THE IMPACTS OF MINERAL EXPLOITATION AND ASSOCIATED TRADE ON WILDLIFE IN THE DJA-BOUMBA MINING AREA EAST CAMEROON



Quarter Report

By

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Executive Summary

This study examines the impacts of mineral exploitation and associated trade on wildlife in the Dja-Boumba mining area of east Cameron in 2010. The Dja Faunal Reserve (World Heritage Site) of east Cameroon has the only remaining large block of unlogged forest in the country but the sale of mining permits at the periphery are on the rise. Mineral exploitation and associated trade on wildlife has led to a tremendous devastation of the ecological setting in this zone, hence rending the environment almost useless for wildlife survival. The goal of the study was to survey the mining environment and assess the degree of threat to the endangered wildlife species in the area. The method was based on line transect sampling which allowed the determination of species composition, distribution and levels of human disturbance in the proportion of their estimated occurrence in the study area. Questionnaires were used to investigate knowledge, attitudes and practices of the local population towards mining and the utilization of wildlife in three villages. This gave an account of hunting pressure, associated trade on wildlife and other human activities found to modify wildlife population densities. A total of sixteen wildlife species were confirmed, four were listed in the IUCN Red Data Book (IUCN, 2008) and four species listed in the IUCN Red List of threatened species. Two species were listed in class A and four in class B of the Cameroon legislation (MINFOF, 2006). While two, seven and one were listed in level I, II and III of CITES. Currently wildlife species were threatened by mining activities and an encroaching human population, with subsequent heavy illegal poaching for meat and income.

The sampling was statistically representative of the population by age, gender, and socioeconomic status. The overwhelming majority (95.8%) thought that wildlife was extremely threatened and was important to be saved. The study revealed that mineral exploitation was absolutely essential for development, but its activities fragment the forests, favour the advance of agriculture and facilitate hunting and trade in bushmeat. The links between mining, logging, poaching, agriculture and population influx is a very ambiguous problem that, more than any other problem requires an objective, rational and multidiscipline approach.

To assure species preservation and rational use of wildlife, we recommend the integration of conservation into upstream mining for sustainable development. We also recommend, among other measures a permanent ecological monitoring system for the endangered species in the Nkamouna site and the neighbouring forests (FMU's 10041, 10039, 10037, community forests, multiple use zones **……**) where they have taken refuge because of the destruction.

Keys words: Mineral exploitation, Associated human activities, Habitats destruction, Wildlife, Sustainable development, Dja Fauna Biosphere Reserve, Biodiversity conservation.

Acronyms and Abbreviations

IUCN	International Union for the Conservation of Nature
CITES	Convention on International Trade on Endangered Species
MINFOF	Ministry of Forestry and Fauna
TRIDOM	Tri-National Dja-Odzala-Minkebe landscape
IKA	Index of Abundance
FMU	Forest Management Unit

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1. Introduction 1

1.1 Background of the study

The Dja Faunal Reserve of east Cameroon has the only remaining large block of unlogged forest in the country but the sale of mining permits in the buffer zones are on the rise (Lahm 2000 b). The Dja includes a significant proportion of primary forest, one of the few remaining forest area of the Guineo-Congolian ecosystem in Cameroon. It is contiguous with protected areas in both Gabon and Congo Brazzaville and a unique tri-national conservation programme has been developed called-TRIDOM (Tri-National Dja-Odzala-Minkebe).

A rich source of cobalt and nickel was discovered by Geovic Company Ltd in part of this forest, called Nkamouna, and there are several other mineralized areas at the periphery of this reserve. The proposal for mining of cobalt and nickel at the periphery of the Dja Fauna Reserve has been conceived by Geovic Company Ltd in 1994. Mining started in 2004 and will continue for 25 years. As much as 1631km^2 the forest will be destroyed within 25 years by Geovic mining company (Geovic, 2001).

The Dja Fauna Reserve of east Cameroon has been the focus of increasing conservation activities since the threats to its biological diversity and integrity were first recognised over a decade ago (Bedel *et al.,* 1998).

The Dja Biosphere Reserve is of outstanding conservation interest for a multitude of reasons. For example, the area supports unusually high densities of forest mammals, particularly amongst the so-called “charismatic mega fauna” such as forest elephants (*Loxodonta africana cyclotis)*, western lowland gorilla (*Gorilla gorilla gorilla*), chimpanzees (*Pan troglodytes troglodytes*), bongos (*Tragelaphus euryceros*) and forest buffaloes (*Syncerus caffer nanus*), Leopard (*Panthera pardus*) and sitatunga (*Tragelaphus spekei*).

Moreover, many other species internationally recognized as endangered still thrive in this forest, although they are increasingly threatened by unsustainable exploitation and habitats destruction from industrial mining (Niang *et al.,* 2006; McConelle, 2008).

Industrial mining impacts to wildlife are: direct impacts; indirect impacts and cumulative impacts. The Energy and Biodiversity Initiative (EBI 2003) defines direct impacts as those that result specifically from project activities, are normally limited to project area and life time. Indirect impacts are those that do not usually result directly from project activities, but are rather the result of other people‘s decision and activities triggered by the project’s presence. Cumulative impacts are those impacts that arise in combination with other projects.

Previous research carried out in this area Makazi and Ngandjui (2004) revealed that mineral exploitation was absolutely essential for development, but its activities fragment the forests, favour the advance of agriculture and facilitate hunting and trade in bushmeat. The links between mining, logging, poaching, agriculture and population influx is a very ambiguous problem that, more than any other problem requires an objective, rational and multidiscipline approach.

Dallmeier *et al.,* (2006) reported that the Rabi-Koumaga oil and gas exploitation have created road network throughout Rabi and Toucan that have extensively fragmented the forest. The noise of machinery as well as hunting on the edge and interior of the forest provoked a general departure of mammals from the mining area.

1.2 Statement of the problem

The socioeconomic development of Cameroon depends on the exploitation of her natural resources, and she believes that these resources should be quickly explored and exploited in order to develop and improve the undernourished economy. In face of this accelerated development, mining projects are carried out to extensive scales and for extended periods. Very little information is available regarding the inclusion of the long-term effects on wildlife. A lack of best practices and appropriate mitigation measures poses threats to the sustainability of wildlife in the Dja Reserve.

The integration of wildlife concerns along with industrial mining is rather scarce, especially in the east region of Cameroon. Most strategies and regulations on mining were developed and implemented divorced of wildlife management. Even where these attempts have been made to integrate industrial mining and wildlife diversity, decisions were based on spatial analysis of socioeconomic, cultural and natural resources information.
Wildlife exploitation in this area defies all conservation norms coupled with the lack of management system geared towards effective protection and wildlife management (WCMC, 1997, Kuck and McNair, 2002).

There is enough evidence from the previous studies in the area to substantiate the accusation that mining provide easy access to arms, ammunitions and steel wire cables to enhance ample supply of cheap protein to mine employees (Makazi and Ngandjui, 2004). Much of the forest has been given out to the mining companies, many of whom have no stake in sustainable management. The pressure to maximise profits coupled with the low capacity of the Ministry of Forestry and Fauna (MINFOF) to monitor the mining companies had led to unsustainable rates of habitat destruction, decline in wildlife species and biodiversity loss. At the community level, the greatest impact of mineral exploitation is felt by those sectors of the community (often the poorest) that depend on the wildlife for their livelihoods.

It is the light of these already highlighted problems that this study hinges its goal and objectives. Therefore, the goal of the study is to contribute to the development of the necessary technical and scientific basis for wildlife management planning in the tropical region in general and in east Cameroon in particular. The research would integrate the management of the endangered wildlife species with industrial mining, while meeting the guarantee for sustainable development.

1.3 Goals and objectives of the study

The study intent to survey the mining environment and assess the degree of threat to endangered wildlife species in the area.
This is to enable natural resources allocation and environmental management decisions to be based on up to date and accurate information.

