; DFID, 2002; Bowen-Jones *et al*., 2002; and Fa, 2003), and most of the biological and social pre-conditions for a successful application remain obscure. Methods and models developed by scientists to manage wildlife in tropical rainforests have contributed little to overcome the "bushmeat problem".

Cameroon's forestry and wildlife law offers the possibility to establish wildlife management areas using a co-management strategy (MINEF, 2003), but the approach is relatively new and only few published accounts exist yet (FitzGibbon *et al*., 1996; Eves, 1999; Brown *et al*., 1999; Fimbel *et al*., 2000; Fa, 2000; Borrini-Feyerabend *et al*., 2000; and Tchigio, 2007).

4.4 A concept for wildlife conservation and management in the Korup region: Wildlife Management Zone.

Attempts to wildlife conservation and management through the establishment of protected areas (national park, wildlife sanctuary, wildlife forest reserve) has not always achieved its objectives (Brown and Wyckoff-Baird, 1992). With an increase of human population and demand for wild meat in the 80's, the need to adapt wildlife conservation and management into socio-economic and biological goals became a priority for social scientists and conservation biologists (Brown and Wyckoff-Baird, 1992). The top-down approach in natural resources management characterised by wildlife law enforcement and ownership of wildlife by the states did not integrate local communities living in and around protected areas of wildlife conservation and management (IIED, 1994). The adoption, establishment and implementation of wildlife hunting zone under the management of local communities is a devolution process in wildlife conservation and management. This approach promotes ownership and access to wildlife as well as other forest resources to the indigenous people. It also promotes and protects the use of natural resources in an ecologically and economically sustainable and socially acceptable manner. The establishment of wildlife management zones is governed by principles, goals, objectives and approaches. The following can be listed as principles:

1- The availability of forest land and indications that it contains wildlife and other forest resources.
2- The recognition of community rights by the State to ownership of wildlife and other forest resources.
3- The recognition of local communities as one of the main care-takers over forest resources.

4- The strengthening and capacity building of existing local institutions or the establishment of community-based structures that are responsible for wildlife conservation and management.
5- Elaboration of mechanisms in benefit sharing resulting from sustainable harvesting of wildlife and of other forest resources (e.g.: NTFPs) within the village forest.

The main goal of the wildlife management zone is to ensure the long term conservation of wildlife resources, but also to meet the subsistent needs of the local population that depend on these natural resources. This goal illustrates how conservation can contribute to poverty alleviation. The main objectives of a community hunting zone are to:

1- Develop a management plan of the hunting zone.
2- Assess wildlife population within the forest area allocated for wildlife management zone.
3- Determine hunting quota for non protected wildlife species.
4- Elaborate monitoring and evaluation mechanisms for wildlife within the hunting zone.
5- Elaborate and conduct anti-poaching activities within the hunting zone.
6- Properly manage revenues generated from wildlife hunting zone.
7- Collaborate with relevant stakeholders.

Most of these activities are too technical and could not be carried out by local people without the technical input from other relevant stakeholders. It therefore benefits the government and other organisations interested in the conservation of biodiversity, in providing the local communities with technical expertise on land use planning, monitoring and evaluation. The approach used along the wildlife management zone process is termed as participatory. This approach ranges from passive, in which people participate by being informed of what is happening or has already happened, to active participation, in which people take initiatives and decisions without the influence of external institutions or organisations.

Tchigio (2007) suggested that the maximum sustainable harvest estimates of the study sites are below the carrying capacity that can be supported by unlogged and logged forest study sites. Primates and hornbills in these forests can therefore not support any hunting and should be protected. But wildlife population with higher per capita rate of natural increase (intrinsic rate) such as rodents, blue duiker long tailed pangolins could be hunted on a quota basis.

The establishment of wildlife management zones in the communal forests of the Korup region and the ban on hunting over large mammals, endangered and vulnerable wildlife species for a minimum of 5 years, will enable the recovering of wildlife populations in the region. To meet this goal, local people of the Korup region should be supported and oriented into other activities which could provide them with a sufficient income, but also could enable them to meet their protein needs. This concept has been successful with the CAMPFIRE in Zimbabwe (Murphree, 1994), the Community wildlife management around the Selous game reserve in Tanzania (Baldus, 1991) and the "Comité de Valorisation des Resources Fauniques" COVAREF in the southeast Cameroon (Usongo, 2005).

It is therefore of benefit to the local government and to the international communities, to support the concept of wildlife management zones in tropical forest regions, technically and financially, within a specified period.

5. CONCLUSION

The goals of this study were to evaluate the conservation value of logged forest concession areas of the Korup region compared to the unlogged forests and to propose a conservation and management concept for wildlife in the region. The proposed concept could be applied in other tropical rainforest regions under careful consideration of factors such as social set-up, vegetation composition, species richness and diversity, topography and other human induced factors (e.g.: logging, extensive farming and hunting). To achieve these goals several objectives were elaborated.

We assessed the vegetation parameters such as abundance, species richness and composition, family diversity and diameter distribution measuring the dbh of all trees ≥ 8 cm in unlogged and logged study sites. We found that logged forests of our study sites did not significantly differ with unlogged forests in tree abundance, species richness, trees composition and family distribution. These findings suggests that the habitat of logged forests is not yet highly disturbed and could constitute a suitable habitat for wildlife including primate and hornbill species. However, these forests could rapidly loose their ecological value due to an increase rate of farming, which destroys both the habitat and food tree resources for primates, hornbills and other forest generalist species.

In addition to the assessment of parameters stated above, we also assessed the abundance of potential trees that constitute food resources for primates and hornbills in unlogged and logged study sites with the assumption that primates and hornbills diet could not differ as fruit consumption is concerned (Poulsen *et al.,* 2002). The results show that logged forests as well as unlogged forests of the Korup region contained a higher diversity of trees bearing fruits that are used by primates and hornbills in their daily diet. We found no significant difference in food tree abundance between unlogged and logged forests study sites. At transect level (n=6), we found negative, strong and significant correlations between food abundance and *Cercopithecus pogonias*, *Cercocebus torquatus* encounter rates, but other studied primate and hornbill species were not correlated with food abundance. At site level (n=12) only the *Cercopithecus mona* and *Cercopithecus nictitans* were negatively but significantly correlated with food abundance. We sorted out the *Pycnanthus angolensis*, *Cola spp*, *Irvingia gabonensis* and *Musanga cecropioides*, trees described to constitute key food resources for primates and hornbills (Terborgh, 1986 and Tutin *et al.,* 1997) in both study sites. Correlations between the two variables (food resources and encounter rates) were negative, but significant only between the *Pycnanthus angolensis* and the *Cercopithecus mona*, *Cercopithecus nictitans nictitans*, *Cercocebus torquatus* and *Ceratogymna cylindricus*. The relative differences in food tree abundance between unlogged and logged study sites indicates that logged forest study sites contained a higher potential of trees bearing fruits for both primates and hornbills. The ecological value of unlogged and logged study sites is not directly influenced by the difference between unlogged and logged forests, but by the tree composition. Behavioural patterns of primate and hornbill species of our study sites such as movement, foraging and defecating patterns, coupled with habitat preference, could ensure the dissemination of seeds thus the survival of food bearing tree species in the region. The relationship between food abundance, primate and hornbill encounter rates suggests that the studied wildlife species did not increase with fruit abundance and that food availability is not a limiting factor for primates and hornbills in the Korup region. Other factors such as predation, habitat quality and hunting, may contribute to regulate primate and hornbill population densities in the region.

Population density of all studied primate species are below carrying capacity observed in tropical rainforests. The *C. mona* and *C. nictitans nictitans, C. pogonias, Cc. torquatus* and *P. troglodytes* population densities were relatively high in logged forests study sites compared to unlogged forest study sites. This suggest that primate species in the logged study sites seem presently not to be affected by logging activities, however, it may require several years before logging to observe significant decline in primate population densities (Struhsaker, 1997). The *C. erythrotis* was highly estimated in unlogged forests (17.55 ind/km^2) compared to logged forest (10.93 ind/km^2) study sites. However, the difference in population density of the *C. erythrotis* in unlogged and logged study sites could indicate that habitat quality constitute a limiting factor for the red-eared monkey (Rosenbaum *et al.,* 1998). But it could also be explained by the high reproduction rate and low mortality, rather than low hunting pressure and food availability.

Among the eight studied primates, three (*P. troglodytes*, *M. leucophaeus* and *P. pennantii preussi*) are listed by IUCN (Hilton-Taylor, 2000) as endangered. In both unlogged and logged study sites these species were either not found (preuss' red colobus in unlogged study site) or were estimated at very low population density. The preuss' red colobus, the chimpanzee and the drill are described to live in dense tropical high forests (Struhsaker, 1975; Davies and Oates, 1994). The low population densities of these three endangered species estimated in this study compared with the further decline observed by Waltert *et al.* (2002) could be the result of a combination of hunting and habitat destruction caused by logging and extensive farming. These factors predispose these species to an increased risk of extinction. Wildlife species of the Korup region such as primates that depend on unmodified habitat, such as primates and hornbills, therefore have a risk of local extinction. Fimbel (1994) describes biological traits to be responsible for the persistence or extinction of species in disturbed habitats.

Compared to the unlogged study sites, the logged sites show a relative high population density of *Ceratogymna atrata*, although the decrease in the population density from year two to year three was remarkable. On the other hand, the brown-checked hornbill (*C. cylindricus*) population density was higher in unlogged study sites compared to logged study sites. However, our data show no significant difference in population densities of both *C. atrata* and *C. cylindricus* species in unlogged and logged forest habitats of our study area. Our results suggest a higher diversity of food and large trees in both unlogged and logged study sites which are relevant for the survival of hornbills during the breeding period (Datta, 2001). Our study suggest the ecological value of secondary forests in the logged study site forests, and these forests may highly contribute to maintain larger populations of hornbills and primates. The conservation value of these forests therefore should be of higher priority to the local government and to the relevant international organisations operating in the region.

Following the results obtained in this study, we recommend no hunting of primates in unlogged and logged forests of the Korup region within a period of at least five years to enable the recovering of the population. But this can only be effective with the establishment of wildlife management zones which includes the participation of local communities, governmental institutions in charge of wildlife management and law enforcement and relevant international organisations for technical and financial assistance. Although logged forests of the Korup region are surrounded by protected areas (Korup National Park, Nta ali, Edjagham, Rumpi Hills Forest Reserves and Mbayang-mbo sanctuary), other fragile ecological areas within the non protected which constitute a suitable habitat for wildlife should be identified and protected. These fragile ecological areas will serve as reference areas and safety measures against mismanagement, and as a refuge for sensitive species like drills, red colobus, chimpanzees, elephants and other forest-interior species.

Our study suggest that logged forest concessions of the Korup region are not ecologically different from unlogged forests. There is still a higher potential of wildlife and wildlife habitat of great value in logged forests that require protection. Unlogged and logged forest components of the Korup region ecosystems are subject for further research, such as a long term monitoring of the impact of logging on biodiversity, the ecology and status of endangered wildlife species of the region and a thorough and descriptive study on tree species used by primates and hornbills and their implication for seed dispersal.

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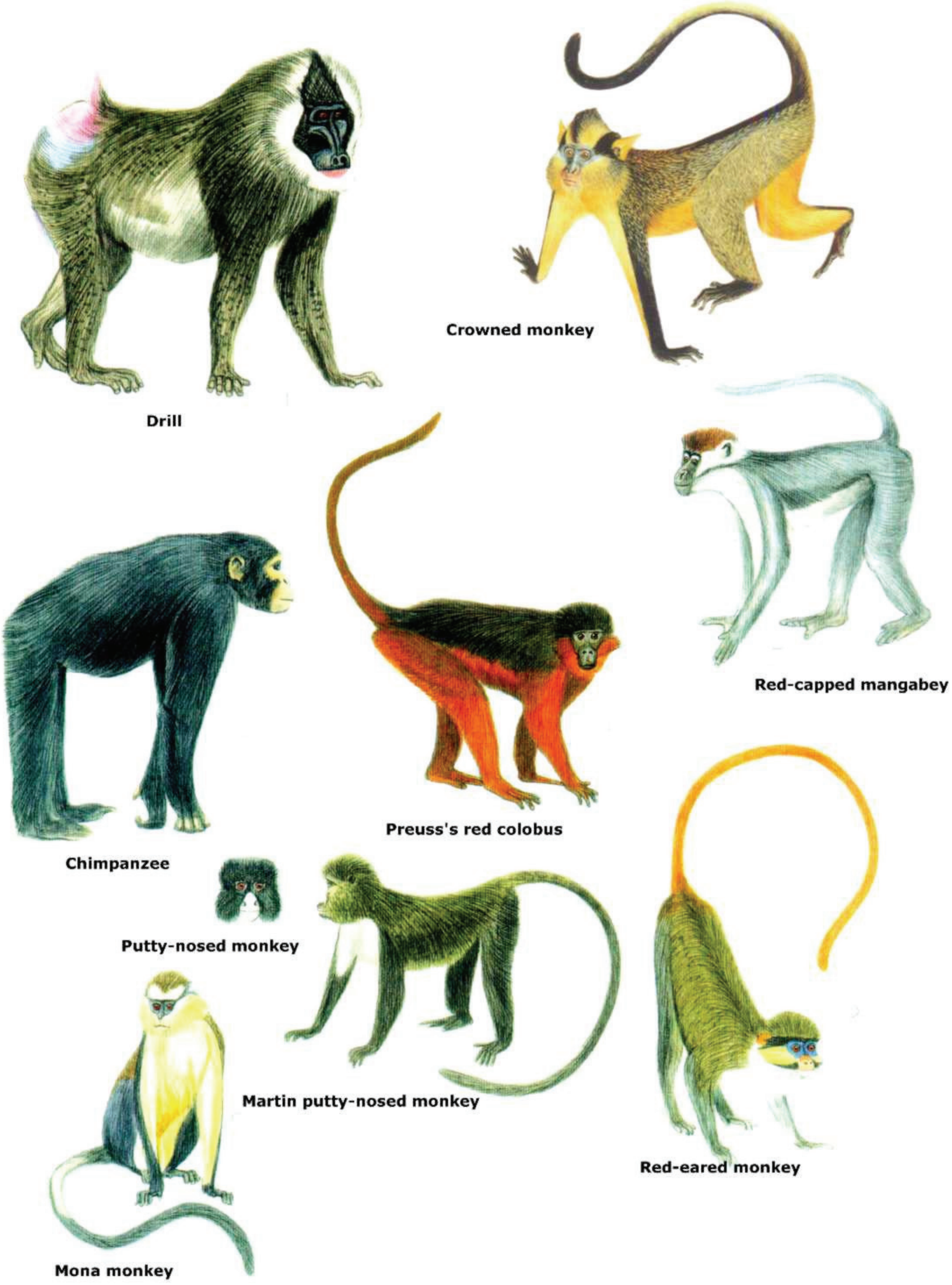
.

APENDICES

Appendix 2.1: Studied primate species



Source: Redrawn from Kingdon, 1997.

