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Mammal Richness and Diversity in Tropical Ecosystem: The Role of Protected Area in Conserving Vertebrate Fauna, Oban Hill's Region

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Abstract

Documenting the diversity and distribution of vertebrates is crucial to achieving sustainability and assists in planning for the protection and conservation strategy. We conducted a line transect via stratified distance sampling techniques to estimate the densities and diversity of forest mammal in tropical ecosystem landscape of Oban Hills

Region, Cross River Park National (CRNP), Nigeria. A detection function was estimated individually for each land use types by pooling all the animal data from the transects. For fauna species, all sighting records of the two out of four land use types (core and buffer) were used because both accounted for the high significant percentage 36% core and 30% buffer of the species composition encountered in the land use types respectively. In total, core, buffer, farmfallow and plantation recorded 868, 519, 136, and 48 individuals respectively. Their individual density was estimated at 69.8km^2, 64.8km^2, 25.7km^2 and 8.3km^2 for all the land use types respectively. Core of the park accounted for the highest fauna species richness (D=4.138) and plantation recorded the least of (D=2.583). Analysis of Fauna species evenness and species diversity revealed that, farm fallow had the highest values (J′= 0.7536) and (H′= 2.55) respectively. The density in our study area are among the highest in the tropical rainforest. Our results indicate that Oban hills habour highest diversity of fauna in the region and also gives an updated account of fauna composition present in the region. Our finding conclude that core of the park is of the highest conservation value and priority should be given for its protection. The study also provides baseline data for future managing and planning of vertebrate population in the Oban region. We recommend that a biomonitoring study of mammals be initiated to help determine population trends, update species status in this biodiversity hotspot.

Keywords: Fauna, Density, Oban Hill region, rainforest, land use, Ecosystem, diversity.

1. Introduction

Tropical rainforests (TRF) are the most diverse terrestrial ecosystem in the world (Richard, 1996; Gillespie et al., 2004). Tropical forests of Africa harbour unique biodiversity much of which are distributed in forest isolates that have been poorly investigated (Biological Conservation Editorial, 2007). The Guinean forests of West Africa are recognised as a Biodiversity Hotspot, supporting about a quarter of the African mammals, displaying significant endemism across a range of animal and plant groups

(Myer et al., 2000). Guinean forests are seriously threatened from human activities. Numerous endemic species are threatened with extinction and only small proportion of the area is protected (Norris et al., 2010). Understanding how biodiversity (especially fauna) responds to habitat change caused by human anthropogenic activities is very vital for conservation efforts in the region, however, our current knowledge in this regard is scanty. Limited scientific work has been conducted on Fauna in human-modified forest landscapes in West Africa compared with other parts of the world (Gardner et al., 2009)

Oban Division of Cross River National Park (CRNP) in Nigeria is located in the Guinean forests of West Africa known to be among the top 25 biodiversity hot spots in the world (Myer et al., 2000). Oban Division of CRNP is the only area in the sub-region with near intact largest block of contiguous forest and high level of endemism (Oates et al., 2004). Bergl et al., (2007) listed some taxa in the area that showed high level of species richness and endemism. These include primates, amphibians, birds, butterflies, dragonflies, fish and vascular plants. Despite the biological diversity value this area, the future of the area is not secured. This is due to the high level of human activities currently going around the park (Jimoh et al., 2012). Agricultural encroachment, plantation development, Logging, hunting and other human activities are on the increase in the area. This has giving the area the recognition as one of the deforestation hotspots in West Africa (Oates et al., 2004).

In spite of all these, the area is still considered to be understudied. Limited work has been conducted on biodiversity in human-modified forest landscapes surrounding CRNP. Most of the studies only assessed the composition of taxa in the area without considering their composition across the various land use types.

Hunting is currently considered to be one of the most important conservation challenges in tropical rainforest of West Africa. There is continual harvesting of wild fauna species for bushmeat in West Africa, the management of which is often ignored. The unsustainable hunting coupled with habitat loss is driving many species in the area to

extinction. Wild animal hunting for bushmeat is one of the primary activities in Cross Rivers State of Nigeria. Local people in the State engaged in hunting for income generation and for the supply of animal protein. Therefore, hunting for bushmeat in the area is considered to be unsustainable (Ogar et al., 2005). Onadeko (2006) concluded that basic data needed to support the management and conservation of Oban division of CRNP are scarce and few certain taxa remain studied. Therefore, this study was conducted to investigate the current status and composition of fauna species in different land use types in Oban with a view to prescribing sustainable biodiversity management strategies.