The research wishes to develop and promote practices for integrating conservation into upstream mining for sustainable development. Since both mining and wildlife are vital to us, it is not a challenge to our ingenuity to discover a way of preserving the "goose that lays golden eggs".

The survey will provide insights into the critical factors that affect the habitat, survival, threats and sustainable management of endangered wildlife species in the Dja-Boumba mining area of the rainforest of east Cameroon.

The specific objectives of this study are:

- To determine effects of mining activities on the endangered wildlife species and their habitat;
- To estimate the current status (densities, indices of abundance, encounter rate), spatial distribution and level of human disturbance;
- To conduct interviews on the knowledge, attitudes and practices towards mining and the utilization of wildlife as bushmeat and trade in the mining area.
- To carryout environmental education programme to raise awareness and to engage local stakeholders in active dialogue on the protection of rare and endangered wildlife species.

1.4 Research questions

The goals and objectives of the research presented here can be translated into the following questions:

a) What mining operations are being carried out by the mining company that affect endangered wildlife species and their habitats?

b) What factors are responsible for endangered wildlife species disturbance in the mining area?

c) Does population density of endangered wildlife in the mining area directly related to associated trade.

2. Materials and Methods

2.1 Study area

2.1.1 Geographical and Administrative location

The study area is the buffer zone of the Dja Faunal Reserve (La Réserve de Faune du Dja), called the Nkamouna forest, east Cameroon. The project lies within the Lomie sub-division of the Huat-Nyong Division, approximately 25km east of Lomie town (Fig. 1and 2). The villages of Kongo, Ngola I, Ngola Baka, Achip, Ntam and Melen are closest to the project site. A 33km laterite road linked Lomie to Kongo village and a 9 km road access to the mining site. The study area is located within 6 villages of the Nzime ethnic group.

The region is characterized as a broad plateau incised by the uppermost reaches of the Congo River drainage system. The plateau stands at an elevation of 720 to 850 meters above sea level. Prominent landmarks include the town of Lomie and the Edjie river.

The climate is equatorial in type, with four seasons: the long rains from mid-September to December, a three month dry season, the small rains between mid-March and June, and a short dry season from July to September. The mean annual rainfall is around 1,570mm with less than 100mm falling during the driest months. Humidity is high all year. Temperatures are similar throughout the year with a mean of 23.3°C (recorded at 640m). August is the coolest month, with a mean monthly minimum of 18°C and maximum of 27°C; April is the hottest month with a mean minimum temperature of 19°C and a mean maximum of 30°C.

The major habitat categories recognized in the study are:

- Primary forest with relatively open under growth;

- Primary forest with relatively dense under growth of lianas from the ground to the canopy;

- Secondary forest with dense growth of lianas and *Macaranga sp.* in the forest interior;
- Logged forest with very dense under growth of shrubs and seedlings in the forest interior;
- Small open and regenerating secondary forest near roads and wellheads;
- The forest rich in lianas with herbaceous layer composed principally of *Marantaceae* and *Mapania spp*;
- Riparian terrain associated with forest streams and rivers (Bedel *et al.*, 1998).

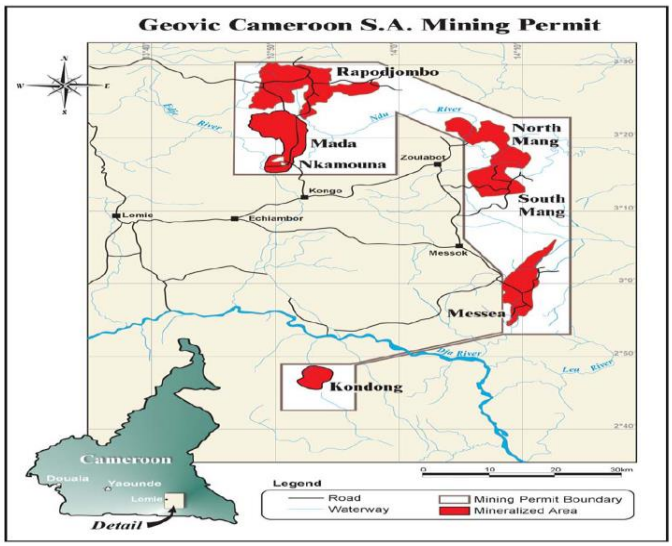

Fig. 1. Location of the mining areas

Source: Geovic geological survey,2006

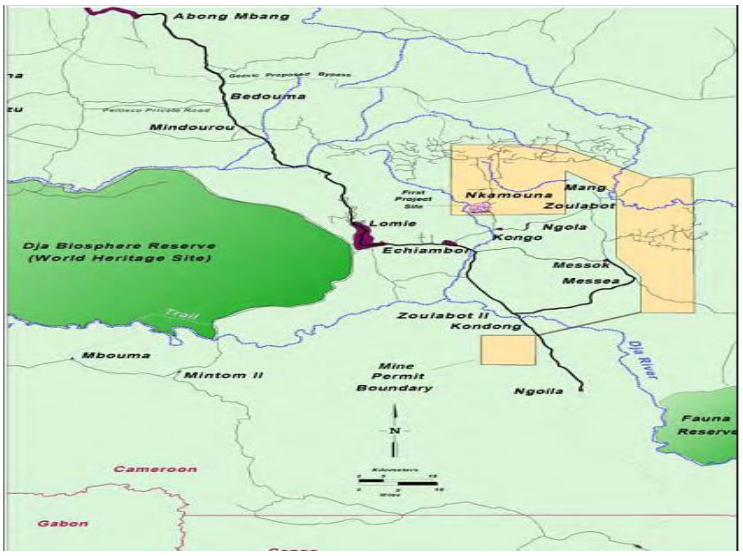

Fig. 2. Location of the Dja World Heritage site and the mining areas.

Source: Geovic geological map 2006.

2.2 Line transect sampling

Line transect sampling (Buckland *et al*., 1993) was employed to determine species composition, distribution and levels of human disturbance in the proportion of their estimated occurrence in the study area. The route of each transect was decided in advance by plotting the course and distance on the map.

Each transect was cut 2km apart and perpendicular to each other, using a compass bearing to keep it straight, a metre to record the distance cut and a global positioning system(GPS) to locates transect positions and interesting features. Transects were oriented to cross major drainage features in order to sample a representative proportion of all vegetation types. Transects had length of 3-5 km transects.

Recce walk were undertaken prior to line transect to establish transects locations. At the end of each transect the researcher performed a Recce to the next transect, in direction perpendicular to the direction of the transect (Walsh *et al*., 1999; White *et al.*, 2000).

The researcher on Recce followed the paths of least resistance through the forest, rather than a perfect straight line. Observations on Recce were noted but perpendicular distances were not measured.

2.3 Questionnaire interviews in the mining villages

2.3.1 Village census

Sampling frame constituted the households in the mining villages. The study adopted the multistage approach to sampling, in order to maximize the benefit of both simple random and strata sampling methods. Thus the various sampling units were classified into different groups (strata) based on socioeconomic activities like hunting, commerce, mine workers and farmers.

Preliminary meetings were held in each of the three earmarked villages to describe the work and to receive permission to work in the villages.
The initial research activity in a village was to locate and map all salient features including each household. The census for each village was conducted following map making. The census form included the following components: an assigned corresponding number, date and village. (Mucheal *et al.*, 1999).

2.4 Data collection

2.4.1 Transect survey

The survey team consisted of four personnel. On the standard transects the researcher recorded all mammals signs and ape nests, while the assistant helped with perpendicular distance measurement of observations (Lahm *et al*., 2006). The responsibility for direct observations of mammals was the team effort. All data were recorded on standard survey sheets for direct observations, indirect observations (tracks and signs) and ape nests.