Appendix 2.2: Studied hornbill species

The Black-casqued hornbill (*Ceratogymna atrata*, male with large casqued and female with small casqued and black tail. Source: www.oiseaux.net)

The Brown-checked hornbill (*Ceratogymna cylindricus* male with yellow casqued and female with white and brown tail. Source: www.oiseaux.net)

Appendix 3.1: Tree abundance in unlogged and logged study sites (≥8 cm dbh). Family taxonomical order based on **Hutchinson & Dalziel 1968, Vol. 3 part I.**

Species	F. Nr.	Family	Ul. I	L. I	L. II	Ul. II	T.
Mitragyna stipulosa	4	Annonaceae				1	1
Monodora brevipes	4	Annonaceae		8	3	2	13
Annona senegalensis	4	Annonaceae			1		1
Anonidium mannii	4	Annonaceae	12	2	2	9	25
Cleistopholis patens	4	Annonaceae	1			4	5
Hexalobus caspiflorus	4	Annonaceae	8				8
Pachypodanthium barteri	4	Annonaceae		1	1	1	3
Polyalthia suaveolens	4	Annonaceae	61	46	20	46	173
Beilschmiedia anacardioides	6	Lauraceae		2			2
Beilschmiedia obscura	6	Lauraceae	11	6	1	25	43
Hypodaphnis zenkeri	6	Lauraceae	12	12	7	5	36
Coelocaryon preussii	8	Myristicaceae	9	2		19	30
Pycnanthus angolensis	8	Myristicaceae	23	36	10	65	134
Scyphocephalium mannii	8	Myristicaceae	1		1	3	5
Scytopetalum klaineanum	8	Myristicaceae		1	2	1	4
Staudtia kamerunensis	8	Myristicaceae	37	29	1	65	132
Rinorea oblongifolia	20	Violaceae			12		12
Rinorea sp	20	Violaceae	53	86	36	64	239
Erismadelphus exsul	23	Vochysiaceae		2		7	9
Hilleria latifolia	35	Phytolaccaceae		4		4	8
Symphonia globulifera	37	Amaranthaceae	1			1	2
Uvariodendron giganteum	37	Amaranthaceae				3	3
Uvariopsis sp	37	Amaranthaceae	30	2	1	4	37
Xylopia aethiopica	37	Amaranthaceae	24	41	26	15	106
Xylopia aurantiiodora	37	Amaranthaceae	4				4
Caloncoba glauca	53	Flacourtiaceae	13	2	3	1	19
Caloncoba welwitschii	53	Flacourtiaceae				2	2
Camptostylus mannii	53	Flacourtiaceae	2				2
Dasylepis sp	53	Flacourtiaceae	5	8	7	5	25
Scottellia coriacea	53	Flacourtiaceae	46	12	23	23	104
Homalium letestui	55	Samydaceae	54	40	49	55	198
Barteria fistulosa	58	Passifloraceae	4	5	6		15
Lophira alata	63	Ochnaceae	20	7	6	16	49
Ouratea sp	63	Ochnaceae	1	3		14	18
Syzygium rowlandii	66	Myrtaceae		4			4
Crateranthus talbotii	67	Lecythidaceae	7	11	3	9	30
Petersianthus macrocarpum	67	Lecythidaceae		1	1		2
Memecylon sp	68	Melastomataceae			9		9
Combretum sp	69	Combretaceae			3		3
Strephonema grandifolia	69	Combretaceae		1		2	3
Strephonema sp	69	Combretaceae	1	6		7	14
Terminalia ivorensis	69	Combretaceae				5	5
Terminalia superba	69	Combretaceae	5	1	3	2	11
Poga oleosa	70	Rhizophoraceae				1	1
Allanblackia gabonensis	72	Guttiferae	4	1		6	11

Enantia chlorantha	72	Guttiferae	7	1	2	10	20
Garcinia mannii	72	Guttiferae	48	45	35	73	201
Garcinia sp	72	Guttiferae				25	25
Mammea africana	72	Guttiferae	5	2		6	13
Oubanguia alata	73	Scytopetalaceae	8		17	154	179
Duboscia macrocarpa	74	Tiliaceae	12		1	117	130
Grewia coriacea	74	Tiliaceae	18	26	28	34	106
Cola acuminata	75	Sterculiaceae	1	2	7		10
Cola chlamydantha	75	Sterculiaceae	1	1		11	13
Cola gigantea	75	Sterculiaceae			2		2
Cola lateritia	75	Sterculiaceae		28	19		47
Cola lepidota	75	Sterculiaceae	34	15	80	10	139
Cola nitida	75	Sterculiaceae		3	3		6
Cola rostrata	75	Sterculiaceae	1			4	5
Cola sp	75	Sterculiaceae	6			4	10
Cola verticillata	75	Sterculiaceae	29	1	3	8	41
Eribroma oblongum	75	Sterculiaceae	30	10		1	41
Pterygota macrocarpa	75	Sterculiaceae	3			8	11
Sterculia subviolacea	75	Sterculiaceae	3	3			6
Sterculia tragacantha	75	Sterculiaceae	8	38	8	20	74
Ceiba pentandra	76	Bombaceae	4	7	5	3	19
Dichostemma glaucescens	86	Euphorbiaceae	3	20	10	69	102
Antidesma sp	86	Euphorbiaceae	23	6	5	18	52
Antidesma venosum	86	Euphorbiaceae		3	6		9
Bridelia ferruginea	86	Euphorbiaceae		2	1		3
Bridelia micrantha	86	Euphorbiaceae			3		3
Cyrtegonone argentea	86	Euphorbiaceae		5		9	14
Discoglypremna caloneura	86	Euphorbiaceae	5	4	2	9	20
Drypetes sp	86	Euphorbiaceae	21	22	35	51	129
Klaineanthus gaboniae	86	Euphorbiaceae	16	12		64	92
Macaranga heterophylla	86	Euphorbiaceae			2		2
Macaranga monandra	86	Euphorbiaceae			4		4
Macaranga sp	86	Euphorbiaceae		1	2	2	5
Maesobotrya barteri	86	Euphorbiaceae	15	4	2	22	43
Mareyopsis longifolia	86	Euphorbiaceae		4	5	9	18
Protomegabaria macrophylla	86	Euphorbiaceae	16			9	25
Protomegabaria stapfiana	86	Euphorbiaceae	4	12		1	17
Ricinodendron heudelotii	86	Euphorbiaceae	3	5	1	15	24
Sapium sp	86	Euphorbiaceae	2	1	2	3	8
Uapaca guineensis	86	Euphorbiaceae	26	29	38	72	165
Hirtella cupheiflora	87	Rosaceae	1			3	4
Tapura africana	88	Chailletiaceae	22	23	29	32	106
Afzelia africana	89	Caesalpiniaceae	5	3	4	2	14
Afzelia bipidensis	89	Caesalpiniaceae	4			2	6
Amphimas ferrugineus	89	Caesalpiniaceae	1	1		1	3
Anthonotha fragrans	89	Caesalpiniaceae	9		9		18
Anthonotha macrophylla	89	Caesalpiniaceae	193	65	40	44	342
Berlinia auriculata	89	Caesalpiniaceae	5			4	9
Berlinia bracteosa	89	Caesalpiniaceae	36	15	26	77	154

Brachystegia zenkeri	89	Caesalpiniaceae	7			14	21
Cynometra hankei	89	Caesalpiniaceae	22	22	8	5	57
Cynometra mannii	89	Caesalpiniaceae	18	7	6	6	37
Cynometra sanagaensis	89	Caesalpiniaceae			5		5
Detarium macrocarpum	89	Caesalpiniaceae	2			30	32
Dialium dinklagei	89	Caesalpiniaceae	2		3		5
Dialium guineensis	89	Caesalpiniaceae	11		1		12
Dialium sp	89	Caesalpiniaceae	10	33	23	58	124
Dialium tessmannii	89	Caesalpiniaceae	4		3		7
Dialium zenkeri	89	Caesalpiniaceae	34				34
Didelotia africana	89	Caesalpiniaceae				26	26
Distemonanthus benthamianus	89	Caesalpiniaceae	3	2		5	10
Erythrophleum ivorense	89	Caesalpiniaceae	6	1		9	16
Gilbertiodendron grandiflorum	89	Caesalpiniaceae		1	1	35	37
Guibourtia ehie	89	Caesalpiniaceae		1			1
Guibourtia tessmannii	89	Caesalpiniaceae	8	1		8	17
Hylodendron gabunense	89	Caesalpiniaceae	34	30	2	32	98
Hymenostegia afzelii	89	Caesalpiniaceae	11	48	6	19	84
Hymenostegia talbotii	89	Caesalpiniaceae	6			1	7
Julbernadia seretii	89	Caesalpiniaceae	1			25	26
Loesenera talbotii	89	Caesalpiniaceae	21	12	13	4	50
Microberlinia sp	89	Caesalpiniaceae				9	9
Monopetalanthus letestui	89	Caesalpiniaceae				3	3
Oxystigma mannii	89	Caesalpiniaceae	11			3	14
Albizia ferruginea	90	Mimosaceae	7	1			8
Albizia gummifera	90	Mimosaceae	2			1	3
Albizia zigia	90	Mimosaceae	61	42	68	60	231
Cylicodiscus gabunensis	90	Mimosaceae	1	3		1	5
Newtonia zenkeri	90	Mimosaceae			2		2
Parkia bicolor	90	Mimosaceae		1		8	9
Pentaclethra macrophylla	90	Mimosaceae	2	1		7	10
Piptadeniastrum africanum	90	Mimosaceae	7	4	2	16	29
Tetrapleura tetraptera	90	Mimosaceae			1	1	2
Angylocalyx zenkeri	91	Papilionaceae	1	1	2	5	9
Baphia leptobotrys	91	Papilionaceae		14	1		15
Baphia nitida	91	Papilionaceae	52	94	52	47	245
Millettia barteri	91	Papilionaceae	1	4			5
Pterocarpus soyauxii	91	Papilionaceae	42	18	1	29	90
Celtis africana	95	Ulmaceae	1			3	4
Milicia excelsa	96	Moraceae	8	1		1	10
Musanga cecropioides	96	Moraceae	6	44	42	5	97
Myrianthus arboreus	96	Moraceae	1		1	1	3
Treculia africana	96	Moraceae	27	26	18	105	176
Panda oleosa	101	Pandaceae	6	3	16	8	33
Leptaulus daphnoides	102	Icacinaceae	22	10	1	19	52
Diogoa zenkeri	104	Olacaceae	9	16	72	18	115
Strombosia grandifolia	104	Olacaceae	1	13	26		40
Strombosia pustulata	104	Olacaceae	55	47	50	91	243
Strombosiopsis tetandra	104	Olacaceae	26	8	5	29	68

Ocktonemma sp	108	Octoknemataceae		4		8	12
Maesopsis eminii	112	Rhamnaceae		3	4	7	14
Fagara macrophylla	114	Rutaceae		2	7	3	12
Hannoa klaineana	115	Simaroubaceae	2				2
Desbordesia glaucescens	116	Irvingiaceae	7	6	19		32
Irvingia gabonensis	116	Irvingiaceae	16	40	31	27	114
Irvingia grandifolia	116	Irvingiaceae	2		1	4	7
Klainedoxa gabonensis	116	Irvingiaceae	30	14	19	3	66
Canarium schweinfurthii	117	Burseraceae	6	4	2	4	16
Dacryodes edulis	117	Burseraceae	10	31	27	10	78
Santiria trimera	117	Burseraceae	12	15	15	23	65
Santiria trimera	117	Burseraceae	14	16	15	22	67
Carapa grandiflora	118	Meliaceae	3	6	5		14
Carapa procera	118	Meliaceae	41	14	13	55	123
Entandrophragma angolense	118	Meliaceae	1	1		1	3
Entandrophragma cylindricum	118	Meliaceae	5	5	7	1	18
Entandrophragma utile	118	Meliaceae	2	1			3
Guarea cedrata	118	Meliaceae	1	1	3	2	7
Trichilia sp	118	Meliaceae	17	12	13	5	47
Trichilia tessmannii	118	Meliaceae	3		1		4
Trichilia welwitschii	118	Meliaceae	1			2	3
Turraeanthus africanus	118	Meliaceae	1	1			2
Blighia sapida	119	Sapindaceae	6	9	1	5	21
Blighia welwitschii	119	Sapindaceae	8	3	3	7	21
Eriocoelum macrocarpum	119	Sapindaceae	20		3		23
Paullinia pinnata	119	Sapindaceae	3		5	7	15
Anacardium occidentale	121	Anacardiaceae	2				2
Antrocaryon klaineanum	121	Anacardiaceae				2	2
Lannea sp	121	Anacardiaceae		3			3
Sclerocarya birrea	121	Anacardiaceae		1		2	3
Sorindeia grandifolia	121	Anacardiaceae	32	28	36	42	138
Soyauxia sp	121	Anacardiaceae				1	1
Trichoscypha acuminata	121	Anacardiaceae	10	2		9	21
Diospyros bipidensis	127	Ebenaceae			7		7
Diospyros crassiflora	127	Ebenaceae	3				3
Diospyros longiflora	127	Ebenaceae			12		12
Diospyros sp	127	Ebenaceae	74	90	47	115	326
Omphalocarpum elatum	129	Sapotaceae	1		1	7	9
Gambeya africana	129	Sapotaceae	10	17	21	35	83
Afrostyrax kamerunensis	131	Styracaceae		3			3
Anthocleista schweinfurthii	132	Longaniaceae				1	1
Strychnos sp	132	Longaniaceae	30	2	2	13	47
Alstonia boonei	134	Apocynaceae	10	2		10	22
Funtumia elastica	134	Apocynaceae	13	2	3	8	26
Picralima nitida	134	Apocynaceae	13	4		3	20
Rauvolfia vomitoria	134	Apocynaceae			1		1
Tabernaemontana crassa	134	Apocynaceae	21	11	11	20	63
Voacanga africana	134	Apocynaceae	18	2		3	23
Voacanga obtusa	134	Apocynaceae	9		1		10

Aulacocalyx sp	137	Rubiaceae	8	9		6	23
Aulacocalyx tabotii	137	Rubiaceae		2	3		5
Aulacocalyx talbotii	137	Rubiaceae		2	7		9
Aulococalyx caudata	137	Rubiaceae			2		2
Calpocalyx dinklagei	137	Rubiaceae	299	150	53	299	801
Canthium arnoldianum	137	Rubiaceae				2	2
Canthium sp	137	Rubiaceae	10	4	7	10	31
Heinsia crinita	137	Rubiaceae	2			1	3
Morinda lucida	137	Rubiaceae	3	5	3	3	14
Nauclea diderrichii	137	Rubiaceae	3		1	3	7
Pausinystalia johimbe	137	Rubiaceae	2	15	12	8	37
Pausinystalia talbotii	137	Rubiaceae			7	1	8
Rothmannia hispida	137	Rubiaceae	30	17	12	9	68
Schumanniophyton magnificum	137	Rubiaceae	1		1		2
Dracaena arborea	138	Dipsacaceae		2			2
Cordia africana	150	Boraginaceae	5		2	1	8
Spathodea campanulelata	157	Bignoniaceae				1	1
Vitex grandifolia	160	Verbenaceae	16	18	12	11	57
Vitex sp	160	Verbenaceae	21	11	7	14	53
Elaeis guineensis	193	Palmae	2	11	2	7	22
Physostigma venenosum		(Leer)		1			1
Usteria guineensis		(Leer)				2	2
Anisophyllea polyneura		Anisophylleaceae	2	1		9	12
Magnistipula tessmannii		Chrysobalanaceae	1	2	5		8
Maranthes sp		Chrysobalanaceae	2				2
Total			**2499**	**1921**	**1583**	**3124**	**9134**

F.Nr.: Family number; Ul.I: Unlogged I: Ul. II: Unlogged II; L.I Logged I; L.II: Logged II

Appendix 3.2: Abundance of trees per plot and per transect in unlogged and logged study sites

Site	Habitat		M.T A/plot	T.A/ transect	T.A/site	M.T.A/site
Bajo	Unlogged	1	75.57	529		
Bajo	Unlogged	2	49.16	295		
Bajo	Unlogged	3	77.7	544		
Bajo	Unlogged	4	69.00	483		
Bajo	Unlogged	5	51.00	357		
Bajo	Unlogged	6	48.5	291	2499	416.50
Mgebgati	Unlogged	1	76.71	537		
Mgebgati	Unlogged	2	75.28	527		
Mgebgati	Unlogged	3	80.00	480		
Mgebgati	Unlogged	4	75.00	525		
Mgebgati	Unlogged	5	86.00	602		
Mgebgati	Unlogged	6	65.14	456	3127	521.16
Bayip	Logged	1	42.28	296		
Bayip	Logged	2	63.00	441		
Bayip	Logged	3	43.00	301		
Bayip	Logged	4	40.85	286		
Bayip	Logged	5	44.57	312		
Bayip	Logged	6	41.14	288	1924	320.66
Etinkem	Logged	1	37.42	262		
Etinkem	Logged	2	32.71	229		
Etinkem	Logged	3	33.71	236		
Etinkem	Logged	4	39.57	277		
Etinkem	Logged	5	43.85	307		
Etinkem	Logged	6	39.00	273	1584	264.00

M.T.A: Mean tree abundance; T.A: Trees abundance

Appendix 3.3: Abundance of food trees for primates and hornbills in unlogged and logged study sites.

Site	Habitat	Tr.	Ab.f. t./tr.	M. f.t/ site	% of fruit trees.	Mean % of fruit trees
Bajo	Unlogged	1	196		37.05	
Bajo	Unlogged	2	129		43.72	
Bajo	Unlogged	3	254		46.69	
Bajo	Unlogged	4	205		42.44	
Bajo	Unlogged	5	189		52.94	
Bajo	Unlogged	6	147	186.66	50.51	45.56
Mgebgati	Unlogged	1	294		54.74	
Mgebgati	Unlogged	2	201		38.14	
Mgebgati	Unlogged	3	236		49.16	
Mgebgati	Unlogged	4	218		41.52	
Mgebgati	Unlogged	5	282		46.84	
Mgebgati	Unlogged	6	205	239.33	44.95	45.89
Bayip	Logged	1	154		52.02	
Bayip	Logged	2	201		45.57	
Bayip	Logged	3	142		47.17	
Bayip	Logged	4	168		58.74	
Bayip	Logged	5	174		55.76	
Bayip	Logged	6	143	163.66	49.65	51.49
Etinkem	Logged	1	152		58.01	
Etinkem	Logged	2	129		56.33	
Etinkem	Logged	3	78		33.05	
Etinkem	Logged	4	154		55.59	
Etinkem	Logged	5	208		67.75	
Etinkem	Logged	6	161	147.00	58.97	54.95

Tr: transect; Ab.f. t: Abundance food trees; M. f.t: Mean food trees;

Appendix 3.4: Check list of food trees for primates and hornbills in unlogged and logged study sites.

Species	Family	Animal species	Part eaten	Local name
Afrostyrax kamerunensis	Styracaceae	P, H	F, Fl, Yl	Bekang
Allanblackia sp.	Guttiferae	P	F,	
Angylocalyx zenkeri	Papilionaceae	P, H	F	Nsap
Annonidium manii	Anonaceae	P, H	F, Fl	
Anthonotha sp.	Caesalpiniaceae	P		Echi-mbeck
Baillonella toxisperma	Sapotaceae	P, H	F	Ofu
Blighia sapida	Sapotaceae	P, H	F	
Canarium schweinfurthii	Burseraceae	P, H	F, S	Osuk asung
Carapa procera	Meliaceae	P, H	F, Fl, Yl, S	
Chytranthus angustifolius	Sapindaceae	P, H	F, Yl	
Cleistopholis sp.	Anonaceae			
Coelocaryon preussii	Myristicaceae	P, H	F, S	
Cola acuminata	Sterculliaceae	P	S, Yl, Fl	Ebliki
Cola chlamydantha	Sterculliaceae	P	S, Yl, Fl	Ebongachi
Cola lateritia	Sterculliaceae	P	S, Yl, Fl	
Cola lepidota	Sterculliaceae	P	S, Yl, Fl	Ebonge
Cola sp.	Sterculliaceae	P	S, Yl, Fl	
Cyrtogonone argentea	Euphorbiaceae			
Dacryodes edulis	Burseraceae	P, H	F, S	Ojack
Dialium sp.	Caesalpiniaceae	P, H	F	
Diogoa zenkeri	Olacaceae	P, H	F, S	Ekonjock
Duboscia macrocarpa	Tiliaceae	P, H	F, S	
Elaeis guineensis	Palmae	P, H	F, S	Opkeoso
Enantia chlorantha	Guttiferae	P, H	F, Yl	Oluck
Eriocoelum macrocarpum	Sapidaceae	P, H	S	
Ficus sp.	Moraceae	P, H	F, Yl, S, Fl	
Funtumia africana	Apocynaceae	P, H	S	
Gambeya africana	Sapotaceae	P, H	F, S	
Garicinia mannii	Guttiferae	P, H	Fl, R	Esar
Grewia coriacea	Tiliaceae	P, H	S	
Guarea cedrata	Meliaceae			
Hypodaphnis zenkeri	Lauraceae	P, H	F	
Irvingia gabonensis	Irvingiaceae	P, H	F	Nseng
Lophira alata	Ochnaceae	P, H	Yl, Fl	Echawut
Maesopsis eminii	Rhamnaceae			
Maesobotrya sp.	Euphorbiaceae			
Mareyopsis longifolia	Euphorbiaceae	P, H	F, Fl	
Monodora sp.	Anonaceae	P, H	F, S	
Musanga cecropioides	Moraceae	P, H	S, Fl, Yl	Enemaphock
Myrianthus arboreus	Moraceae	P, H	F, S	
Napoleona sp.	Lecythidaceae	P, H	F, S	
Picralima nitida	Apocynaceae	P, H	F	
Piptadeniastrum africanum	Mimosaceae	P, H	F,S	
Protomegabaria stapfiana	Euphorbiaceae	P, H	F	
Pseudospondias microcarpa	Anacardiaceae	P, H	F	
Pycnanthus angolensis	Myristicaceae	P, H	S, Yl, Fl	
Rauvolfia vomitoria	Apocynaceae	P, H	F	

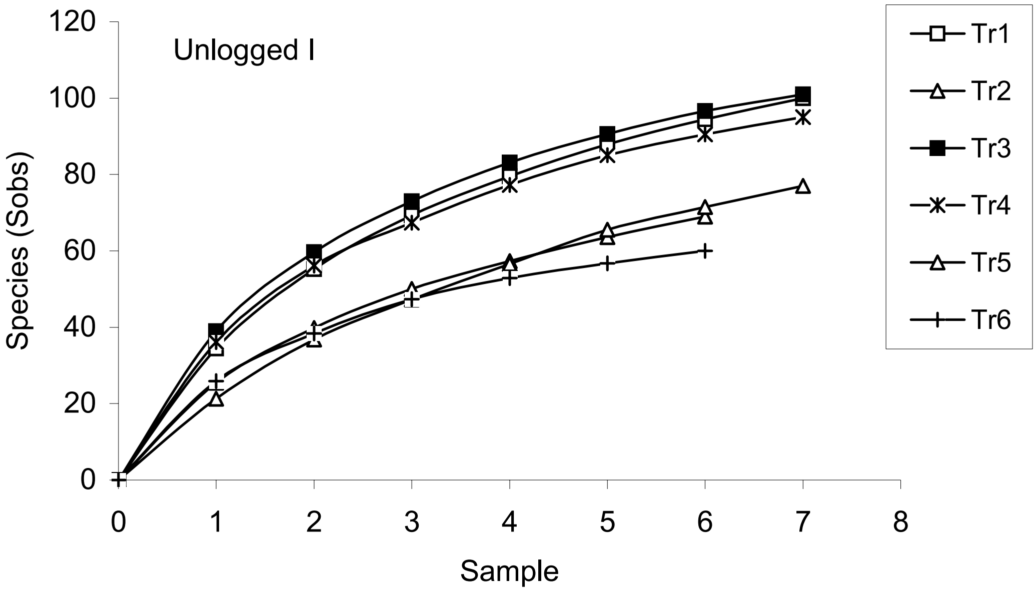
Ricinodendron heudelotii	Euphorbiaceae	P, H	S, Yl	Ngiock
Rinoria sp.	Violaceae	P, H	F, S	
Rothmannia sp.	Rubiaceae	P, H	F	
Santiria trimera	Burseraceae	P, H	F	Nkwaolenge
Scottellia coriacea	Flacourtiaceae	P, H	F	
Sorindeia grandifolia	Anarcadiaceae	P, H	F, S	
Staudtia kamerunensis	Myristicaceae	P, H	S, Fl	Ekaneokon
Sterculia tragacantha	Sterculiaceae	P, H	F, Fl	
Strombosia sp.	Olacaceae	P, H	F	Nkong
Strombosiopsis tetrandra	Olacaceae	P, H	F, Yl	
Tabernaemontana crassa	Apocynaceae	P, H		
Treculia africana	Moraceae	P, H	F, S	Eberamen
Treculia obovoidea	Moraceae	P, H	F, S	Eberamen
Trichilia sp.	Meliaceae	P, H	F	
Trichoscypha acuminata	Anarcadiaceae	P, H	F, S	Okoyong
Uapaca guineensis	Euphorbiaceae	P, H	F, S, Fl	Oleng
Uvariodendron giganteum	Amaranthaceae			
Vitex grandifolia	Verbenaceae	P, H	F	
Xylopia aethiopica	Amaranthaceae	P, H	F, S	Era

P: Primates, H: Hornbills; F: Fruits; Fl: Flowers; Yl: Young leaves; S: seeds

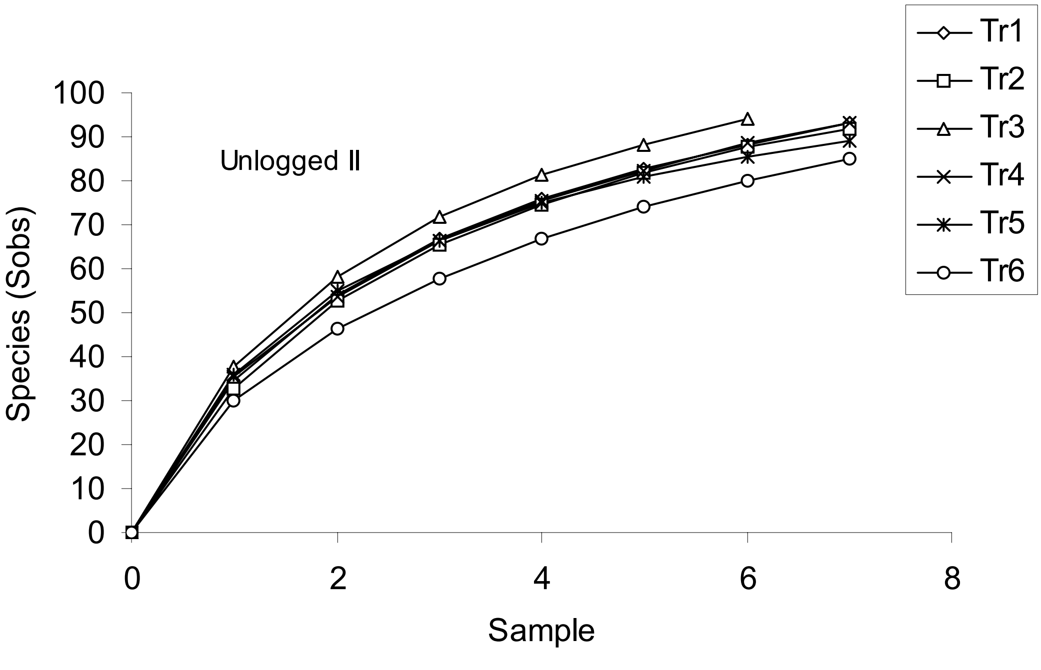
Appendix 3.5: Plot/based of 21 species accumulation curve of tree ≥8 cm dbh of the study.

Samples	Allplots	Bothunlogged	Bothlogged	U. I	Ul. II	L. I	L. II
1	26.66	32.12	23.56	30.08	35.12	22.22	22.48
2	45.52	51.98	38.3	50.42	54.5	38.84	37.18
3	57.58	68.78	49.02	64.02	68.28	51.1	48.24
4	68.94	79.82	58.92	74.74	79.12	60.38	56.8
5	78.96	89.5	67.2	83.26	87.74	67.8	63.24
6	86.76	97.26	72.9	91.14	94.62	73.84	69.2
7	94.66	104.02	77.96	97	100.84	79.96	74.26
8	100.54	110.6	83.32	101.4	106.34	85.14	78.94
9	105.72	115.3	88.2	105.7	111.08	88.74	83.02
10	110.6	119.86	92.18	109.4	114.96	92.74	86.14
11	115.28	123.9	95.66	113.02	118.96	96.06	89.8
12	118.88	127.44	98.84	115.6	122.22	98.7	92.74
13	122.42	130.9	101.84	118.66	125.62	101.24	95.7
14	126.2	134.12	104.84	121.14	128.18	104.32	98.34
15	128.9	136.74	107.74	123.6	130	106.66	100.7
16	131.76	139.58	110.4	125.8	132.2	109.36	102.92
17	134.88	141.78	112.84	128.54	134.54	111.66	104.72
18	137.44	144.34	114.8	130.36	136.36	113.86	106.78
19	140.46	146.4	117.56	132.42	138.44	115.96	108.86
20	143.08	148.36	119.66	134.02	139.88	118.16	110.52
21	145.58	150.08	121.16	135.78	141.26	119.7	112.28

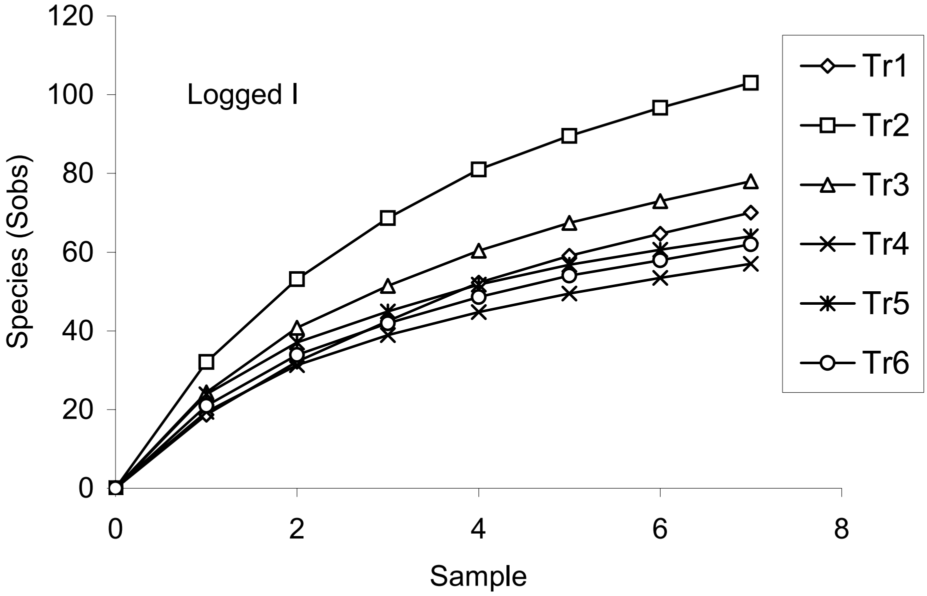
Appendix 3.6a: The mean estimate from samples (plots) pooled by transect of the differences in species richness in unlogged I (Tr: transect)



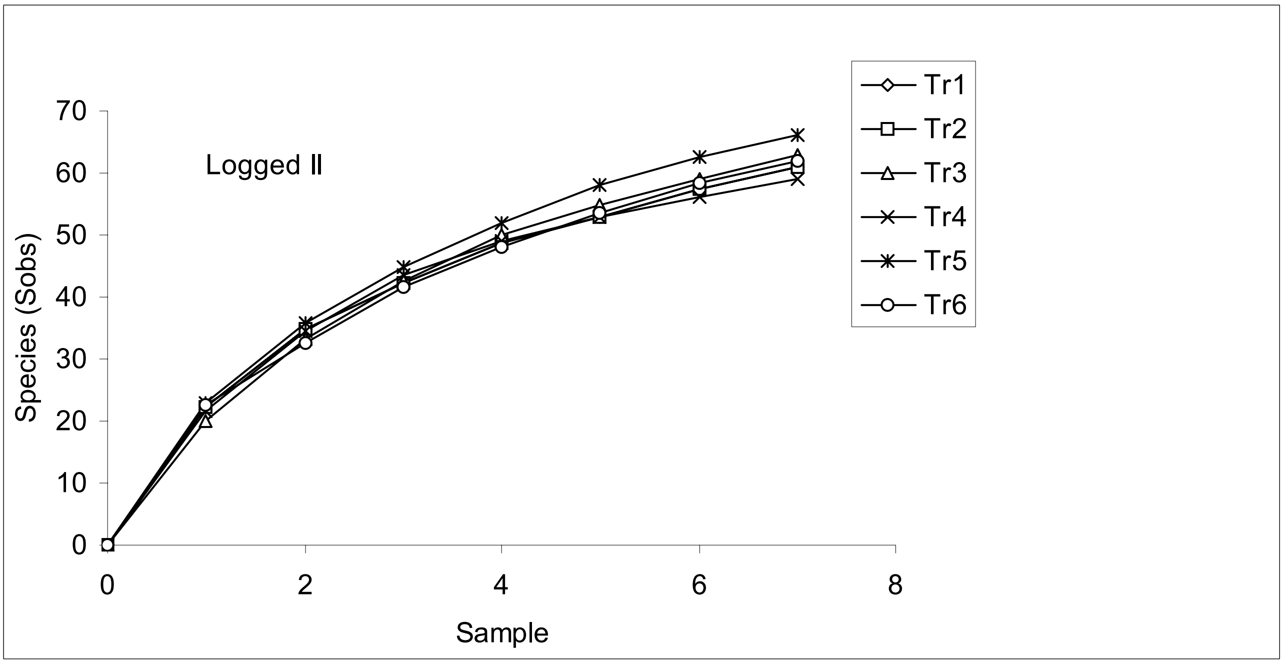
Appendix 3.6b: The mean estimate from samples (plots) pooled by transect of the differences in species richness in unlogged II (Tr: Transect)