The team scanted the forest from the ground to the canopy for mammals, their signs and ape nests (Bennun *et al*., 2000). The team listened to vegetation movement and vocalization, and

monitored the ground for tracks, dung, scent, burrows, resting sites, scrapes, hair, bones, and distinctive digging and feedings signs(White *et al*., 2000; Barnes 2001) .

Field guides: Mammiferes d'Afrique et Madagascar (Theodore *et al.*, 1995) and the kingdon field guide to African mammals (Kingdon, 2003) were used for species confirmation.

The following information were collected upon detecting an animal or sign: time of encounter, species, type of observation, position of the signs (using GPS), number of animals or signs seen, age of sign (fresh, recent, old, very old), and the vegetation type and density (Williamson *et al.*, 1995).

For each chimpanzee and gorilla nest or group of nest seen the team designed a nest group configuration in relation to the trails and recorded nest age (fresh, recent, old, very old), the type of construction according to the vegetation employed, the height of each nest and tree used if applicable, faecal sample and the habitat type using methods of Tutin *et al* (1984, 1995).

The team noted sign of human presence including spent cartridges, cable snares and camp sites.

2.4.2 Interviews

The questionnaire first sought to profile the individuals by seeking information on sex, age, marital status, ethnic group, residence or indigene, education level and occupation. It then attempt to assess the individual's level of awareness on wildlife issues. This was done by seeking answers to questions relating to personal importance of wildlife and knowledge of conservation agencies. The interviewees was then asked questions which sought to establish personal attitude towards mining activities, threats to wildlife from mining and associated trade and ways of integrating mining and wildlife management, practices or interaction of wildlife through hunting, pet, ivory, skin trade or other parts of wildlife.

Data were collected by a team of two trained researchers. Usually the male and the female heads of households were present during the interview.

As precautions against misreporting of information, the team used cross-checks both within the questionnaire and by interviewer. By hiring two local residents as key informants and assistants, we were able to verify certain key elements of the information base.

2.5 Data analysis

Buckland *et al*., (1993) suggested that a sample size of at least 60-80 sightings for adequate estimation of density. Where sample falls below this value caution is needed in interpreting the results. Density estimates (D) were determined as:

$$D = nf(0)/2L$$

Where n is the number of sightings, $f(0)$is the probability density function of the perpendicular density data at zero distance from the survey transect and L is the total length of the survey transect. For species with the number of sightings low to reliably estimate density, encounter rates was be used to estimates species diversity and abundance. Data for the questionnaire interviews were analysised with SPSS 17.0 statistical package and Integrated Micro processing Systems (IMS) used for data processing. Responses to all questions were first analyzed by frequency and percentage. Subsequent to these, various question correlations were investigated to examine possible significant relationships in responses. Chi-Square tests were used for this analysis, (occupation versus number of wildlife hunted, sold or bought, eaten as bushmeat per year, Reasons for hunting ratio, sex versus trade on animals parts, degree of threats versus occupation, linear by linear association,). ANOVA was used to determine the variation of observations between transects.

3. Results

3.1 Status of wildlife species

Sixteen medium and large-sized mammals were recorded in the study area, four were listed in the 2008 IUCN Red Data Book and four species listed in the IUCN Red List of threatened species (www.redlist.org). Four species were listed in class A and two in class B of the Cameroon wildlife legislation (MINFOF, 2010). Two, seven and one were listed in level I, II and III of CITES and two were data deficient (Table I).

Table 1. List of medium and large-sized mammals present in the study area and their conservation status (IUCN 2008, CITES and Cameroon legislation).

Family-species	IUCN (2008)	CITES	Cameroon legislation	Indices of animals presence	Direct observation
PRIMATA					
Pan troglodytes	EN	I	A	N	DO
Gorilla gorilla	EN	I	A	N, FT, F, FP	
Cercopithecus nictitans		II		VO	DO
Cercopithecus cephus	DD			VO	DO
Cercopithecus pogonias	EN	II		VO	
Colobus polykomos satanas	VU			VO	
ARTIODACTYLA					
Cephalophus dorsalis	LRnt			P	
Cephalophus nigrifon	LRnt			P	
Cephalophus sylvicultor	LRnt	II	B	FP	
Philantomba monticola		II		P, FP	
Patomochoerous porcus				D	
Tragelaphus spekei		III	B	FP	
PHOLIDOTA					
Smutsia gigantea		II	A	D	
Uramanis tetradactyla		II		FT	
CARNIVORA					
Panthera pardus	LRcd	II	A	VO	
RODENTIA					
Atherurus africana	DD			T	

Source: Field data, 2010

Conservation status

The species identified as threatened by IUCN are assigned a category indicating the degree of threat as follows:

EN = Endangered;

VU = Vulnerable;

LRcd = Lower risk but conservation dependent;

LRnt = Lower risk, but near threatened;

DD = Data Deficient.

CITES: I, II, III = Appendix I, II or III of CITES

Cameroon Legislation (Law No. 0648 of 18 December 2006, Articles 2(1) and 3(1) laying down forestry and fauna regulations:

Class A = Rare or Endangered species with full protection.

Class B = Species where by hunting and export should be regulated or monitored.

nal presence: FP = Footprint, N = Nest, P = Pellets, FT = Feeding trails,

T=Trace, DO = Direct observations, VO = Vocalisation,

Table: 2. Number and composition of ape nest groups recorded per transect in the study area.

Transect	Chimpanzee			Gorilla				
	Number of nest	Number of nest groups	Number of solitary nests	Number of nests	Number of nest groups	Number of solitary nests	Total number of ape nests	% of Total
T1	10	2	0	0	0	0	10	9.5
T2	8	2	0	8	1	0	16	15.2
T3	0	0	0	0	0	0	0	0
T4	42	13	3	0	0	0	42	40
T5	3	3	3	1	1	1	4	3.8
T6	7	5	4	0	0	0	7	6.7
T7	7	3	2	0	0	0	7	6.7
T8	16	4	1	0	0	0	16	15.2
T9	3	1	0	0	0	0	3	2.9
TOTAL	**96**	**33**	**13**	**9**	**2**	**1**	**105**	**100**

Source: Field data, 2010

Table: 3. Total number of mammals encounter per transect N = 412.

Observation	Transect									% of Obs.
	T1	T2	T3	T4	T5	T6	T7	T8	T9	
Chimpanzee	**10**	**8**	**0**	**42**	**3**	**7**	**7**	**16**	**3**	**23.31**
Gorilla	**2**	**8**	**0**	**1**	**3**	**0**	**0**	**0**	**0**	**3.41**
Philantomba monticola	**2**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0.73**
Cephalophus dorsalis	**0**	**0**	**2**	**0**	**1**	**0**	**0**	**0**	**0**	**0.73**
Cephalophus nigrifons	**0**	**0**	**1**	**1**	**0**	**0**	**0**	**0**	**0**	**0.51**
Cephalophus sylvicultor	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0.24**
Potamochoerus porus	**3**	**1**	**1**	**2**	**1**	**1**	**0**	**1**	**0**	**2.43**
Tragelaphus spekii	**1**	**0**	**0**	**2**	**0**	**0**	**0**	**0**	**0**	**0.73**
Cercopithecus nictitans	**0**	**0**	**104**	**5**	**15**	**15**	**36**	**0**	**0**	**42.51**
Cercopithecus pogonias	**0**	**1**	**1**	**0**	**7**	**15**	**0**	**0**	**0**	**5.83**
Cercopithecus cephus	**0**	**0**	**57**	**0**	**0**	**0**	**0**	**0**	**0**	**13.83**
Colobus satanas	**0**	**0**	**0**	**0**	**0**	**20**	**0**	**0**	**0**	**5.01**
Panthera pardus	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0.24**
Uramanis tetradactyla	**0**	**0**	**0**	**0**	**1**	**0**	**0**	**0**	**0**	**0.24**
Smutsia gigantea	**0**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.24**
Atherurus africana	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0.24**
Total all species	**19**	**19**	**166**	**54**	**33**	**58**	**43**	**17**	**3**	

Source: Field data, 2010

T**able: 4. Total number of human signs recorded per transect in the study area N = 416.**

Signs	Transect									Grand total	% of Total
	T1	T2	T3	T4	T5	T6	T7	T8	T9		
Hunting camps	3	0	2	1	3	0	4	0	0	**13**	**3.0**
Snare lines	1	4	81	17	125	7	4	20	107	**366**	**84.0**
Cartridge shells	1	0	6	0	6	4	9	7	4	**37**	**8.4**
Total	**5**	**4**	**89**	**18**	**134**	**11**	**17**	**27**	**111**	**416**	**100**

Source: Field data, 2010

ONE-WAY

Table 5. Descriptive observation of animals.