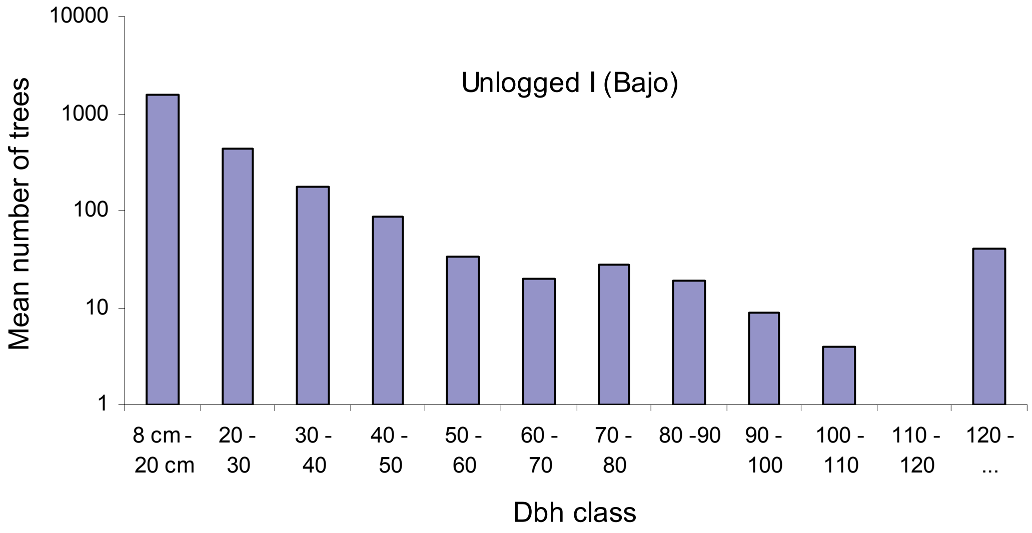
Appendix 3.6c: The mean estimate from samples (plots) pooled by transect of the differences in species richness in species richness in logged (Tr: Transect)



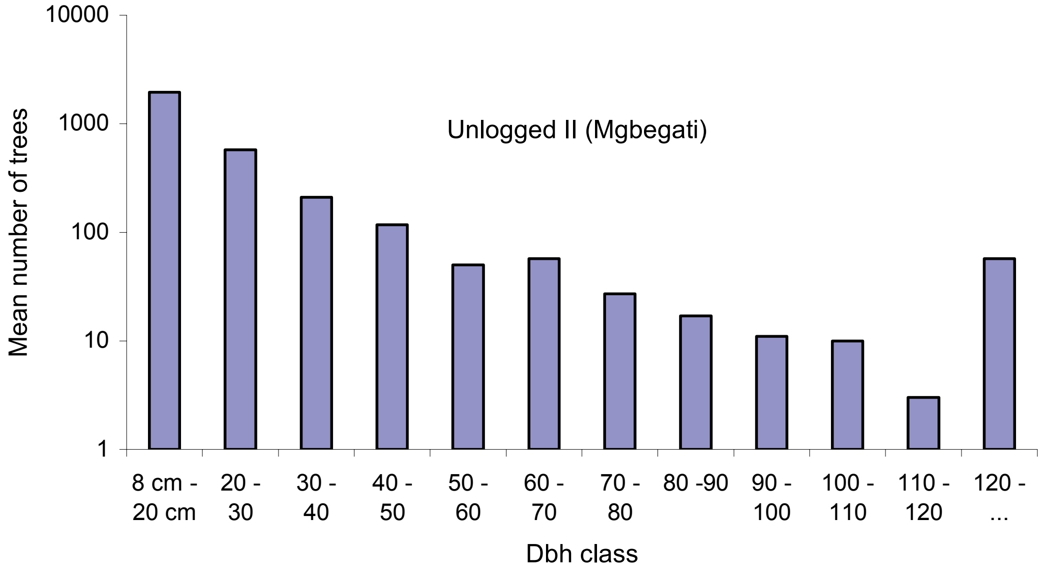
Appendix 3.6d: The mean estimate from samples (plots) pooled by transect of the differences in species richness in logged II (Tr. Transect).



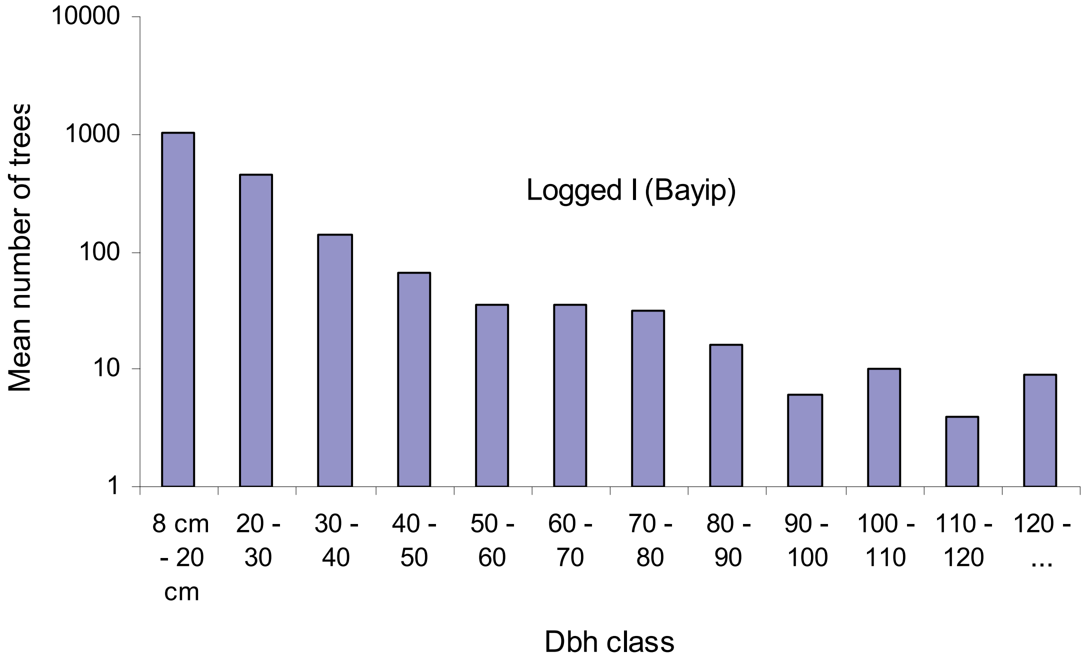
Appendix 3.7a: Tree diamater distribution in unlogged I (dbh ≥8 cm).



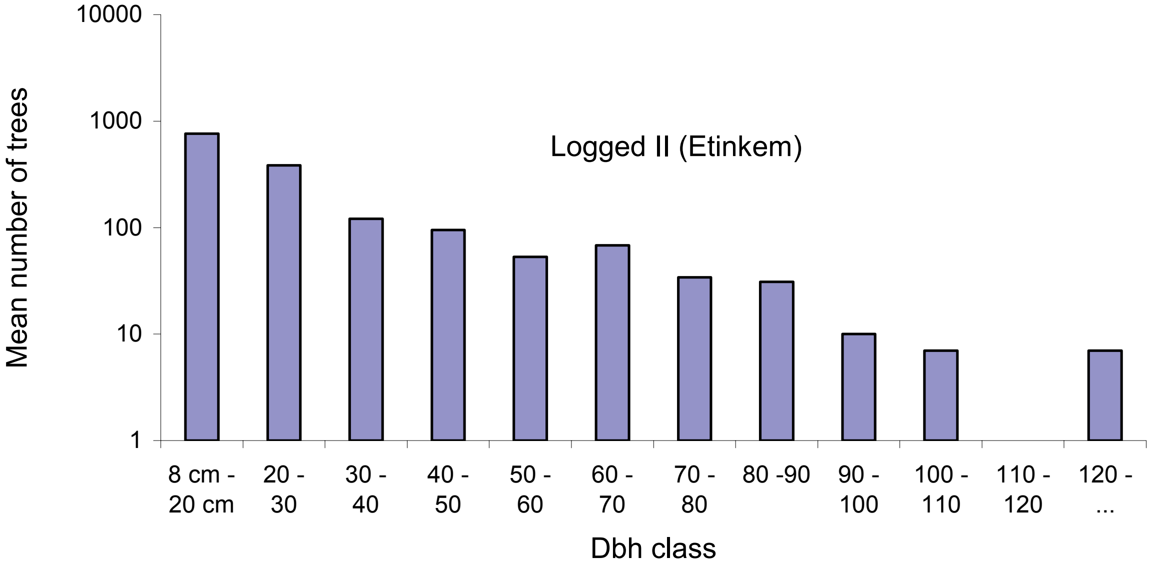
Appendix 3.7b: Tree diameter distribution in logged II (dbh ≥8 cm).



Appendix 3.7c: Tree diameter distribution in logged I (dbh ≥8 cm).



Appendix 3.7d: Tree diameter distribution in logged II (dbh ≥8 cm)



Appendix 3.8: Primates distance file in unlogged and logged study sites from 2001-2002.Baj: Bajo or unlogged I; Mgb: Mgbegati or unlogged II; Bay: BayipArsibong or logged I and Eti.: Etinkem or logged II.*: species' local name (Ejagham)

Region	Area	Transect	Lenght	Species*	P. Distance	Cluster size
Baj	16	1	10	mbare-mbock	25	22
Baj	16	1	10	mbare-mbock	27	22
Baj	16	1	10	mbare-mbock	160	1
Baj	16	1	10	mbare-mbock	25	1
Baj	16	1	10	mbare-mbock	120	1
Baj	16	1	10	mbare-mbock	250	1
Baj	16	1	10	mbare-mbock	150	1
Baj	16	1	10	mbare-mbock	130	1
Baj	16	1	10	mbik-mbock	24	2
Baj	16	1	10	nyake-mbock	28	22
Baj	16	1	10	nyake-mbock	150	1
Baj	16	1	10	nyake-mbock	120	1
Baj	16	1	10	nyake-mbock	150	1
Baj	16	1	10	nyake-mbock	180	1
Baj	16	1	10	nyake-mbock	200	1
Baj	16	2	10	mbare-mbock	19	22
Baj	16	2	10	mbare-mbock	130	1
Baj	16	2	10	mbare-mbock	150	1
Baj	16	2	10	mbare-mbock	160	1
Baj	16	2	10	mbare-mbock	30	22
Baj	16	2	10	mbare-mbock	150	1
Baj	16	2	10	mbare-mbock	30	22
Baj	16	2	10	mbare-mbock	70	1
Baj	16	2	10	mbik	35	22
Baj	16	2	10	nyake-mbock	120	1
Baj	16	2	10	nyake-mbock	300	1
Baj	16	2	10	nyake-mbock	130	1
Baj	16	2	10	nyake-mbock	130	22
Baj	16	2	10	nyake-mbock	150	1
Baj	16	2	10	nyake-mbock	80	1
Baj	16	2	10	nyake-mbock	150	8
Baj	16	3	12	mbare-mbock	17	22
Baj	16	3	12	mbare-mbock	200	1
Baj	16	3	12	mbare-mbock	120	1
Baj	16	3	12	mbare-mbock	150	1
Baj	16	3	12	mbik	60	2
Baj	16	3	12	mbik-mbock	150	1
Baj	16	3	12	mbik-mbock	18	10
Baj	16	3	12	nka-bock	45	22
Baj	16	3	12	nka-bock	150	1
Baj	16	3	12	nka-bock	200	2
Baj	16	3	12	nyake mbock	75	1
Baj	16	3	12	nyake-mbock	180	1
Baj	16	3	12	nyake-mbock	150	1
Baj	16	3	12	nyake-mbock	180	1
Baj	16	3	12	nyake-mbock	28	22
Baj	16	3	12	nyake-mbock	150	1

Baj	16	3	12	nyake-mbock	150	1
Baj	16	3	12	nyake-mbock	70	1
Baj	16	3	12	nyake-mbock	150	1
Baj	16	3	12	nyake-mbock	50	1
Baj	16	3	12	nyake-mbock	90	1
Baj	16	3	12	oko-mbock	50	1
Baj	16	4	12	mbare-mbock	150	1
Baj	16	4	12	mbare-mbock	25	22
Baj	16	4	12	mbare-mbock	90	1
Baj	16	4	12	mbare-mbock	20	1
Baj	16	4	12	mbare-mbock	200	1
Baj	16	4	12	mbare-mbock	13	22
Baj	16	4	12	mbare-mbock	45	1
Baj	16	4	12	mbare-mbock	45	22
Baj	16	4	12	mbare-mbock	350	1
Baj	16	4	12	mbare-mbock	70	1
Baj	16	4	12	mbare-mbock	30	1
Baj	16	4	12	mbare-mbock	120	1
Baj	16	4	12	mbare-mbock	200	1
Baj	16	4	12	mbik-mbock	30	1
Baj	16	4	12	mbik-mbock	18	22
Baj	16	4	12	mbik-mbock	45	22
Baj	16	4	12	nyake-mbock	90	1
Baj	16	4	12	nyake-mbock	12	22
Baj	16	4	12	nyake-mbock	150	1
Baj	16	4	12	nyake-mbock	150	1
Baj	16	4	12	nyake-mbock	300	1
Baj	16	4	12	nyake-mbock	250	1
Baj	16	4	12	nyake-mbock	30	1
Baj	16	4	12	nyake-mbock	170	1
Baj	16	4	12	nyake-mbock	250	1
Baj	16	4	12	nyake-mbock	150	1
Baj	16	4	12	nyake-mbock	200	1
Baj	16	4	12	nyake-mbock	200	1
Baj	16	4	12	nyake-mbock	250	1
Baj	16	4	12	nyake-mbock	40	1
Baj	16	4	12	oko-mbock	120	1
Baj	16	4	12	oko-mbock	150	1
Baj	16	4	12	oko-mbock	75	1
Baj	16	5	12	mbare-mbock	15	22
Baj	16	5	12	mbare-mbock	45	22
Baj	16	5	12	mbare-mbock	150	1
Baj	16	5	12	mbare-mbock	250	1
Baj	16	5	12	mbare-mbock	200	1
Baj	16	5	12	mbare-mbock	150	1
Baj	16	5	12	mbare-mbock	85	1
Baj	16	5	12	mbare-mbock	200	1
Baj	16	5	12	mbare-mbock	25	1
Baj	16	5	12	mbare-mbock	150	1
Baj	16	5	12	mbare-mbock	250	1
Baj	16	5	12	mbare-mbock	180	1
Baj	16	5	12	mbik	70	1

Baj	16	5	12	mbik	150	2
Baj	16	5	12	mbik	35	18
Baj	16	5	12	mbik-mbock	20	22
Baj	16	5	12	mbik-mbock	18	1
Baj	16	5	12	nyake-mbock	80	1
Baj	16	5	12	nyake-mbock	250	1
Baj	16	5	12	nyake-mbock	150	1
Baj	16	5	12	nyake-mbock	150	1
Baj	16	5	12	nyake-mbock	180	1
Baj	16	5	12	nyake-mbock	20	1
Baj	16	5	12	nyake-mbock	160	1
Baj	16	5	12	nyake-mbock	24	1
Baj	16	5	12	nyake-mbock	250	1
Baj	16	6	12	mbare-mbock	200	1
Baj	16	6	12	mbare-mbock	150	1
Baj	16	6	12	mbare-mbock	20	22
Baj	16	6	12	mbare-mbock	180	1
Baj	16	6	12	mbare-mbock	180	1
Baj	16	6	12	mbare-mbock	18	1
Baj	16	6	12	mbare-mbock	200	1
Baj	16	6	12	mbare-mbock	200	1
Baj	16	6	12	mbare-mbock	80	1
Baj	16	6	12	mbik	80	1
Baj	16	6	12	mbik-mbock	35	22
Baj	16	6	12	mbik-mbock	25	22
Baj	16	6	12	mbik-mbock	25	22
Baj	16	6	12	mbik-mbock	20	22
Baj	16	6	12	mbik-mbock	65	1
Baj	16	6	12	nyake-mbock	180	1
Baj	16	6	12	nyake-mbock	150	1
Baj	16	6	12	nyake-mbock	15	22
Baj	16	6	12	nyake-mbock	130	1
Baj	16	6	12	nyake-mbock	85	1
Baj	16	6	12	nyake-mbock	160	1
Baj	16	6	12	nyake-mbock	150	1
Baj	16	6	12	nyake-mbock	250	1
Baj	16	6	12	nyake-mbock	250	1
Baj	16	6	12	nyake-mbock	150	1
Baj	16	6	12	nyake-mbock	250	1
Baj	16	6	12	oko-mbock	35	6
Bay	16	1	10	mbare-mbock	60	25
Bay	16	1	10	mbare-mbock	130	23
Bay	16	1	10	mbare-mbock	80	25
Bay	16	1	10	mbik	160	18
Bay	16	1	10	mbik	130	25
Bay	16	1	10	nyake-mbock	200	30
Bay	16	1	10	nyake-mbock	250	30
Bay	16	1	10	nyake-mbock	90	21
Bay	16	1	10	nyake-mbock	160	25
Bay	16	1	10	nyake-mbock	25	20
Bay	16	1	10	nyock	250	25
Bay	16	1	10	nyock	200	15

Bay	16	1	10	nyock	75	15
Bay	16	2	10	mbare-mbock	70	25
Bay	16	2	10	nyake-mbock	80	26
Bay	16	2	10	nyake-mbock	112	30
Bay	16	2	10	nyake-mbock	250	30
Bay	16	2	10	nyake-mbock	150	21
Bay	16	3	14	mbare-mbock	80	25
Bay	16	3	14	mbare-mbock	70	21
Bay	16	3	14	mbare-mbock	75	25
Bay	16	3	14	mbare-mbock	50	30
Bay	16	3	14	mbare-mbock	15	25
Bay	16	3	14	mbare-mbock	22	25
Bay	16	3	14	nyake-mbock	120	26
Bay	16	3	14	nyake-mbock	150	25
Bay	16	4	8	mbare-mbock	55	24
Bay	16	4	8	mbare-mbock	150	25
Bay	16	4	8	mbare-mbock	150	25
Bay	16	4	8	mbare-mbock	300	25
Bay	16	4	8	mbare-mbock	70	31
Bay	16	4	8	mbik	275	23
Bay	16	4	8	nyake-mbock	175	30
Bay	16	4	8	nyake-mbock	60	28
Bay	16	4	8	nyake-mbock	250	1
Bay	16	5	14	mbare-mbock	90	26
Bay	16	5	14	mbare-mbock	28	25
Bay	16	5	14	mbare-mbock	85	15
Bay	16	5	14	mbare-mbock	30	30
Bay	16	5	14	nyake-mbock	200	20
Bay	16	5	14	nyake-mbock	126	30
Bay	16	5	14	nyake-mbock	60	22
Bay	16	5	14	nyake-mbock	10	26
Bay	16	5	14	nyock	100	15
Bay	16	6	14	mbare-mbock	65	25
Bay	16	6	14	mbare-mbock	20	20
Bay	16	6	14	mbik-mbock	200	25
Bay	16	6	14	nyake-mbock	140	25
Bay	16	6	14	nyake-mbock	100	30
Bay	16	6	14	nyake-mbock	300	25
Bay	16	6	14	nyake-mbock	150	23
Bay	16	6	14	nyake-mbock	175	35
Eti	16	1	10	mbare-mbock	180	31
Eti	16	1	10	mbare-mbock	125	22
Eti	16	1	10	mbare-mbock	125	22
Eti	16	1	10	mbik	22	20
Eti	16	1	10	mbik-mbock	72	28
Eti	16	1	10	mbik-mbock	117	22
Eti	16	1	10	mbik-mbock	300	1
Eti	16	1	10	nyake-mbock	175	30
Eti	16	1	10	nyake-mbock	450	20
Eti	16	1	10	nyake-mbock	400	15
Eti	16	1	10	nyake-mbock	129	22
Eti	16	1	10	nyake-mbock	72	22

Eti	16	1	10	nyake-mbock	146	22
Eti	16	1	10	nyake-mbock	125	22
Eti	16	1	10	nyake-mbock	139	22
Eti	16	1	10	nyake-mbock	200	28
Eti	16	1	10	nyock	350	23
Eti	16	1	10	nyock	350	17
Eti	16	1	10	oko-mbock	350	16
Eti	16	1	10	oko-mbock	36	22
Eti	16	2	10	mbare-mbock	113	22
Eti	16	2	10	mbare-mbock	120	22
Eti	16	2	10	mbare-mbock	23	10
Eti	16	2	10	mbare-mbock	710	22
Eti	16	2	10	mbik-mbock	66	22
Eti	16	2	10	mbik-mbock	38	12
Eti	16	2	10	nka-bock	295	22
Eti	16	2	10	nyake-mbock	70	22
Eti	16	2	10	nyake-mbock	200	22
Eti	16	2	10	nyake-mbock	43	16
Eti	16	2	10	nyake-mbock	375	22
Eti	16	2	10	nyake-mbock	400	22
Eti	16	2	10	nyake-mbock	300	22
Eti	16	2	10	nyock	450	22
Eti	16	3	12	mbare-mbock	27	22
Eti	16	3	12	mbare-mbock	400	22
Eti	16	3	12	mbare-mbock	450	22
Eti	16	3	12	mbare-mbock	155	22
Eti	16	3	12	mbare-mbock	280	32
Eti	16	3	12	mbik	200	22
Eti	16	3	12	mbik	78	22
Eti	16	3	12	mbik-mbock	27	22
Eti	16	3	12	nyake-mbock	124	22
Eti	16	3	12	nyake-mbock	240	22
Eti	16	3	12	nyake-mbock	30	14
Eti	16	3	12	nyake-mbock	180	22
Eti	16	3	12	nyake-mbock	95	22
Eti	16	3	12	nyake-mbock	300	22
Eti	16	3	12	nyake-mbock	28	22
Eti	16	3	12	nyake-mbock	27	22
Eti	16	3	12	nyake-mbock	26	1
Eti	16	3	12	nyock	300	22
Eti	16	3	12	nyock	350	22
Eti	16	3	12	nyock	380	1
Eti	16	4	10	mbare-mbock	83	22
Eti	16	4	10	mbare-mbock	150	22
Eti	16	4	10	mbare-mbock	100	22
Eti	16	4	10	mbik	114	22
Eti	16	4	10	mbik-mbock	340	22
Eti	16	4	10	mbik-mbock	38	22
Eti	16	4	10	nyake-mbock	350	22
Eti	16	4	10	nyake-mbock	400	22
Eti	16	4	10	nyake-mbock	88	28
Eti	16	4	10	nyake-mbock	125	22

Eti	16	4	10	nyake-mbock	300	22
Eti	16	4	10	nyock	125	33
Eti	16	5	14	mbare-mbock	77	22
Eti	16	5	14	mbare-mbock	208	22
Eti	16	5	14	mbare-mbock	30	25
Eti	16	5	14	mbare-mbock	700	22
Eti	16	5	14	mbare-mbock	47	20
Eti	16	5	14	mbare-mbock	250	22
Eti	16	5	14	mbare-mbock	35	20
Eti	16	5	14	mbik-mbock	125	18
Eti	16	5	14	mbik-mbock	47	22
Eti	16	5	14	mbik-mbock	30	10
Eti	16	5	14	mbik-mbock	100	7
Eti	16	5	14	mbik-mbock	40	6
Eti	16	5	14	nyake-mbock	300	22
Eti	16	5	14	nyake-mbock	41	12
Eti	16	5	14	nyake-mbock	280	22
Eti	16	5	14	nyake-mbock	300	22
Eti	16	5	14	nyake-mbock	27	23
Eti	16	5	14	nyake-mbock	100	22
Eti	16	5	14	nyake-mbock	400	22
Eti	16	5	14	nyake-mbock	115	20
Eti	16	5	14	nyake-mbock	400	1
Eti	16	6	12	mbare-mbock	120	22
Eti	16	6	12	mbare-mbock	12	28
Eti	16	6	12	mbare-mbock	340	22
Eti	16	6	12	mbare-mbock	20	15
Eti	16	6	12	mbare-mbock	22	31
Eti	16	6	12	mbare-mbock	270	1
Eti	16	6	12	mbik	26	36
Eti	16	6	12	mbik-mbock	20	10
Eti	16	6	12	mbik-mbock	22	25
Eti	16	6	12	nyake-mbock	440	25
Eti	16	6	12	nyake-mbock	20	20
Eti	16	6	12	nyake-mbock	112	22
Eti	16	6	12	nyake-mbock	11	22
Eti	16	6	12	nyake-mbock	420	22
Eti	16	6	12	nyake-mbock	200	20
Eti	16	6	12	nyake-mbock	200	1
Eti	16	6	12	nyock	125	22
Mgb	16	1	12	x	0	1
Mgb	16	2	10	mbare-mbock	13	20
Mgb	16	2	10	mbik	13	12
Mgb	16	2	10	mbik-mbock	3	21
Mgb	16	2	10	nyake-mbock	13	17
Mgb	16	3	8	nyake-mbock	155	1
Mgb	16	3	8	nyake-mbock	250	1
Mgb	16	3	8	nyock	200	7
Mgb	16	3	8	nyock	200	5
Mgb	16	3	8	nyock	170	6
Mgb	16	4	10	mbare-mbock	150	1
Mgb	16	4	10	mbare-mbock	10	15

Mgb	16	4	10	mbik-mbock	11	25
Mgb	16	4	10	nyake-mbock	13	22
Mgb	16	4	10	nyake-mbock	10	16
Mgb	16	5	10	x	0	1
Mgb	16	6	10	mbare-mbock	3	37
Mgb	16	6	10	mbare-mbock	15	25
Mgb	16	6	10	mbik-mbock	11	12
Mgb	16	6	10	mbock	125	1

Appendix 3.9: The Yellow casqued hornbill (*C. atrata*) distance file in unlogged and logged study sites from 2001-2002. *: Hornbill species' local name (Ejagham).

Region	**Area**	**Transect**	**Lenght**	**Species***	**P. Distance**	**Cluster size**
Logged I	16	1	10	enyaghe-ngone	35	1
Logged I	16	1	10	enyaghe-ngone	70	2
Logged I	16	1	10	enyaghe-ngone	65	1
Logged I	16	1	10	enyaghe-ngone	50	2
Logged I	16	1	10	enyaghe-ngone	10	4
Logged I	16	1	10	enyaghe-ngone	60	1
Logged I	16	1	10	enyaghe-ngone	80	2
Logged I	16	1	10	enyaghe-ngone	25	4
Logged I	16	1	10	enyaghe-ngone	80	2
Logged I	16	1	10	enyaghe-ngone	50	2
Logged I	16	2	10	enyaghe-ngone	55	2
Logged I	16	2	10	enyaghe-ngone	12	5
Logged I	16	2	10	enyaghe-ngone	35	1
Logged I	16	2	10	enyaghe-ngone	30	3
Logged I	16	2	10	enyaghe-ngone	75	1
Logged I	16	2	10	enyaghe-ngone	65	1
Logged I	16	2	10	enyaghe-ngone	20	3
Logged I	16	2	10	enyaghe-ngone	60	2
Logged I	16	2	10	enyaghe-ngone	50	2
Logged I	16	2	10	enyaghe-ngone	40	2
Logged I	16	2	10	enyaghe-ngone	30	2
Logged I	16	2	10	enyaghe-ngone	65	1
Logged I	16	2	10	enyaghe-ngone	90	2
Logged I	16	3	14	enyaghe-ngone	50	3
Logged I	16	3	14	enyaghe-ngone	40	2
Logged I	16	3	14	enyaghe-ngone	25	2
Logged I	16	3	14	enyaghe-ngone	25	3
Logged I	16	3	14	enyaghe-ngone	55	2
Logged I	16	3	14	enyaghe-ngone	80	1
Logged I	16	3	14	enyaghe-ngone	16	2
Logged I	16	3	14	enyaghe-ngone	50	3
Logged I	16	4	8	enyaghe-ngone	35	1
Logged I	16	4	8	enyaghe-ngone	30	2
Logged I	16	4	8	enyaghe-ngone	15	2
Logged I	16	4	8	enyaghe-ngone	40	1
Logged I	16	4	8	enyaghe-ngone	150	1
Logged I	16	4	8	enyaghe-ngone	25	4
Logged I	16	4	8	enyaghe-ngone	200	1
Logged I	16	4	8	enyaghe-ngone	60	1

Logged I	16	4	8	enyaghe-ngone	55	1
Logged I	16	4	8	enyaghe-ngone	23	2
Logged I	16	4	8	enyaghe-ngone	70	1
Logged I	16	4	8	enyaghe-ngone	50	1
Logged I	16	4	8	enyaghe-ngone	40	2
Logged I	16	5	14	enyaghe-ngone	60	1
Logged I	16	5	14	enyaghe-ngone	31	4
Logged I	16	5	14	enyaghe-ngone	56	1
Logged I	16	5	14	enyaghe-ngone	60	2
Logged I	16	5	14	enyaghe-ngone	15	2
Logged I	16	5	14	enyaghe-ngone	35	3
Logged I	16	5	14	enyaghe-ngone	45	2
Logged I	16	5	14	enyaghe-ngone	50	2
Logged I	16	5	14	enyaghe-ngone	45	1
Logged I	16	5	14	enyaghe-ngone	30	3
Logged I	16	5	14	enyaghe-ngone	150	2
Logged I	16	5	14	enyaghe-ngone	0	2
Logged I	16	6	14	enyaghe-ngone	50	2
Logged I	16	6	14	enyaghe-ngone	50	2
Logged I	16	6	14	enyaghe-ngone	15	5
Logged I	16	6	14	enyaghe-ngone	50	2
Logged I	16	6	14	enyaghe-ngone	12	2
Logged I	16	6	14	enyaghe-ngone	13	3
Logged I	16	6	14	enyaghe-ngone	20	3
Logged I	16	6	14	enyaghe-ngone	56	1
Logged I	16	6	14	enyaghe-ngone	10	2
Logged I	16	6	14	enyaghe-ngone	70	2
Logged I	16	6	14	enyaghe-ngone	25	2
Logged I	16	6	14	enyaghe-ngone	10	2
Logged I	16	6	14	enyaghe-ngone	0	4
Logged I	16	6	14	enyaghe-ngone	45	1
Logged I	16	6	14	enyaghe-ngone	9	2
Logged I	16	6	14	enyaghe-ngone	20	2
Logged I	16	6	14	enyaghe-ngone	68	1
Logged I	16	6	14	enyaghe-ngone	27	2
Logged I	16	6	14	enyaghe-ngone	80	1
Logged II	16	1	10	enyaghe-ngone	38	1
Logged II	16	1	10	enyaghe-ngone	54	1
Logged II	16	1	10	enyaghe-ngone	72	2
Logged II	16	1	10	enyaghe-ngone	31	1
Logged II	16	1	10	enyaghe-ngone	32	2
Logged II	16	1	10	enyaghe-ngone	110	2
Logged II	16	1	10	enyaghe-ngone	61	6
Logged II	16	1	10	enyaghe-ngone	85	1
Logged II	16	1	10	enyaghe-ngone	720	1
Logged II	16	1	10	enyaghe-ngone	74	1
Logged II	16	1	10	enyaghe-ngone	69	4
Logged II	16	1	10	enyaghe-ngone	80	6
Logged II	16	1	10	enyaghe-ngone	112	1
Logged II	16	1	10	enyaghe-ngone	82	1
Logged II	16	1	10	enyaghe-ngone	112	1
Logged II	16	1	10	enyaghe-ngone	50	1