	N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
					Lower Bound	Upper Bound		
T1	19	3.4211	3.94850	.90585	1.5179	5.3242	1.00	16.00
T2	19	2.8947	3.54173	.81253	1.1877	4.6018	1.00	14.00
T3	166	9.5964	1.20594	.09360	9.4116	9.7812	4.00	11.00
T4	54	2.5370	3.14260	.42765	1.6793	3.3948	1.00	13.00
T5	33	7.5152	3.41066	.59372	6.3058	8.7245	1.00	14.00
T6	58	9.2931	3.35611	.44068	8.4107	10.1755	1.00	12.00
T7	43	7.6977	2.98835	.45572	6.7780	8.6174	1.00	9.00
T8	17	1.3529	1.45521	.35294	.6047	2.1011	1.00	7.00
T9	3	1.0000	.00000	.00000	1.0000	1.0000	1.00	1.00
Total	412	7.2670	3.94815	.19451	6.8846	7.6494	1.00	16.00

ANOVA

Table 6. Observation of animals.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	3713.614	8	464.202	69.466	.000
Within Groups	2693.017	403	6.682		
Total	6406.631	411			

If $F_{cal} > F_{critical}$, there is a variation among the groups.

Since the calculated Anova result with an F-value of 69.466 is greater than the critical F-value of 1.94 (at df = 8, 403); there is a variation in the observations of animals among the nine (9) transects. The result is significant at 0.05 level, as p-value = 0.000. Hence the observations of animals in all the transects differ from each other significantly.

Table 7. Human activity correlated with animal observations.

		Observation		Total
		Human activity	Observation of animals	
Transect	T1	5	19	24
	T2	4	19	23
	T3	89	166	255
	T4	18	54	72
	T5	134	37	171
	T6	11	54	65
	T7	17	43	60
	T8	27	17	44
	T9	111	3	114
Total		416	412	828

Table 8. Chi-Square Tests.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	258.512(a)	8	.000
Likelihood Ratio	295.446	8	.000
Linear-by-Linear Association	102.750	1	.000
N of Valid Cases	828		

a 0 cells (.0%) have expected count less than 5. The minimum expected count is 11.44.

If $X^2_{cal} > X^2_{critical}$, there is an association between the level of human activities and the frequency of animal observations in each transect

Since the calculated chi-square result is 258.512, which is greater than the critical chi-square value of 15.507 (at df = 8), there is therefore an association between level of human activities and the frequency of animal observations in each transect. This result is significant at 0.05 level, as p-value = 0.000. Hence human activity has an impact on animal observations in the study area.

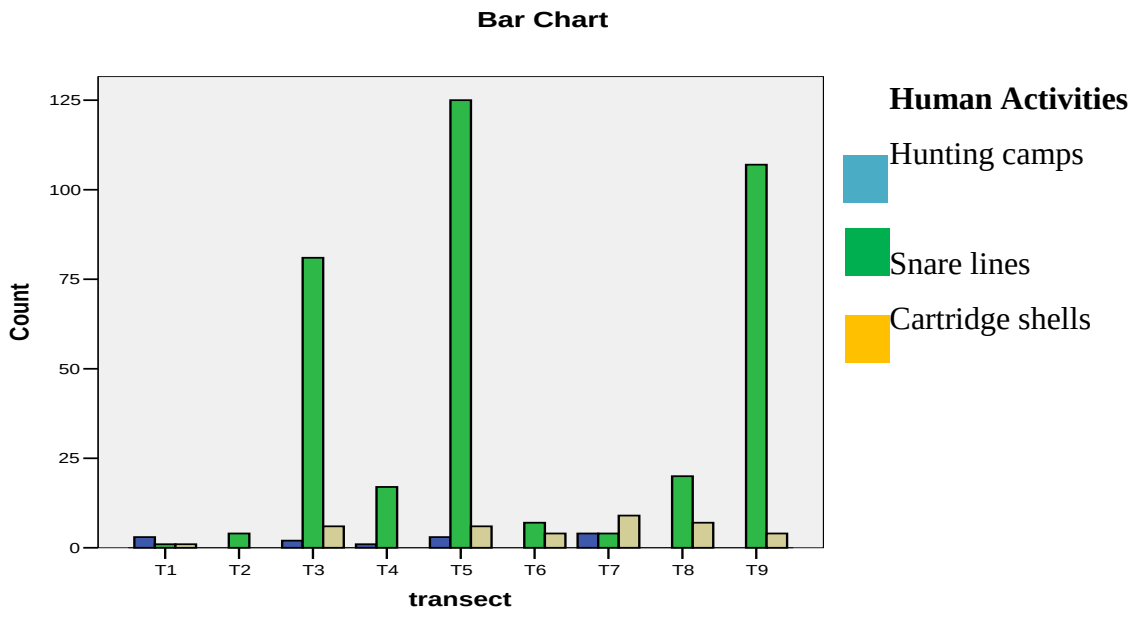

Figure 3. Encounter rates of human signs on the transects.

ANOVA

Table 9. Analysis of variance for human activity on the transects.

	Sum of Squares	df	Mean Square	F	Sig.
Between Groups	4.602	8	.575	5.319	.000
Within Groups	44.013	407	.108		
Total	48.615	415			

If $F_{cal} > F_{critical}$, there is a variation among the groups.

Since the calculated Anova result with an F-value of 5.319 is greater than the critical F-value of 1.94 (at df = 8, 407); there is a variation of human activity among the nine (9) transects. The result is significant at 0.05 level, as p-value = 0.000. Hence the occurrences of human activity in all the transects differ from each other significantly.

3.2 Interviews

3.2.1 Demography

A total of 119 people were interviewed in the 3 out of the 6 mining villages (table10):
Kongo; 33N 373714; 353226; Achip; 33N 382126; 353505; Melen; 33N 367844; 351085.
The sampling was statistically representative of the population by age, gender, occupation, level of education, tribe and resident or indigene. The majority of the individuals ranged from 25–34(29.4%) and 35– 44(26.9%) in age (table 11). These two age groups accounted for 56.3% of the sample. Ninety three (93) males and twenty six (26) females were sampled. The sample also gave a wide representation of occupations. A general breakdown of occupational backgrounds consisted of approximately of 25.2% hunters, 34.5% farmer/hunters, 4.2% farmers, 18.5% commerce, 10.1% mine workers and 7.6% other occupations.

Marriage was found to be an important social value for the inhabitants of the study area as about 90% of the interviewees were married. Having wives and husbands implied producing children as the 119 interviewees were found to have 201 children (mean = 2.21; std = 1.72). The overall household size (including other relatives), considered as dependent was appreciably high totalling 433 persons.

The sample also accounted for education backgrounds. Out of the 199 interviewees 82.4% had a complete primary level, 8.4% had a complete secondary level, and 0.8% had a complete tertiary education level and 8.4% had no formal education.