Logged II	16	1	10	enyaghe-ngone	45	1
Logged II	16	1	10	enyaghe-ngone	150	1
Logged II	16	1	10	enyaghe-ngone	20	1
Logged II	16	1	10	enyaghe-ngone	15	1
Logged II	16	1	10	enyaghe-ngone	12	1
Logged II	16	1	10	enyaghe-ngone	28	2
Logged II	16	1	10	enyaghe-ngone	28	4
Logged II	16	1	10	enyaghe-ngone	57	3
Logged II	16	2	10	enyaghe-ngone	24	1
Logged II	16	2	10	enyaghe-ngone	175	2
Logged II	16	2	10	enyaghe-ngone	283	1
Logged II	16	2	10	enyaghe-ngone	256	1
Logged II	16	2	10	enyaghe-ngone	300	1
Logged II	16	2	10	enyaghe-ngone	140	1
Logged II	16	2	10	enyaghe-ngone	88	2
Logged II	16	2	10	enyaghe-ngone	33	3
Logged II	16	2	10	enyaghe-ngone	180	1
Logged II	16	2	10	enyaghe-ngone	15	3
Logged II	16	2	10	enyaghe-ngone	35	1
Logged II	16	2	10	enyaghe-ngone	200	1
Logged II	16	2	10	enyaghe-ngone	31	2
Logged II	16	2	10	enyaghe-ngone	34	3
Logged II	16	2	10	enyaghe-ngone	88	1
Logged II	16	2	10	enyaghe-ngone	47	1
Logged II	16	3	12	enyaghe-ngone	80	1
Logged II	16	3	12	enyaghe-ngone	83	1
Logged II	16	3	12	enyaghe-ngone	33	1
Logged II	16	3	12	enyaghe-ngone	53	1
Logged II	16	3	12	enyaghe-ngone	86	1
Logged II	16	3	12	enyaghe-ngone	59	3
Logged II	16	3	12	enyaghe-ngone	92	1
Logged II	16	3	12	enyaghe-ngone	180	1
Logged II	16	3	12	enyaghe-ngone	57	2
Logged II	16	3	12	enyaghe-ngone	126	1
Logged II	16	3	12	enyaghe-ngone	137	1
Logged II	16	3	12	enyaghe-ngone	200	4
Logged II	16	3	12	enyaghe-ngone	210	1
Logged II	16	3	12	enyaghe-ngone	94	2
Logged II	16	3	12	enyaghe-ngone	25	1
Logged II	16	3	12	enyaghe-ngone	110	1
Logged II	16	4	10	enyaghe-ngone	86	1
Logged II	16	4	10	enyaghe-ngone	28	2
Logged II	16	4	10	enyaghe-ngone	113	1
Logged II	16	4	10	enyaghe-ngone	95	1
Logged II	16	4	10	enyaghe-ngone	110	1
Logged II	16	4	10	enyaghe-ngone	71	2
Logged II	16	4	10	enyaghe-ngone	14.5	4
Logged II	16	4	10	enyaghe-ngone	32	2
Logged II	16	4	10	enyaghe-ngone	125	1
Logged II	16	4	10	enyaghe-ngone	33	2
Logged II	16	4	10	enyaghe-ngone	36	4
Logged II	16	4	10	enyaghe-ngone	40	3

Logged II	16	4	10	enyaghe-ngone	170	1
Logged II	16	5	14	enyaghe-ngone	68	1
Logged II	16	5	14	enyaghe-ngone	17	1
Logged II	16	5	14	enyaghe-ngone	60	1
Logged II	16	5	14	enyaghe-ngone	130	1
Logged II	16	5	14	enyaghe-ngone	46	1
Logged II	16	5	14	enyaghe-ngone	50	2
Logged II	16	5	14	enyaghe-ngone	275	1
Logged II	16	5	14	enyaghe-ngone	250	1
Logged II	16	5	14	enyaghe-ngone	250	1
Logged II	16	5	14	enyaghe-ngone	190	1
Logged II	16	5	14	enyaghe-ngone	115	1
Logged II	16	5	14	enyaghe-ngone	300	1
Logged II	16	5	14	enyaghe-ngone	88	2
Logged II	16	5	14	enyaghe-ngone	200	1
Logged II	16	5	14	enyaghe-ngone	193	1
Logged II	16	5	14	enyaghe-ngone	200	1
Logged II	16	5	14	enyaghe-ngone	120	1
Logged II	16	5	14	enyaghe-ngone	77	1
Logged II	16	5	14	enyaghe-ngone	46	3
Logged II	16	5	14	enyaghe-ngone	76	1
Logged II	16	5	14	enyaghe-ngone	220	1
Logged II	16	6	12	enyaghe-ngone	55	1
Logged II	16	6	12	enyaghe-ngone	53	1
Logged II	16	6	12	enyaghe-ngone	64	1
Logged II	16	6	12	enyaghe-ngone	45	2
Logged II	16	6	12	enyaghe-ngone	52	2
Logged II	16	6	12	enyaghe-ngone	175	1
Logged II	16	6	12	enyaghe-ngone	150	1
Logged II	16	6	12	enyaghe-ngone	95	1
Logged II	16	6	12	enyaghe-ngone	125	2
Logged II	16	6	12	enyaghe-ngone	200	1
Logged II	16	6	12	enyaghe-ngone	200	1
Logged II	16	6	12	enyaghe-ngone	100	1
Logged II	16	6	12	enyaghe-ngone	100	1
Unlogged I	16	1	10	enyaghe-ngone	25	1
Unlogged I	16	1	10	enyaghe-ngone	50	1
Unlogged I	16	1	10	enyaghe-ngone	80	1
Unlogged I	16	1	10	enyaghe-ngone	65	1
Unlogged I	16	1	10	enyaghe-ngone	70	1
Unlogged I	16	1	10	enyaghe-ngone	60	1
Unlogged I	16	1	10	enyaghe-ngone	150	2
Unlogged I	16	1	10	enyaghe-ngone	150	1
Unlogged I	16	1	10	enyaghe-ngone	150	1
Unlogged I	16	1	10	enyaghe-ngone	70	1
Unlogged I	16	1	10	enyaghe-ngone	70	1
Unlogged I	16	1	10	enyaghe-ngone	65	1
Unlogged I	16	1	10	enyaghe-ngone	100	2
Unlogged I	16	1	10	enyaghe-ngone	35	1
Unlogged I	16	2	10	enyaghe-ngone	25	2
Unlogged I	16	2	10	enyaghe-ngone	55	1
Unlogged I	16	2	10	enyaghe-ngone	110	1

Unlogged I	16	2	10	enyaghe-ngone	80	1
Unlogged I	16	2	10	enyaghe-ngone	30	1
Unlogged I	16	2	10	enyaghe-ngone	60	1
Unlogged I	16	2	10	enyaghe-ngone	70	1
Unlogged I	16	2	10	enyaghe-ngone	60	1
Unlogged I	16	2	10	enyaghe-ngone	25	2
Unlogged I	16	2	10	enyaghe-ngone	80	1
Unlogged I	16	2	10	enyaghe-ngone	70	1
Unlogged I	16	2	10	enyaghe-ngone	100	1
Unlogged I	16	2	10	enyaghe-ngone	80	2
Unlogged I	16	2	10	enyaghe-ngone	180	1
Unlogged I	16	2	10	enyaghe-ngone	110	3
Unlogged I	16	2	10	enyaghe-ngone	60	3
Unlogged I	16	3	12	enyaghe-ngone	110	1
Unlogged I	16	3	12	enyaghe-ngone	25	2
Unlogged I	16	3	12	enyaghe-ngone	25	2
Unlogged I	16	3	12	enyaghe-ngone	22	2
Unlogged I	16	3	12	enyaghe-ngone	80	1
Unlogged I	16	3	12	enyaghe-ngone	75	1
Unlogged I	16	3	12	enyaghe-ngone	80	1
Unlogged I	16	3	12	enyaghe-ngone	50	2
Unlogged I	16	3	12	enyaghe-ngone	55	1
Unlogged I	16	3	12	enyaghe-ngone	30	1
Unlogged I	16	3	12	enyaghe-ngone	20	3
Unlogged I	16	3	12	enyaghe-ngone	20	3
Unlogged I	16	3	12	enyaghe-ngone	55	1
Unlogged I	16	3	12	enyaghe-ngone	25	1
Unlogged I	16	3	12	enyaghe-ngone	50	2
Unlogged I	16	3	12	enyaghe-ngone	60	1
Unlogged I	16	3	12	enyaghe-ngone	70	1
Unlogged I	16	3	12	enyaghe-ngone	120	1
Unlogged I	16	3	12	enyaghe-ngone	120	2
Unlogged I	16	3	12	enyaghe-ngone	40	2
Unlogged I	16	3	12	enyaghe-ngone	120	1
Unlogged I	16	3	12	enyaghe-ngone	100	1
Unlogged I	16	3	12	enyaghe-ngone	120	1
Unlogged I	16	3	12	enyaghe-ngone	50	1
Unlogged I	16	3	12	enyaghe-ngone	65	1
Unlogged I	16	3	12	enyaghe-ngone	60	1
Unlogged I	16	3	12	enyaghe-ngone	150	1
Unlogged I	16	3	12	enyaghe-ngone	60	1
Unlogged I	16	3	12	enyaghe-ngone	70	1
Unlogged I	16	3	12	enyaghe-ngone	120	1
Unlogged I	16	3	12	enyaghe-ngone	120	1
Unlogged I	16	3	12	enyaghe-ngone	90	1
Unlogged I	16	3	12	enyaghe-ngone	60	2
Unlogged I	16	4	12	enyaghe-ngone	18	2
Unlogged I	16	4	12	enyaghe-ngone	30	3
Unlogged I	16	4	12	enyaghe-ngone	22	2
Unlogged I	16	4	12	enyaghe-ngone	75	1
Unlogged I	16	4	12	enyaghe-ngone	70	1
Unlogged I	16	4	12	enyaghe-ngone	60	2

Unlogged I	16	4	12	enyaghe-ngone	50	1
Unlogged I	16	4	12	enyaghe-ngone	70	1
Unlogged I	16	4	12	enyaghe-ngone	27	2
Unlogged I	16	4	12	enyaghe-ngone	40	1
Unlogged I	16	4	12	enyaghe-ngone	80	2
Unlogged I	16	4	12	enyaghe-ngone	150	3
Unlogged I	16	4	12	enyaghe-ngone	47	1
Unlogged I	16	4	12	enyaghe-ngone	18	2
Unlogged I	16	4	12	enyaghe-ngone	55	1
Unlogged I	16	4	12	enyaghe-ngone	75	1
Unlogged I	16	4	12	enyaghe-ngone	120	2
Unlogged I	16	4	12	enyaghe-ngone	50	2
Unlogged I	16	4	12	enyaghe-ngone	200	1
Unlogged I	16	4	12	enyaghe-ngone	80	1
Unlogged I	16	4	12	enyaghe-ngone	35	2
Unlogged I	16	4	12	enyaghe-ngone	80	1
Unlogged I	16	4	12	enyaghe-ngone	90	1
Unlogged I	16	5	12	enyaghe-ngone	40	1
Unlogged I	16	5	12	enyaghe-ngone	50	1
Unlogged I	16	5	12	enyaghe-ngone	70	2
Unlogged I	16	5	12	enyaghe-ngone	70	1
Unlogged I	16	5	12	enyaghe-ngone	60	2
Unlogged I	16	5	12	enyaghe-ngone	25	3
Unlogged I	16	5	12	enyaghe-ngone	110	1
Unlogged I	16	5	12	enyaghe-ngone	80	1
Unlogged I	16	5	12	enyaghe-ngone	200	2
Unlogged I	16	5	12	enyaghe-ngone	70	1
Unlogged I	16	5	12	enyaghe-ngone	60	1
Unlogged I	16	5	12	enyaghe-ngone	70	1
Unlogged I	16	5	12	enyaghe-ngone	130	2
Unlogged I	16	5	12	enyaghe-ngone	80	1
Unlogged I	16	5	12	enyaghe-ngone	60	2
Unlogged I	16	5	12	enyaghe-ngone	75	2
Unlogged I	16	5	12	enyaghe-ngone	50	1
Unlogged I	16	5	12	enyaghe-ngone	55	3
Unlogged I	16	5	12	enyaghe-ngone	60	1
Unlogged I	16	5	12	enyaghe-ngone	30	1
Unlogged I	16	5	12	enyaghe-ngone	45	3
Unlogged I	16	5	12	enyaghe-ngone	30	5
Unlogged I	16	5	12	enyaghe-ngone	60	2
Unlogged I	16	5	12	enyaghe-ngone	45	3
Unlogged I	16	5	12	enyaghe-ngone	90	1
Unlogged I	16	5	12	enyaghe-ngone	150	2
Unlogged I	16	5	12	enyaghe-ngone	70	1
Unlogged I	16	5	12	enyaghe-ngone	50	1
Unlogged I	16	5	12	enyaghe-ngone	50	1
Unlogged I	16	5	12	enyaghe-ngone	65	2
Unlogged I	16	5	12	enyaghe-ngone	35	1
Unlogged I	16	5	12	enyaghe-ngone	65	2
Unlogged I	16	5	12	enyaghe-ngone	120	3
Unlogged I	16	5	12	enyaghe-ngone	80	1
Unlogged I	16	6	12	enyaghe-ngone	180	1

Unlogged I	16	6	12	enyaghe-ngone	55	3
Unlogged I	16	6	12	enyaghe-ngone	75	2
Unlogged I	16	6	12	enyaghe-ngone	60	3
Unlogged I	16	6	12	enyaghe-ngone	50	2
Unlogged I	16	6	12	enyaghe-ngone	80	1
Unlogged I	16	6	12	enyaghe-ngone	50	3
Unlogged I	16	6	12	enyaghe-ngone	180	1
Unlogged I	16	6	12	enyaghe-ngone	40	2
Unlogged I	16	6	12	enyaghe-ngone	41	2
Unlogged I	16	6	12	enyaghe-ngone	28	2
Unlogged I	16	6	12	enyaghe-ngone	30	2
Unlogged I	16	6	12	enyaghe-ngone	50	2
Unlogged I	16	6	12	enyaghe-ngone	150	1
Unlogged I	16	6	12	enyaghe-ngone	150	1
Unlogged I	16	6	12	enyaghe-ngone	50	1
Unlogged II	16	1	12	enyaghe-ngone	40	1
Unlogged II	16	1	12	enyaghe-ngone	55	2
Unlogged II	16	1	12	enyaghe-ngone	65	1
Unlogged II	16	1	12	enyaghe-ngone	22	1
Unlogged II	16	1	12	enyaghe-ngone	65	1
Unlogged II	16	1	12	enyaghe-ngone	105	2
Unlogged II	16	1	12	enyaghe-ngone	37	1
Unlogged II	16	1	12	enyaghe-ngone	45	1
Unlogged II	16	1	12	enyaghe-ngone	53	2
Unlogged II	16	1	12	enyaghe-ngone	40	2
Unlogged II	16	1	12	enyaghe-ngone	50	2
Unlogged II	16	1	12	enyaghe-ngone	50	2
Unlogged II	16	1	12	enyaghe-ngone	10	2
Unlogged II	16	2	10	enyaghe-ngone	8	2
Unlogged II	16	2	10	enyaghe-ngone	80	1
Unlogged II	16	2	10	enyaghe-ngone	60	2
Unlogged II	16	2	10	enyaghe-ngone	7	2
Unlogged II	16	2	10	enyaghe-ngone	65	2
Unlogged II	16	2	10	enyaghe-ngone	35	2
Unlogged II	16	2	10	enyaghe-ngone	54	2
Unlogged II	16	2	10	enyaghe-ngone	45	2
Unlogged II	16	2	10	enyaghe-ngone	65	2
Unlogged II	16	2	10	enyaghe-ngone	72	2
Unlogged II	16	3	8	enyaghe-ngone	47	2
Unlogged II	16	3	8	enyaghe-ngone	54	1
Unlogged II	16	3	8	enyaghe-ngone	50	2
Unlogged II	16	3	8	enyaghe-ngone	55	2
Unlogged II	16	3	8	enyaghe-ngone	60	2
Unlogged II	16	3	8	enyaghe-ngone	50	1
Unlogged II	16	3	8	enyaghe-ngone	55	2
Unlogged II	16	3	8	enyaghe-ngone	55	2
Unlogged II	16	4	10	enyaghe-ngone	12	4
Unlogged II	16	4	10	enyaghe-ngone	6.3	2
Unlogged II	16	4	10	enyaghe-ngone	60	1
Unlogged II	16	4	10	enyaghe-ngone	65	2
Unlogged II	16	4	10	enyaghe-ngone	50	2
Unlogged II	16	4	10	enyaghe-ngone	50	2

Unlogged II	16	4	10	enyaghe-ngone	18	2
Unlogged II	16	4	10	enyaghe-ngone	16	2
Unlogged II	16	4	10	enyaghe-ngone	31	2
Unlogged II	16	4	10	enyaghe-ngone	60	2
Unlogged II	16	4	10	enyaghe-ngone	72	2
Unlogged II	16	4	10	enyaghe-ngone	65	2
Unlogged II	16	4	10	enyaghe-ngone	55	2
Unlogged II	16	4	10	enyaghe-ngone	12	2
Unlogged II	16	4	10	enyaghe-ngone	55	2
Unlogged II	16	5	10	enyaghe-ngone	55	1
Unlogged II	16	5	10	enyaghe-ngone	50	1
Unlogged II	16	5	10	enyaghe-ngone	8	2
Unlogged II	16	5	10	enyaghe-ngone	75	1
Unlogged II	16	5	10	enyaghe-ngone	65	1
Unlogged II	16	5	10	enyaghe-ngone	40	1
Unlogged II	16	5	10	enyaghe-ngone	18	2
Unlogged II	16	5	10	enyaghe-ngone	6	2
Unlogged II	16	5	10	enyaghe-ngone	53	2
Unlogged II	16	5	10	enyaghe-ngone	11	2
Unlogged II	16	5	10	enyaghe-ngone	50	2
Unlogged II	16	5	10	enyaghe-ngone	62	2
Unlogged II	16	5	10	enyaghe-ngone	50	1
Unlogged II	16	5	10	enyaghe-ngone	50	2
Unlogged II	16	5	10	enyaghe-ngone	54	2
Unlogged II	16	6	10	enyaghe-ngone	58	1
Unlogged II	16	6	10	enyaghe-ngone	72	1
Unlogged II	16	6	10	enyaghe-ngone	6	2
Unlogged II	16	6	10	enyaghe-ngone	55	2
Unlogged II	16	6	10	enyaghe-ngone	40	2
Unlogged II	16	6	10	enyaghe-ngone	85	4
Unlogged II	16	6	10	enyaghe-ngone	65	2
Unlogged II	16	6	10	enyaghe-ngone	65	2
Unlogged II	16	6	10	enyaghe-ngone	55	2
Unlogged II	16	6	10	enyaghe-ngone	55	1
Unlogged II	16	6	10	enyaghe-ngone	52	2
Unlogged II	16	6	10	enyaghe-ngone	60	2
Unlogged II	16	6	10	enyaghe-ngone	17	2
Unlogged II	16	6	10	enyaghe-ngone	48	2
Unlogged II	16	6	10	enyaghe-ngone	65	2
Unlogged II	16	6	10	enyaghe-ngone	59	2

Appendix 3.10: Mona monkey (*Cercopithecus mona*) population densities in unlogged and logged study sites from 1999-2000.

Study site	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**P**	**AIC**	**Cl. s.**	**ESW**
Logged I	Bayip	122	35	0.29	2.00	30.36	4.34	14.29	22.82 – 40.41	486			27.8	71.90
Logged II	Etinkem	-	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged I	Bajoh	118	14	0.12	0.82	11.55	4.65	40.30	3.47 – 38.39	185			76.4	71.90
Unlogged II	Mgbegati	106	13	0.12	8.85	18.08	6.53	36.13	7.41 – 44.07	289			87.7	71.90

N: number of observed objects (single or clusters of animals); **S.E**: standard error; **CV**: Coefficient of variation; **Ef**: Effort (km);

P: probability of observing an object in defined area; **DS**: estimate of density of clusters (grp/km²); **D**: estimate of density of animals (ind./km²); **n**: estimate of number of animals in specified area; **ESW**: for line transects, effective strip width = W*p; **Cl. s**: cluster size of i-th observation; **AIC**: Akaide’s Information Criterion, use for model selection.

Appendix 3.11: Mona monkey (*Cercopithecus mona*) population densities in unlogged and logged study sites from 2000-2001.

Study site	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**P**	**AIC**	**Cl. s.**	**ESW**
Logged I	Bayip	96	24	0.25	1.25	22.75	5.64	24.80	13.60 – 38.06	364			24.7	100
Logged II	Etinkem	86	31	0.36	1.80	32.18	8.56	26.61	18.57 – 55.78	515			43.9	100
Unlogged I	Bajoh	90	25	0.27	1.40	6.48	2.28	35.21	3.03 – 13.85	104			60.9	100
Unlogged II	Mgbegati	78	7	0.10	0.5	9.87	3.71	37.55	4.25 – 22.91	158			9.4	100

Appendix 3.12: Mona monkey (*C. mona*) population densities in unlogged and logged study sites from 2001-2002.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	70	17	0.24	1.61	40.46	10.08	24.92	23.51 – 69.64	647	-	-	6.4	75.02
Logged II	Etinkem	68	11	0.16	1.07	23.54	8.08	34.13	11.24 – 49.22	377	-	-	19.1	75.02
Unlogged I	Bajoh	68	23	0.34	2.25	33.81	10.90	32.26	17.28 – 66.14	541	-	-	29.9	75.02
Unlogged II	Mgbegati	60	4	0.06	0.44	10.77	5.93	55.11	3.20 – 36.28	172	-	.	12.4	75.02

Appendix 3.13: Mona monkey (*Cercopithecus mona*) population densities in unlogged and logged study sites from 1999-2002.

Area	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	AIC	P	Cl. size	ESW
Logged	Bay/Eti	442	118	0.26	1.60	28.73	3.00	10.35	23.41 – 35.24	919			28.8	84.54
Unlogged	Baj/Mgb	520	86	0.16	0.95	15.24	3.37	22.10	9.74 – 23.84	488			25.4	84.54

Appendix 3.14: Putty-nosed monkey (*C. nictitans nictitans*) population densities in unlogged and logged study sites from 1999-2000.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	122	32	0.26	1.41	26.44	10.08	38.12	1.52 – 45.80	423			3.3	92.74
Logged II	Etinkem	-	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged I	Bajoh	118	37	0.31	1.69	18.74	5.73	30.60	9.87 – 35.57	300			72.8	92.74
Unlogged II	Mgbegati	106	16	0.15	0.81	16.51	6.55	39.68	5.73 – 47.52	264	-	-	46.7	92.74

Appendix 3.15: Putty-nosed monkey (*C. nictitans nictitans*) population densities in unlogged and logged study sites from 2000-2001.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	96	30	0.31	1.56	34.84	7.11	20.43	22.78 - 53.29	558			29.3	100
Logged II	Etinkem	86	29	0.34	1.68	21.50	8.60	40.01	9.35 – 49.41	344			64	100
Unlogged I	Bajoh	90	36	0.40	2.00	12.25	4.00	32.72	6.11- 24.57	196			61.8	100
Unlogged II	Mgbegati	78	20	0.25	1.28	28.79	9.02	31.36	14.89 – 55.65	461			34.6	100

Appendix 3.16: Putty-nosed monkey (*C. nictitans nictitans*) population densities in unlogged and logged study sites from 2001-2002.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	70	7	0.10	0.51	12.00	4.15	35.00	5.53 – 25.21	190	-	-	13.9	96.81
Logged II	Etinkem	68	14	0.20	1.06	18.83	6.18	32.82	9.55 – 37.14	301	-	-	26.9	96.81
Unlogged I	Bajoh	68	15	0.22	1.13	14.81	6.10	41.24	6.29 – 34.84	237	-	-	-62.6	96.81
Unlogged II	Mgbegati	60	3	0.05	0.25	4.73	3.35	70.83	0.97 – 22.88	76	-	-	2	96.81

Appendix 3.17: Putty-nosed monkey (*C. nictitans nictitans*) population densities in unlogged and logged study sites from 1999-2002.

Area	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	AIC	P	Cl. size	ESW
Logged	Bay/Eti	442	112	0.25	1.26	23.35	3.41	14.60	17.40 – 31.35	747			25.9	100
Unlogged	Baj/Mgb	520	128	0.24	1.19	17.90	3.34	18.678	12.33 – 26.00	573			39.1	100

Appendix 3.18: Cameroon red-eared monkey (*C. erythrotis*) population densities in unlogged and logged study sites from 1999-2000.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s	ESW
Logged I	Bayip	122	5	0.04	0.50	8.29	3.00	36.11	3.84 – 17.87	133	-	-	3.00	41.00
Logged II	Etinkem	-	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged I	Bajoh	118	16	0.14	1.65	25.40	12.94	50.96	5.19 – 124.42	406			5.1	41.00
Unlogged II	Mgbegati	106	5	0.05	0.6	7.90	3.00	36.59	3.66 – 17.08	127	-	-	6.2	41.09

Appendix 3.19: Red-eared monkey (*C. erythrotis*) population densities in unlogged and logged study sites from 2000-2001.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	96	3	0.03	0.37	7.34	3.97	54.04	2.19 – 24.63	118			2	41.46
Logged II	Etinkem	86	9	0.10	1.26	20.19	9.44	46.75	7.66 – 53.20	323			45.9	41.46
Unlogged I	Bajoh	90	16	0.18	2.14	26.44	9.86	37.30	12.09 – 57.79	423			31.8	41.46
Unlogged II	Mgbegati	78	8	0.10	1.23	24.03	9.92	41.30	10.40 – 55.70	384			36.6	41.46

Appendix 3.20: Red-eared monkey (*C. erythrotis*) population densities in unlogged and logged study sites from 2001-2002.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	70	0	0	0	0	0	0	0	0	0	0	0	0
Logged II	Etinkem	68	11	0.16	1.55	26.06	9.00	34.46	12.35 – 55.00	417			46.7	52.00
Unlogged I	Bajoh	68	12	0.18	1.70	23.38	10.37	44.36	9.30 – 58.78	374	-	-	30.4	52.00
Unlogged II	Mgbegati	60	3	0.05	0.48	9.30	4.74	51.00	3.04 – 28.40	149			15.2	52.00

Appendix 3.21: Cameroon red-eared monkey (*C. erythrotis*) population densities in unlogged and logged study sites from 1999-2002.

Area	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**AIC**	**P**	**Cl. size**	**ESW**
Logged	Bay/Eti	442	28	0.06	0.65	10.93	3.36	30.74	5.77 – 20.70	350			11.6	48.68
Unlogged	Baj/Mgb	520	62	0.11	1.19	17.35	3.84	22.14	11.02 – 27.32	555			16.6	48.68

Appendix 3.22: Crowned monkey (*C. pogonias*) population densities in unlogged and logged study sites from 1999-2000.

Area	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.D**	**C.V**	**95%CI**	**N**	**AIC**	**P**	**Cl. s.**	**ESW**
Logged I	Bayip	122	0	0	0	0	0	0	0	0	0	0	0	0
Logged II	Etinkem	-	-	-	-	-	-	-	-	-	-	-	-	-
Unlogged I	Bajoh	118	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged II	Mgbegati	106	3	0.03	0.50	0.75	0.57	-	-	12	-	-	-	28.5

Appendix 3.23: Crowned monkey (*C. pogonias*) population densities in unlogged and logged study sites from 2000-2001.

Study site	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**P**	**AIC**	**Cl. s.**	**ESW**
Logged I	Bayip	96	1	0.01	0.06	0.06	0.05	-	-	1	-	-	-	85.21
Logged II	Etinkem	86	3	0.03	0.20	2.70	1.92	72.37	0.59 – 12.04	43		-	-	85.21
Unlogged I	Bajoh	90	1	0.01	0.06	0.06	0.05	-	-	1	-	-	-	85.21
Unlogged II	Mgbegati	78	4	0.05	0.30	0.75	0.44	58.93	0.22 – 2.48	12	-	-	-	85.21

Appendix 3.24: Crowned monkey (*C. pogonias*) population densities in unlogged and logged study sites from 2001-2002.

Study site	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**P**	**AIC**	**Cl. s.**	**ESW**
Logged I	Bayip	70	0	0	0	0	0	0	0	0	0	0	0	0
Logged II	Etinkem	68	1	0.01	0.1	0.1	0.1	-	-	2	-	-	-	78.13
Unlogged I	Bajoh	68	3	0.04	0.28	0.28	0.24	85.67	0.04 – 1.91	5				78.13
Unlogged II	Mgbegati	60	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3.25: Crowned monkey (*C. pogonias*) population densities in unlogged and logged study sites from 1999-2002.

Area	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**AIC**	**P**	**Cl. size**	**ESW**
Logged	Bay/Eti	442	5	0.01	0.08	1.03	0.59	56.81	0.33 – 3.19	33				70.88
Unlogged	Baj/Mgb	520	11	0.02	0.14	0.31	0.15	49.33	0.12 – 0.82	10				70.88

Appendix 3.26:Red-capped mangabey (*Cercocebus torquatus*) population densities in unlogged and logged study sites from 1999-2000.

Area	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**AIC**	**P**	**Cl. s.**	**ESW**
Logged I	Bayip	122	15	0.13	0.61	9.22	7.10	-	-	148			86.6	100
Logged II	Etinkem	-	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged I	Bajoh	118	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged II	Mgbegati	106	1	0.09	0.05	0.05	0.05	-	-	1	-	-	-	100

Appendix 3.27: Red-capped mangabey (*Cercocebus torquatus*) population densities in unlogged and logged study sites from 2000-2001.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	96	5	0.05	0.26	0.26	0.14	-	-	4	-	-	-	100
Logged II	Etinkem	86	5	0.06	0.29	3.80	1.54	40.77	1.63 – 8.72	60	-	-	-	100
Unlogged I	Bajoh	90	1	0.01	0.06	0.06	0.02	-	-	1	-	-	-	100
Unlogged II	Mgbegati	78	1	0.01	0.06	0.06	0.02	-	-	1	-	-	-	100

Appendix 3.28: Red-capped mangabey (*Cercocebus torquatus*) population densities in unlogged and logged study sites from 2001-2002.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	70	0	0	0	0	0	0	0	0	0	0	0	0
Logged II	Etinkem	68	3	0.04	0.27	7.65	5.04	65.91	2.02 – 28.84	122			18.8	80.72
Unlogged I	Bajoh	68	5	0.07	0.45	0.45	0.23	52.56	0.15 – 1.32	7	-			80.72
Unlogged II	Mgbegati	60	1	0.02	0.10	1.12	1.03	-	0.15 – 10.11	20				80.72

Appendix 3.29: Red-capped mangabey (*Cercocebus torquatus*) population densities in unlogged and logged study sites from 1999-2002.