The villagers originated from diverse ethnic backgrounds, 14 ethnic groups were identified in the study area. The higher diversity in Cameroon is a reflection of the over 250 ethnic groups in the country. In the indigenous Nzime and Baka represented 82.5% of human population in the study area. Three major immigrant ethnic groups in the study area were Bamelike (4.2%), Beti (2.5%) and Banso (2.5%).

Table. 11. Age groups in the study area.

Table 10. Distribution of sample size.

Village	Frequency	Percent
Kongo	61	51.3
Achip	37	31.1
Melen	21	17.6
Total	119	100.0

Age	Frequency	Percent
15 - 24	18	15.1
25 - 34	35	29.4
35 - 44	32	26.9
45 - 55	20	16.8
55+	14	11.8
Total	119	100.0

Table.12. Occupations in the villages.

Occupation	Frequency	Percent
hunter	30	25.2
farmer/hunter	41	34.5
farmer	5	4.2
commerce	22	18.5
mine worker	12	10.1
other occupations	9	7.6
Total	119	100.0

Table 13. type of activity in the mining area.

Village	type of activity in the mining area				Total
	cutting of trees	drilling	infrastructure development	all of the above	
Kongo	6	4	1	49	60
Achip	0	0	0	36	36
Melen	0	0	3	18	21
Total	6	4	4	103	117

Tables 14. Mean of wildlife killed in the study area.

Village		Mean	S.E. of Mean	Std Deviation	Minimum	Maximum
Kongo	how many animals do you sell, hunt, buy or eat bush meat per year?	880.18	104.21	813.89	3.00	4800.00
Achip	how many animals do you sell, hunt, buy or eat bush meat per year?	774.16	77.89	473.77	360.00	2400.00
Melen	how many animals do you sell, hunt, buy or eat bush meat per year?	968.00	170.14	779.66	240.00	3120.00

Table 15. Mining and associated human activities / level of threats to wildlife

Mining operations		Frequency	Percent
Type of activity in the mining area	cutting of trees	6	5.0
	drilling	4	3.4
	infrastructure development	4	3.4
	all of the above	105	88.2
Total		119	100.0
p-value		0.000	
Z-value		5.550	
Other activities that have impacted on wildlife	agriculture and logging	21	17.6
	hunting	18	15.1
	logging	38	31.9
	Commercial activities	42	35.3
	Total	119	100.0
	p-value	0.000	
	Z-value	2.878	
Do mining activities pose threat to wildlife?	yes	119	100.0
Total		119	100.0
What are the types of threat	habitat fragmentation	1	.8
	habitat destruction	4	3.4
	all of the above threats	114	95.8
	Total	119	100.0
	p-value	0.000	
	Z-value	5.776	

If $Z_{cal} > Z_{critical}$, the responses with the highest frequency is significant

The Z_{cal} value for all the questions represented in the table above is greater than 1.96 ($Z_{critical}$ value), therefore the major mining activities in the study area are cutting of trees, drilling and infrastructure development, and these have threats such as habitat fragmentation and habitat destruction in the study area. This result is significant at 0.05 level, as p-values for all the questions are 0.000.

4. Discussion

4.1 Fauna inventory

Mammals are very sensitive to diverse habitat perturbations. Geovic company Ltd has been carrying out intense mining activities in the study area since 1994: opening of massive roads, cutting of topographical transects, large unsightly excavations and stockpiles of overburden dumped on the soil top, open pit panel development about 150 m wide at the ground surface and 400 m long, construction of infrastructures, air strip, regular movement of heavy machines and vehicles, noise and light from heavy generators, blockage of free flow of watercourses, has caused the destruction of entire part of the home range and territories of small, medium and large-sized mammals in the study area. Laurence *et al*., (2000) observed similar effects at the Lope National Park in the north–central Gabon, where roads, pipelines and installations have impacts on the populations of arboreal primates and other large mammals.

4.1.1 Densities and species distribution in the study area

In the nine surveyed transects the encounter rates for all species were significantly low (table 3). The encounter rates of feeding trails, pellets, tracks and nests of all species concerned were too low to permit the calculations of their densities. The exception being that of chimpanzees when all indictors were lumped for the whole area.

4.1.2 Gorillas

Over the survey period 2 gorilla nest sites were registered in 40km of transects in 50km^2 sample block. Amongst which were 1 nest site constituting 8 nests and 1 nest site of 1 nest site. Within the 2 nest sites; 1(50 %) were fresh (1day) and 1(50 %) were very old (3 months). Fresh footprints of gorillas were registered on T4 and T5 respectively. While old feeding trials and faeces were recorded on T1.

Gorillas encounter rates were very low on all the transects. The relative abundance of gorilla signs increases from south to the west. Three IKA gradients of gorillas signs(feedings trails, tracks and nests) shows the highest IKA of 0.2, average IKA range of ($0.2 \leq IKA < 0.05$) and a relatively low IKA range of ($0 \leq IKA \leq 0.05$) towards the south. This result tallies with the work of (Nagahuedi *et al.,* 2006) who reported that, as the landscape is gradually opened by mining activity, the impact of hunters is increasing and the heart of the forests- the last refuge of the fauna is being threatened. Considering the fact that each gorilla in a group, with the exception of infants which sleep with their mothers, makes a nest each night in which to sleep. IKA of 0.4/km were calculated for gorillas' activity signs (feeding trials, tracks and nests). This figure is on the low side of the range when compared with data from other regions. It is somewhat lower than the figure for the Boumba Bek/Nki from the 1998 study and much lower than the findings from the Dja fauna Reserve study of 1999.

Table 16. Gorilla densities in different regions of Africa.

Dja Wal & Nku, 1999	Lope (Gabon) White, 1992	Dja Williamson, 1995	Lac Lobeke WCS 1996	Boumba Bek/Nki Atanga 1998
I.9 {1.3-2.7}	0.8-2.7	1.7	1.6 {0.2-6.4)	0.9 {0.7-1.1}

The highest densities of gorilla nests and signs were found in the western part of the study area (table 2 and 3). This area was an abandoned logging road covered with dense layer of monocotyledons of the family *Zingiberaceae* and *Marantaceae* and provides an ideal habitat for gorillas. In an extensive study of nest building in Gabon, nest sites were also more common than expected in secondary forest along old forest roads and light gaps (Tutin *et al.,* 1995).

In the study area gorillas avoided regions subjected to habitat alteration by mining, logging and high level of poaching due to easy accessibility by roads. It seems that a certain level of human activities does not necessarily drive gorillas away, as mine workers admitted seeing groups of gorillas during working hours. But intense disturbance of humans is not comparable with gorilla

survival. In Gabon gorillas were found to be absent from areas of human settlement. Roads and plantations were avoided (Tutin & Fernandez, 1984).

4.1.3 Chimpanzees

A total of 33 Chimpanzee nest sites were recorded in the study area. Amongst which 13 nest sites consisted of single nest, 5 nest sites of 2 nests, 5 nest sites of 3 nests, 3 nest sites of 6 nests, 3 nest sites of 4 nests, 2 nest sites of 5 nests, 1nest site of 7 nests and 1nest site of 11 nests, totalling 96 nests. Of the 33 nest sites; 7(21.2 %) were fresh (between 1-5days), 4(12.1 %) were recent (1 week), 7(21.2 %) were old (1 month) and 15(45.5 %) were very old (between 2-3months). There were direct observation of 25 chimpanzees on transect (T7) at the southern part of the study area. GPS 33N 373483; 367117.

Chimpanzee nests, direct observations and other signs were encountered throughout the study area and they showed no correlation with any of the transects (table 6). Relatively high encounter rates were recorded on T1, T2, T4 and T8. Chimpanzee densities were estimated at 0.03 individuals/km^2. Comparison with the results from other sites suggests that the Nkamouna has a relatively low densities (table 17).