Area	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	AIC	P	Cl. size	ESW
Logged	Bay/Eti	442	28	0.06	0.31	6.65	2.75	41.49	2.86 – 15.46	213				100
Unlogged	Baj/Mgb	520	9	0.01	0.08	1.01	0.63	62.77	0.29 – 3.46	32				100

Appendix 3.30: Preuss's red colobus (*Colobus pennantii preussi*) population densities in unlogged and logged study sites from 2001-2002.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.D	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	70	0	0	0	0	0	0	0	0	0	0	0	0
Logged II	Etinkem	68	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged I	Bajoh	68	1	0.01	0.07	0.07	0.05	-	-	1	-	-	-	100
Unlogged II	Mgbegati	60	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3.31: Preuss'red colobus (*Colobus pennantii preussi*) population densities in unlogged and logged study sites from 1999-2002.

Area	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	AIC	P	Cl. size	ESW
Logged	Bay/Eti	442	1	0.002	0.02	0.83	0.79	-	-	27	-	-	-	40.88
Unlogged	Baj/Mgb										-	-	-	

Appendix 3.32: Chimpanzee (*Pan troglodytes*) population densities in unlogged and logged study sites from 1999-2000.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	AIC	P	Cl.s.	ESW
Logged I	Bayip	122	12	0.1	0.50	0.50	0.42		-	8				100
Logged II	Etinkem	-	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged I	Bajoh	118	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged II	Mgbegati	106	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3.33: Chimpanzee (*Pan. troglodytes*) population densities in unlogged and logged study sites from 2000-2001.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	96	2	0.02	0.10	0.10	0.05	55.43	0.03 – 0.34	2	-	-	-	100
Logged II	Etinkem	86	2	0.02	0.11	1.16	0.95	81.91	0.20 – 6.50	19	-	-	-	100
Unlogged I	Bajoh	90	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged II	Mgbegati	78	2	0.02	0.12	0.12	0.12	-	-	2	-	-	-	100

Appendix 3.34: Chimpanzee (*P. troglodytes*) population densities in unlogged and logged study sites from 2001-2002.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	70	1	0.03	0.14	0.14	0.11	-	-	2	-	-	-	100
Logged II	Etinkem	68	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged I	Bajoh	68	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged II	Mgbegati	60	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3.35: Chimpanzee (*Pan troglodytes*) population densities in unlogged and logged study sites from 1999-2002.

Area	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	AIC	P	Cl. size	ESW
Logged	Bay/Eti	442	18	0.04	0.20	2.03	0.90	44.21	0.83 – 5.00	65	-	-	-	100
Unlogged	Baj/Mgb	520	2	0.004	0.01	0.018	0.01	-	-	1	-	-	-	100

Appendix 3.36: Drill (*Mandrillus leucophaeus*) population densities in unlogged and logged study sites from 1999-2000.

Area	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	AIC	P	Cl. s	ESW.
Logged I	Bayip	122	1	0.008	0.05	0.90	0.00	0.00	22 - 22	14-	-	-	-	100
Logged II	Etinkem	-	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged I	Bajoh	118	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged II	Mgbegati	106	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3.37: Drill (*M. leucophaeus*) population densities in unlogged and logged study sites from 2000-2001.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	96	0	0	0	0	0	0	0	0	0	0	0	0
Logged II	Etinkem	86	0	0	0	0	0	0	0	0	0	0	0	0
Unlogged I	Bajoh	90	1	0.01	0.22	1.67	0.98	59.03	0.29 – 9.50	27	-	-	-	100
Unlogged II	Mgbegati	78	0	0	0	0	0	0	0	0	0	0	0	0

Appendix 3.38: Drill (*Mandrillus leucophaeus*) population densities in unlogged and logged study sites from 1999-2002.

Area	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	AIC	P	Cl. size	ESW
Logged	Bay/Eti	442	1	0.002	0.04	0.91	0.1	-	-	29		-	-	27.30
Unlogged	Baj/Mgb	520	1	0.002	0.03	1.03	0.1	-	-	33	-	-	-	27.30

Appendix 3.39: Black-casqued hornbill (*Ceratogymna atrata*) population densities in unlogged and logged study sites from 1999-2000.

Study site	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**P**	**AIC**	**Cl. s.**	**ESW**
Logged I	Bayip	122	114	0.93	9.34	26.42	6.03	22.84	6.02 – 115.93	423			10.2	50
Logged II	Etinkem	-	-	-	-	-	-	-	-	-	-	-	-	-
Unlogged I	Bajoh	118	85	0.72	7.20	10.80	2.54	23.54	5.44 – 21.41	173			42.5	50
Unlogged II	Mgbegati	106	67	0.63	6.32	15.69	2.23	14.22	10.94 – 22.49	251			42.0	50

N: number of observed objects (single or clusters of animals); **S.E**: standard error; **CV**: Coefficient of variation; **Ef**: Effort (km);

P: probability of observing an object in defined area; **DS**: estimate of density of clusters (grp/km^2); **D**: estimate of density of animals (ind./km^2); **n**: estimate of number of animals in specified area; **ESW**: for line transects, effective strip width = W*p; **Cl. s**: cluster size of i-th observation; **AIC**: Akaide's Information Criterion, use for model selection.

Appendix 3.40: Black-casqued hornbill (*Ceratogymna atrata*) population densities in unlogged and logged study sites from 2000-2001.

Study site	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**P**	**AIC**	**Cl. s.**	**ESW**
Logged I	Bayip	96	94	1.00	9.80	27.09	3.85	14.22	19.92 – 36.83	433			27.8	50
Logged II	Etinkem	86	105	1.23	12.21	20.66	3.59	17.40	14.13 – 30.20	331			27.6	50
Unlogged I	Bajoh	90	95	1.05	10.55	17.60	4.76	27.06	8.50 – 36.42	282			12.5	50
Unlogged II	Mgbegati	78	153	2.00	19.61	49.71	10.10	20.30	30.98 – 79.76	795			11.7	50

Appendix 3.41: Black-casqued hornbill (*Ceratogymna atrata*) population densities in unlogged and logged study sites from 2001-2002.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	70	49	0.70	7.00	19.69	3.90	19.58	12.81 – 30.25	315			24.6	50
Logged II	Etinkem	68	30	0.44	4.41	8.08	3.57	44.19	3.17 – 20.62				44.9	50
Unlogged I	Bajoh	68	46	0.67	6.76	16.91	3.66	21.66	10.47 – 27.31	271			28.4	50
Unlogged II	Mgbegati	60	36	0.60	6	12.85	2.32	18.08	8.59 – 19.24	206			13.6	50

Appendix 3.42: Brown-checked hornbill (*Ceratogymna cylindricus*) population densities in unlogged and logged study sites from 1999-2000.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	122	99	0.81	8.11	21.72	2.81	12.97	16.76 – 28.14	348			78	50
Logged II	Etinkem	-	-	-	-	-	-	-	-	-	-	-	-	-
Unlogged I	Bajoh	118	92	0.80	8.00	10.72	2.21	20.64	6.76 – 17.	172			85.9	50
Unlogged II	Mgbegati	106	72	0.67	7.00	14.79	1.66	11.49	11.52 – 18.23	232			71.9	50

Appendix 3.43: Brown-checked hornbill (*Ceratogymna cylindricus*) population densities in unlogged and logged study sites from 2000-2001.

Study site	Village	Ef.	n	n/Ef	Ds	D	S.E	C.V	95%CI	N	P	AIC	Cl. s.	ESW
Logged I	Bayip	96	104	1.08	10.83	27.60	3.19	11.56	21.71 – 35.08	442			29.7	50
Logged II	Etinkem	86	88	1.02	10.23	21.92	4.25	19.40	14.70 – 32.70	351			69	50
Unlogged I	Bajoh	90	146	1.62	16.22	29.74	4.86	16.35	20.85 – 42.41	476			46	50
Unlogged II	Mgbegati	78	62	0.80	7.95	23.19	5.66	24.42	13.34 – 40.27	371			17.3	50

Appendix 3.44: Brown-checked hornbill (*Ceratogymna cylindricus*) population densities in unlogged and logged study sites from 2001-2002.

Study site	**Village**	**Ef.**	**n**	**n/Ef**	**Ds**	**D**	**S.E**	**C.V**	**95%CI**	**N**	**P**	**AIC**	**Cl. s.**	**ESW**
Logged I	Bayip	70	47	0.67	6.71	18.13	3.38	18.68	12.19 – 27.00	290			35.4	50
Logged II	Etinkem	68	38	0.55	5.58	18.16	5.17	28.49	9.22 – 35.78	291			65,6	50
Unlogged I	Bajoh	68	109	1.60	16.03	23.51	4.83	20.55	15.43 – 35.82	376			61.5	50
Unlogged II	Mgbegati	60	67	1.11	11.17	41.88	6.11	14.61	30.99 – 56.60	670			46.1	50

Appendix 3.45: *C. atrata and C. cylindricus* population densities in unlogged and logged study sites from 1999-2002

			Logged			**Unlogged**	
Year	**Hornbills**	Ds	D	SE	Ds	D	SE
1999 - 2002	*Ceratogymna atrata*	9.07	23.15	2.74	9.27	21.61	1.96
	Ceratogymna cylindricus	8.70	22.43	1.83	10.53	25.08	2.85

Appendix 4.1: Relationship between primate, hornbill species encounter rates and food trees abundance

			Encounter rates									
Habitat	**Tr.**	**F.T.a**	*C. mona*	*C. nictitans*	*C. erythrotis*	*C. pogonias*	*Cc. torquatus*	*P. pennantii p. colobus*	*P. troglodytes*	*M. leucophaeus*	*C.atrata*	*C. Cylindricus*
Logged I	1	154	0.35	0.45	0.03	0	0.24	0.01	0.13	0.01	1.02	0.96
Logged I	2	201	0.29	0.46	0.04	0.01	0.11	0	0.05	0	1.32	0.95
Logged I	3	142	0.32	0.21	0	0	0	0.09	0	0	0.88	1
Logged I	4	168	0.43	0.4	0.03	0	0.03	0	0	0	1.03	1.03
Logged I	5	174	0.22	0.22	0	0	0	0	0.05	0	0.83	0.83
Logged I	6	143	0.22	0.39	0.05	0	0	0	0.05	0	1.17	0.83
Logged II	1	152	0.27	0.61	0.17	0.05	0.08	0	0.05	0	2.5	1.64
Logged II	2	129	0.4	0.5	0.19	0.03	0.13	0.03	0.09	0	2.44	1.03
Logged II	3	78	0.54	0.61	0.14	0.07	0.14	0	0.18	0	1.54	0.96
Logged II	4	154	0.38	0.62	0.13	0.03	0.04	0	0.13	0	1.96	1.16
Logged II	5	208	0.44	0.66	0.28	0	0	0	0	0	1.89	1.44
Logged II	6	161	0.5	0.5	0.19	0	0.06	0	0.06	0	1.38	1.19
Unlogged I	1	196	0.36	0.86	0.21	0	0	0	0	0.01	2.25	1.37
Unlogged I	2	129	0.45	0.81	0.09	0.02	0.05	0.02	0	0	2.11	1.3
Unlogged I	3	254	0.38	0.79	0.21	0.01	0.21	0	0	0	2.71	2.42
Unlogged I	4	205	1	1.07	0.21	0.31	0.07	0	0	0	2.5	2.28
Unlogged I	5	189	1	0.75	0.17	0	0.25	0	0	0	2.83	2.16
Unlogged I	6	147	0.75	0.92	0.42	0.08	0.08	0	0	0	1.33	1.85
Unlog. II	1	294	0.15	0.19	0.06	0.03	0	0	0	0	1.16	0.87
Unlog. II	2	201	0.18	0.42	0.07	0.04	0.04	0	0.08	0	1.8	0.86
Unlog. II	3	236	0.18	0.55	0.09	0.04	0	0	0.14	0	2.04	1.36
Unlog. II	4	218	0.17	0.25	0.04	0	0	0	0	0	2.08	2.21
Unlog. II	5	282	0	0	0	0	0	0	0	0	1.67	1.42
Unlog. II	6	205	0.14	0.17	0.14	0	0	0	0	0	2.28	1.33

Tr: transect; F.t.a: Food tree abundance

KORUP

CONSERVATION DEVELOPMENT
COMPONENT
KORUP NATIONAL PARK

gtz

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Satellite Fax: 00873-761628511
e-mail: LOEBENSTEI@aol.com

Letter of recommendation for Mr. Lien

To Whom It May Concern:

This is to confirm that Mr. Lien, forester by profession, is employed in the Korup project from January 1996 till date. He has occupied the following post of responsibilities:

- Forestry Consultant
- Forest Resource Management Officer
- Conservation Development Officer
- Biomonitoring Co-ordinator

The analytical abilities of Mr. Lien and his solution-orientated approach in difficult situations made him a highly competent colleague. He has demonstrated his strategic capacities and his sense of responsibility in the conception and implementation of field activities. His organisational skills and social integration are highly appreciated by the overall Korup Project Team.

I do not hesitate to recommend Mr. Lien for any further studies he want to carry out in Germany.

Karin von Loebenstein

GTZ Conservation Development Adviser

WWF

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To Whom It May Concern:

This letter serves as a formal recommendation for Mr Lien conservation development officer with Korup Project who is an active member of the core team of Cameroon Biomonitoring Network where I am Chairman. Mr Lien is one of the Founders of the Network. He was the chairman of the core team from 1998 to 1999 with the main objective of establishing and implementing the Network.

Mr. Lien worked with diligence and commitment whilst undertaking this work and worked with considerable initiative. His conceptual appreciation of the assessments was sound and his intellectual capacity to incorporate and adopt new techniques was admirable.

In short, I have no reservation in recommending Mr. Lien for MSc study and am convinced that he would undertake his studies with the utmost commitment and that he is more than capable of such rigorous study.

Yours sincerely

Dr. A.E

Atanga EKOBO, PhD.
Visiting Research Fellow, DICE, University of Kent, U.K.
Biodiversity Monitoring Officer, WWF Cameroon Programme.

CURRICULUM VITAE

Lien, Born on the 18th.09. 1967 at Elogbantindi; Cameroonian and Married, one daughter.

EDUCATION

Year	School /University	Town /Country	Diplom/Degree
Jan. 2008	Georg-August University Faculty of Biology	Göttingen/Germany	Ph.D rer. nat (Doctor renum naturalium)
Fev. 2004	Georg-August University Faculty of Forest Sciences	Göttingen/Germany	M.Sc Forestry Grade:1.8 - Good
Aug. 1995	Federal School of Forestry Forestry Research Institute	Jos/Nigeria	Diploma in Forestry Technology
Sept.1991	University of Yaoundé	Yaoundé/Cameroon	

Language skills (Mark 1 to 5 for competence, where 5 is the highest)

Language	Passive	Spoken	Written
French	5	5	5
English	4	4	4
German	2	2	2
Pidgin-English	4	4	4

Professional experience

Date	Position	Institution
Dec. 02 to date	Scientific research assistant and CBWM Project Coordinator	Centre for Nature Conservation, Uni. Goettingen and African Nature e.V
Oct. 01 to date	Wildlife expert	CODEV, Mundemba Cameroon
Jul. 00 – Sept. 01	Biomonitoring Coordinator	GTZ Korup Project, Mundemba
June 98 – Sept. 00	Conservation Development Officer	GTZ Korup Project, Mundemba
Jan. 96 – May 98	Forest Consultant/ Forest Resources management Officer	GTZ Korup Project, Mundemba Cameroon

Key qualifications

1. Tropical biodiversity conservation.
2. Forest inventories, wildlife assessment and monitoring.
3. Biodiversity impacts monitoring and protected areas management.
4. Facilitation, moderation, training of trainer and project coordination.

Publications:

Lien, Waltert, M., Faber, K. (2000):3 Community-based wildlife population assessment in the Korup Project Area, SW – Cameroon. *ETFRN News* 32: 59-60.

Waltert, M., Lien, Koen, F., and Mühlenberg, M. (2002): Further declines of threatened primates in the Korup Project Area, SW Cameroon. *Oryx 36: 257-265*.

Waltert, M., Heber, S., Riedelbauch, S., Lien, L.J. & Mühlenberg, M. (2006): Estimates of blue duiker densities from diurnal and nocturnal line transects in the Korup region, SW Cameroon. *African Journal of Ecology*.

Goettingen, 29 October 2007

Lien