Table 17. Chimpanzee densities in different regions of Africa

Dja Williamson, 1995	Dja Wal & Nku, 1999	Lope (Gabon) White, 1992	Lac Lobeke WCS 1996	Boumba Bek/Nki Atanga, 1998
0,8 {0,6 -1.0}	0.7{0.6 - 0.9}	0.1 – 1.1	0.14	0.3{0.2 – 0.4}

Chimpanzees generally prefer mature, primary forest to secondary forest (Ihobe, 1993). In the study area the same preference was apparent. Areas with less habitat alteration and human impact (table7) had high relative abundance of chimpanzees than those with high level of disturbances. A high concentration of activity signs ($1.1 \leq IKA \leq 0.9$) were recorded in the northern part of the study area. The existence of primary forest in between difficult terrain

within drilling compartments was shown to be of great importance to the survival of the chimpanzee communities.

The high proportion of solitary (39.4% for chimpanzees and 50% for gorillas) is a clear evidence that gorillas and chimpanzees were hunted at the exploitation site. The solitary ones are probably those that are old, or those individuals that other members of the group have been killed by hunters.

More gorillas and chimpanzees nest sites were recorded during this study as compared to 2004, and in view of the fact that a greater proportion of the nest sites were classified as fresh and recent (42.4% this study in comparison with 8.6% in 2004 for chimpanzee and 50% this study in comparison with 0% gorilla in 2004), shows that the great apes have regained the Nkamouna forest after 2004.

4.1.4 Ungulates

Four species of duikers, blue duiker (*Philantomba monticola*), bay duiker (*Cephalophus dorsalis*), black fronted duiker (*C. nigrifons*), and yellow backed duiker (*C. sylvicultor*) were recorded in the study area.

The trend line for the red duiker group encounter rates suggest that their distribution in Nkamouna is related to the presence of man (table 7). The low frequency of tracks and pellets and information from local hunters indicates that the ungulate population of Nkamouna has reached a critical stage.

The indices of abundance (IKA) for the red duikers as a group were estimated at 0.2 individuals/km. This fall well below the findings from other studies (table18).

Table 18. Red duiker densities in different regions of Africa

Lac Lobeke WCS 1996	Dja Wal & Nku, 1999	Lope (Gabon) White, 1992	Boumba Bek/Nki Atanga, 1998
8.9	6.4{4.5 – 9.4}	3.5 - 15	5{3.9 – 6.0)

The indices of abundance (IKA) of blue duiker in the study area was calculated at 0.08 individuals/km.

Only one species of wild pigs, the red river hog (*Potamochoerus porus)* was registered during the survey period. Results recorded gave indices of abundance of 0.3individuals/km. The giant forest hog (*Hylochoerus meinertzhageni*) present in the area was not confirmed, probably due to confusion in activity signs of the two species.

The tracks of Sitatunga were encountered on two transects. These low encounter rates (no dropping encounters at all) did not permit the estimation of their densities. Since Sitatunga prefer swampy vegetation types it is likely that their tracks and signs were: a) easily overlooked since they remain underwater, and b) their tracks disintegrate rapidly, thus resulting in an under estimation of their numbers. The Sitatunga (*Tragelaphus spekei*) had indices of abundance of 0.08 individuals/km.

4.1.5 Diurnal primates

Four species of arboreal primates were observed in the study area; *Cercopithecus nictitans, C. cephus, C. pogonias* and *Colobus polykomos satanas.*

Of the 18 groups of arboreal primates observed, 12 (or 66.7%) were the greater white nosed monkeys (*Cercopithecus nictitans),* with an encounter rate of 2.2 groups/km. Crowned guenons (Cercopithecus pogonias) were observed four times comprising 22.2 % of sighting, recording an encounter rate of 0.3 groups/km. The next most frequently observed species were the moustached monkey (*Cercopithecus cephus)* of which 2 groups were observed or 11.1 % of the observations and an encounter rate of 0.71 groups/km^2. The black colobus (*Colobus satanas*) was observed once during the survey with an encounter rate of 0.25groups/km.

Seventeen observations 94.4 % of the monkey groups observed were in the dense secondary forest habitat. *C. pogonias* were recorded from the large interior of the primary forest of the study area.

Mixed groups of monkeys were recorded on two occasions, *C. nictitans* and *C. cephus* were seen in associations on one occasion, *C. pogonias* were associated with *C. nictitans* once.
The primate group sizes varied from small groups of 2 individuals to 25 and not more than 30 individuals.
C. nictitans and *C. cephus* were the only species that occurred in significantly higher encounter rates in the mining area. The encounter rates in the mining area (in the midst of logging concessions) were distinctly lower when compared with figures of Mitani (1991) in the Campo Ma'an National Park (2.03 groups/km^2 and 0.64groups/km^2).The results indicate a decline following mining, logging activities and poaching.

4.1.6 Other mammals in the Nkamouna area

One leopard (*Panthera pardus*) was heard and tracks seen during the inventory in FMU10039. This northern part of the study area contains steep hills, rocks and caves that provides an ideal habitat for leopards.

The giant pangolin (*Smutsia gigantea)* seems to have reduced drastically in the study area. Faeces and tracks were recorded on the transect once (n=1). The long tailed pangolin (*Uromanis tetradactyla*) was also recorded once in the study area.

The brush tailed porcupines (*Atherurus africana*) were common in the entire Nkamouna forest. Trail and feeding signs were frequently observed during the survey. The brush tailed porcupine was among the most frequently hunted animals in the study area. Both *Uromanis tetradactyla* and *Atherurus africana* are not endangered.

4.2 Human activity

We recorded 416 signs of human presence on all the transects. Human signs were encountered throughout the study area. Relatively high 'encounter rates' of human activity were recorded on T3, T5 and T9 (Table 4 and 5).Low encounter rates were recorded on T1 and T2 in the western part of the Nkamouna forest. These results are contradictory as T1, T2 and T3 were all located at the western part of the study area. There appears to be an association between the distribution of mammal observations and human signs on the surveyed transect (Table 6 and 7). There was a general perceived pattern of decrease of mammal data corresponding to an increase human signs along all the transect lengths. The reduction of mammal observations was undoubtedly more influenced by proximity to the mining construction site and associated general human activity in the local area.

To get an idea about the relationship between population density of endangered wildlife to human activities, the category of human activities were further sub-divided into a) snare; b) other human signs e.g. shot gun shells and hunting camps. Fig. 3. shows that the level of snares encountered was more than any other human activity in the study area.

The statistical relationship between the two data (human activity and mammal observations) was very high, with a geometrical trend line. It should be mentioned that the total number of snares encountered on the transect lines was (n = 366).

This buffer zone is highly exposed to human pressure as Baka pygmies, Nzime and non-indigenous people exploit its natural resources. The study area was highly disturbed with 9.2 human signs/km of transect.

4.3 Biodata of questionnaires

Perceptions from village meetings revealed issues related to knowledge, attitude and practices towards mining and associated trade on wildlife in the study area.

4.3.1 The values of wildlife

Hunting is one of the lucrative ways the local people derive their direct economic benefit from the forest. Mammal population not only provide an important source of protein but also a major source of income for the local population of Nkamouna cobalt-nickel exploitation site. 93.3% of the respondent admitted that wildlife represent both primary source of protein and the main cash-earning commodity for the inhabitants of the study area. Bennett and Robinson (2000) reported the returns from hunting are generally higher than average local wages. The household sample size also accounted for the higher consumption of wildlife in the study area. Wilkie and Carpenter, (2008) observed that bushmeat consumption across the Congo basin may exceed one million metric tons, and the harvest rates may range from 50-897kg/km2/year.

4.3.2 Wildlife conservation awareness

The role of awareness, lack of education and skills to easily find alternative employment were identified as some of the factors affecting the decline in wildlife population in the study area.
When asked about awareness of the laws protecting wildlife, 70.6% were aware of these laws. The forestry guards and local Non-governmental organisations were cited for a greater role in public education on the subject of wildlife protection. Many of the respondents felt that the regulatory measures being used by governments and Non-governmental organisations (NGOs) operating in the region were mainly repressive and have met with little or no success.
The interviewees because of their low education level believe that wildlife were infinite resources and were not conscious of the possibility of wildlife extinction in their forest.

According to Bennett (2002) the role of education and generating awareness needs to be across the board because there are so many misconceptions as to the problem of bushmeat. The survey revealed that work has to be done in raising awareness on wildlife issues in the general villages. In the study area penalties for illegal traffickers of wildlife and wildlife derivatives are weak and ineffective while public education of the issue is lagging at best and sometimes misleading (Kiyono, 1997, Sakamoto, 1999).

4.3.3 Mining activities and threats to wildlife

Interviews and direct observations in the field revealed that there were roads construction, infrastructure development in the virgin forest, cutting of huge grids called transects through the forest for drilling. Open pits and soils were stripped off the vegetation, which scare the landscape. Large unsightly excavations and stock piles of overburden were dumped on the topsoil.

Conflicts between the logging company and mining company, reasons being that mining pits for mineral extractions were filled up by the logging company (PALLISCO) during the felling and transportation of logs in the forest with bulldozers.

Of the 199 interviewees, 95.8% considered wildlife to be threatened. This question is statistically significant when correlated to age and occupations of respondents (Appendix 1.Table 20.). Of those that thought of wildlife as threatened, 93 targeted habitat destruction from mining activities, 12 targeted agriculture and logging, while 14 said commercial activities and hunting of wildlife represent the greatest threats. When analysed by age and occupations there was a statistical significant apparently due to the age range 25-34 and traders, mine workers and farmer/hunters targeting habitat destruction generally as the main threat to wildlife.

Bennett, (2002) describe habitat destruction as wildlife hazard as these changes the entire dynamics of the community. Not only do the roads make travel and hunting easier, they also enable people to transport large amounts of meat out of the forest on mining trucks to be sold in city markets. The roads allow hunters to exploit larger animals such as gorillas and elephants, whose meat cannot be carried to market easily without trucks. This decimation of animal populations is having serious consequence. In fact, the entire ecology of the forest was in jeopardy.

Noise and activity associated with the project disturbed wildlife in the project area and caused changes in wildlife occurrence and distribution. Noise disturbances may include, drilling, construction, power plant, vehicles movement and other activity associated with the mine and camps.

Another major impact on wildlife resource was caused by the slash-and-burn agricultural methods, which move from one plot to another in the forest. To increase their yields and supply food to the mine workers, the peasant open plots in the dense forest, more favourable to plantains, the most common food crop in the region, and to cucumber, the most expensive one. Hence, recourse to the chain saw to fell trees were more and more frequent. Oyono, (1998) reported that in ten years, there has been a notable increase in cultivated area from 0.30 ha to 1.10 ha among the villagers in the study area. Most farmers have become part-time agriculturists or full-time hunters. The factors that determine whether a household farms, hunts or undertakes a combination of the two was correlated with the economy vulnerability of the country (Nasi *et al*., 2008).

4.3.4 Hunted species and intensity

A total of 31wildlife species were identified as those hunted by the villagers, yielding a (mean=862.7, std=716.2) killed per year in the study area (Table 22). *Artiodactyla, Cephalophus*, primates and rodents constitute the large majority of game harvested by the hunters (Infield, 1998, Mucheal and Ngandjui, 1993) or sold in the villages (Ngandjui, 1993). There is a significant relationship between human activities and the frequency of animal observations in each transect (sd=0.05, p-value = 0.000). The Nzime ethnic group who were considered to be the indigenous inhabitants of the area, concentrated on large mammals, for example gorillas, chimpanzees and elephants.

This study show that hunting pressure has increased in the study area. Reasons justifying the increase in wildlife harvest in the Nkamouna site:

- The irregular recruitment of old hunters as labourers of Geovic has greatly increased hunting pressure in the area;

- The increased number of restaurants(2/household), commercial wildlife trade middlemen and re-sellers were more compared to the number of hunters;
- There was also evidence that the vertical integration of the bushmeat trade has important gender aspects, and provides important benefits to women and children, often from activities requiring widely available skills and offering low financial risk (e.g. cooked meal sales);
- Many youths bitter about the economic situation in Douala and Yaoundé, come back to the villages which has resulted in an increase in the number of hunters (4 to 5 every month in each village).
- In reality, many people exploit wildlife as a buffer to see them through times of hardship (e.g. unemployment), or to gain additional income for special needs (e.g. school fees). Increased in hunting pressure during this period was due to school reopening where parents seek alternative source of income to supply school needs.

The current harvest of meat in Central was one to five million metric tons (984,200 - 4,921,000 tons) per year. Since the maximum sustainable production of wild meat from tropical forests was 102 kilograms (224.4 pounds) per square kilometer per year, wildlife was being taken from the forest at more than six times the sustainable rate. As large animals disappear, hunters kill smaller and smaller ones (Bennett, 2002). Ngandjui, (1998) also demonstrated over-harvesting of wildlife in the Lobeke region in southeastern Cameroon. This increased in hunting pressure on wildlife should be reverse, as mammal population will be lost in the foreseeable future.

4.3.5 Commercial trade in wildlife pets, skin, ivory and other animal parts

Commercial trade in wildlife skin, pet, ivory and other animal parts has a more extensive market. There was clearly a level of ambiguity on the subject of trade in wildlife pets, skin and other animal parts. In comparison with responses by age group and occupations, greater interest was shown in acquiring wildlife pets and other wildlife parts by 41% of the farmer/hunter within the age group of 25-34. The data suggest that this age group are more involved in trading on pets, skins, bones, ivory and other animal parts.

A stockpile of ivory was recorded in one of the hunter's resident, consisting of 40cm/6kg, 33cm/3kg, 26cm/2.5kg,33cm/3kg and 20cm/1.5 kg in weights and lengths respectively. Six diurnal primate orphans and one great ape were observed in the study area: 2 *Cercopithecus pogonias*, 2 *Cercopithecus nictitans*, I *pan troglodytes,* and *2 Cercopithecus agilis.* These orphans were those that their mothers have been killed by poachers.
Two of the primates were observed to have been infected. This posed the risk by some of the wild species introducing zoonotic diseases to the humans and domestic animal stock.

Two out of every four households had animal parts (skulls of great apes, elephant teeth and tails, horns of Sitatunga and teeth of *Potamochoerus porus*) primarily for sale and as trophies.
As long as ivory sales and other endangered wildlife pets were lucrative, illegal methods for laundering will be exploited in disregard of domestic and international laws (Sakamoto, 1999).

With regards to transportation of their trophies to the market, almost all the hunters mentioned that they face problems in smuggling the products through Lomie town to cities like Douala and Yaoundé. This could be particularly attributed to the clandestine nature of the animal parts and laws protecting the ivory trade and other endangered species.

5. Recommendations and conclusion

The result of this study have provided technical detail on the impacts of mining and associated trade on wildlife in the Dja-Boumba mining area.

Medium and large-sized mammals are very sensitive to various disturbance of their milieu. Since 1994, GEOVIC started intensive cutting of transects, prospection, topography studies in the Nkomuna site, coupled with logging, the consequences were habitat destruction for fauna species, noise and opening of area for hunters. Species such as elephant, buffalo (testimony from hunters, that these species were present before exploration period), have departed to refuge in the neighbouring forests (FMUs 10041, 10039, 10037, community forests, multiple used zone) in the waiting hands of the armed immigrants poachers.

The greatest majority (45.5%) of chimpanzee nest sites observed were classified as very old, of more than three months. There was no doubt that the recent and intensive activities of Geovic, primarily the exploitation of mineral in the site have driven chimpanzees from the site towards the neighbouring forests. The same applies for gorillas that have left the site earlier than the chimpanzees. Internationally protected species were still hunted by the village hunters in the study area. Especially those species inhabiting the mining vicinity that were not sufficiently protected.

With the active participation of all the stakeholders (actors, governments and beneficiaries) involved in the mining process, the result of this research has come out with the following recommendations:

- Put in place a permanent ecological monitoring system for the endangered species in the Nkamouna site and the neighbouring forests (FMU's 10041, 10039, 10037, community forests, multiple use zones **……**) where they have taken refuge because of the destruction of the Dja Reserve buffer zones and also to keep away from other disturbances caused by the mining exploitation.

- There should be the permanent presence of a biologist on the site that will be in charge of prospecting the area during cutting into an open space and propose necessary recommendations in order to protect endangered species before all the intervention states in the exploitation.
- Promote extension programs as indicated by the interviewees, with the aim to develop alternative livelihoods to reduce dependence on wild meat;
- Promote public education and awareness programs among the forestry guards and the local communities, so that they are aware of the problems, potential solutions and long term benefits of protecting endangered species.
- Mitigations and compensatory measures should be integrated into mining project's overall planning, design, budget, and implementation calendar.
- Supply side mitigation options: Increasing production of bushmeat. Theoretically the production of bushmeat could be increased by: a) increasing the production of species that constitute a food source for bushmeat species; and b) controlling bushmeat predators and other competitors. Even if we understood enough about the biology of bushmeat species, their food sources, and their competitors to develop appropriate interventions, the open-access nature of the bushmeat trade and the problem of free-riders makes investment in bushmeat production by hunters unlikely. Moreover, the costs of increasing bushmeat production in the forest would probably match or exceed the costs of livestock rearing, making this an unlikely option even if the forest was privatised.

What can one say about a country which consumes inordinate amounts of natural resources in flagrant violation of various international laws not to mention good will? Clearly the first step in alleviating the egregious effects of massive wildlife consumption should be to educate the public about the scale of the problem. This will not be easy since the media and educational system were basically run to serve elite interests and not the common good. Concerned people will need to step out, maker their voice heard, and work for political changes that will lead to a saner and more sustainable system. If we do not, the continued disintegration of the Dja-Boumba environment will bear predictably grim consequences for all to endure.

Seeking ecologically sustainable natural resources management involves constantly searching for a better understanding of nature and the means to use it more efficiently. The most effective way should be through the widespread integration of genuine natural resources management.

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Appendix 1:

Table: 19. Transects orientation in the study area

Transect	GPS(UTM)	Transect Direction(O^o)	Transect Length (km)
T1	372733	270	4.5
	372406		
T2	372754	270	4.0
	371982		
T3	372791	270	5
	370867		
T4	373590	360	5
	373605		
T5	373251	180	5
	373402		
T6	372896	90	4.5
	369596		
T7	373483	180	3
	367117		
T8	372871	270	5
	366086		
T9	371817	90	4
	362212		

Source: Field data, 2010

Table 20. Age correlated with types of threats and Occupations

Occupation	Age	types of threat			Total
		habitat fragmentation	habitat destruction	all of the above threats	

hunter	Age	15 - 24		0	9	9
		25 - 34		0	7	7
		35 - 44		1	11	12
		45 - 55		0	1	1
		55+		0	1	1
	Total			***1***	***29***	***30***
farmer/hunter	Age	15 - 24	0		4	4
		25 - 34	1		11	12
		35 - 44	0		9	9
		45 - 55	0		8	8
		55+	0		8	8
	Total		***1***		***40***	***41***
farmer	Age	25 - 34		0	1	1
		45 - 55		0	2	2
		55+		1	1	2
	Total			***1***	***4***	***5***
commerce	Age	15 - 24		0	4	4
		25 - 34		1	7	8
		35 - 44		1	5	6
		45 - 55		0	3	3
		55+		0	1	1
	Total			***2***	***20***	***22***
mine worker	Age	25 - 34			5	5
		35 - 44			5	5
		45 - 55			2	2
	Total				***12***	***12***
other occupations	Age	15 - 24			1	1
		25 - 34			2	2
		45 - 55			4	4
		55+			2	2
	Total				***9***	***9***

Table 21. Ages correlated with Occupations / other activities that have impacted on wildlife.

Occupation			other activities that have impacted on wildlife				Total
			agriculture and logging	hunting	logging	Commercial activities	
hunter	Age	15 - 24	0	0	8	1	9

		25 - 34	2	0	4	1	7
		35 - 44	1	1	7	3	12
		45 - 55	0	0	1	0	1
		55+	0	0	1	0	1
	Total		3	1	21	5	30
farmer/hunter	Age	15 - 24	1	0	2	1	4
		25 - 34	2	1	5	4	12
		35 - 44	1	2	2	4	9
		45 - 55	3	0	2	3	8
		55+	3	0	1	4	8
	Total		10	3	12	16	41
farmer	Age	25 - 34			1	0	1
		45 - 55			0	2	2
		55+			0	2	2
	Total				1	4	5
commerce	Age	15 - 24	0	4	0	0	4
		25 - 34	2	1	1	4	8
		35 - 44	1	4	0	1	6
		45 - 55	0	1	1	1	3
		55+	0	1	0	0	1
	Total		3	11	2	6	22
mine worker	Age	25 - 34	1	0	1	3	5
		35 - 44	1	0	0	4	5
		45 - 55	0	1	0	1	2
	Total		2	1	1	8	12
other occupations	Age	15 - 24	0	1	0	0	1
		25 - 34	0	0	0	2	2
		45 - 55	2	0	1	1	4
		55+	1	1	0	0	2
	Total		3	2	1	3	9

Appendix II:

Table 22: Scientific and common names of the species hunted in the study area.

Scientific name	Common name
Artiodactyla	
Cephalophus dorsalis	Bay duiker
Cephalophus nigrifon	Black–fronted duiker
Cephalophus sylvicultor	Yellow-backed duiker
Philantomba monticola	Blue duiker
Cephalophus leucogaster	Gabon duiker
Patomochoerous porcus	Red river hog
Tragelaphus spekei	Sitatunga
PRIMATA	
Pan troglodytes	Chimpanzee
Gorilla gorilla	Gorilla
Cercopithecus nictitans	Spot nose monkey
Cercopithecus cephus	Moustached monkey
Cercopithecus pogonias	Crowned monkey
Colobus polykomos satanas	Black colobus
Cercocebus agilis	Crested mangabey
Lophocephus albigena	Greycheeked mangabey
Cercopithecus neglectus	De Brazza's monkey
PHOLIDOTA	
Smutsia gigantea	Giant pangolin
Uramanis tetradactyla	Long-tailed pangolin
Phatoginus tricuspis	Tree pangolin
CARNIVORA	
Panthera pardus	Leopard
Civettictis civetta	African civet
Genetta servalina	Servaline genet
RODENTIA	
Atherurus africana	Brush tail porcupine
Thrynomys swinderiianus	Cane rat
Cricetmys eminni	Emin's giant rat
ELEPHANTIDAE	
Loxodonta africana cyclotis	African forest elephant
TRAGUIDAE	
Hyemoschus aquaticus	Water chevrotain

Scientific name	Common name
LORISIDAE	
Perodicticus potto	Potto
BOVINAE	

Syncerus caffer nanus	African forest buffalo
HYRCOIDEA	
Dendrohyrax arboreus	Tree hyrax
HERPESTIDAE	
Atilax paludinosus	Marsh mongoose

Source: Field data, 2010

Photos

s: Photo 1: Left; two hunters infront of their camps with killed primates.

Photo 2: Right; large open pit with stock piles of overburden.

Photo 3: Bottom: stock pile of ivory in transit to Douala and Yaoundé.

Photo 4. Fresh gorilla nest with dung (estimated age 3days).

Photo 5.Village meeting in Achip

Photo 6. Discussing work plan with field guides.

Photos courtesy of Makazi (author).

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