2. Materials and methods

2.1. Study area

The study was conducted study in Oban Division of Cross River National Park (CRNP) in the south-eastern corner of Nigeria identify as a Biodiversity hotspot (Myer, 2006). Oban sector is the largest remaining tropical rainforest ecosystem under protected area in Nigeria (3000km^2). It is contiguous with the Korup National Park (Ikyaagba *et al.,* 2015) Western Cameroon, spanning two ranges of east and west. The topography ranges from humid lowland forest to costal mangrove at the sea level in the eastern part of the park (Bisong and Mfon, 2006). It home to sixteen primate species including threatened species like Drill and Chimpanzee (Reid, 1989; Schmitt, 1996; Oates, 2009). The terrain is rugged and elevation rises from the river valleys to over 1,000 m in mountainous areas (Jimoh *et al.,* 2012a&b). The area has a raining season of at least nine months (March-November) and receives between 2500-3500mm of precipitation annually (Oates *et al.,* 2004; Jimoh *et al.,* 2012a&b) annual temperatures are between 22º to 32ºC (Oates et al., 2004; Bisong and Mfon, 2006). The area is known to housed over 1303 plant species, 141 lichens, and 56 species of mosses, 17 of these species area endemic to Nigeria (Schmit, 1996; Ikyaagba *et al.,* 2015). Oban Sector is also home to a high diversity of wildlife, including 134

mammals, 318 birds, 42 snakes and over 1266 species of butterflies ((Schmit, 1996) Western lowland Gorrila, drill and other species listed in CITES with Endangered to Critical on IUCN conservation status are also found in the area.

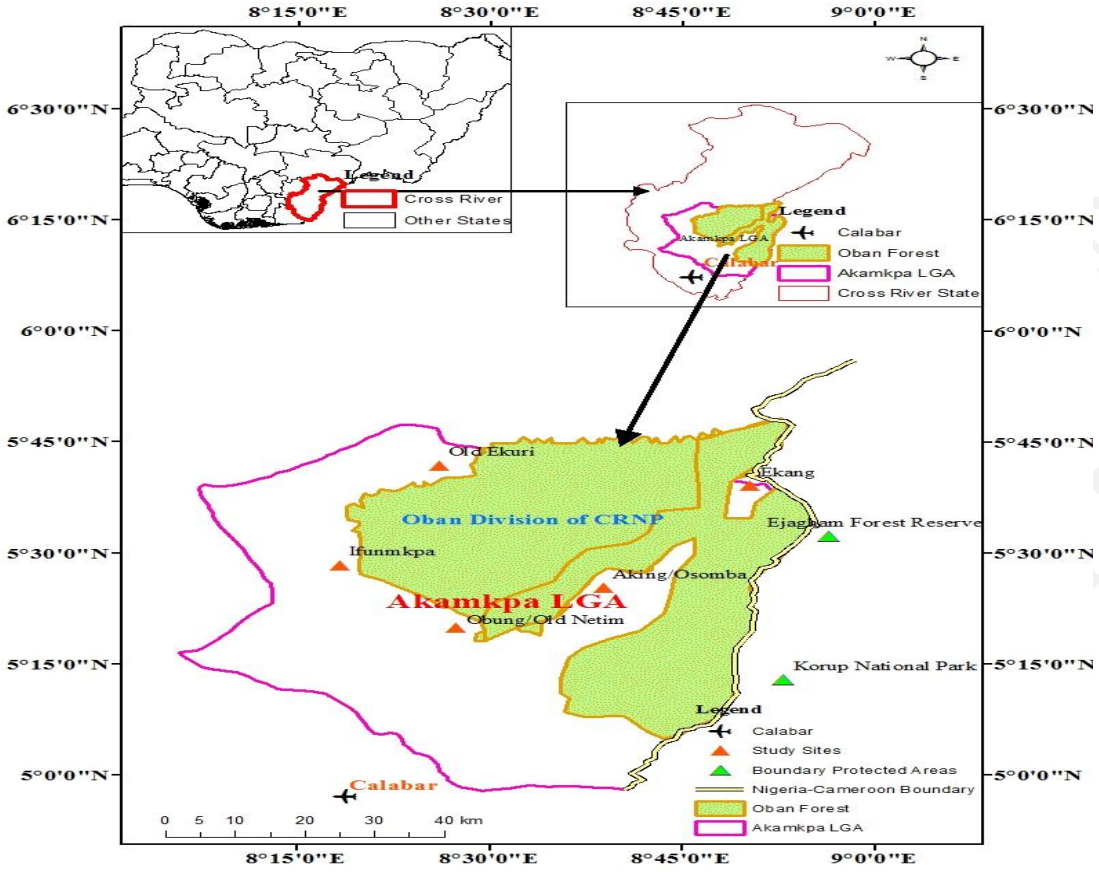

Figure 1. Map of Cross River National Park Showing the Study Locations.

2.3. Data collection

The study area was divided into four land use types using stratified sampling technique. Counts of mammals were made along forty line transects with equal length of 2-km with 10 transects in each of the land use type as described by (Jimoh *et al.*, 2012). These transects passed in a north-south direction and were spaced 2km apart from each other in all the habitat types, the location of the transects were done as described by (Buckland et al., 1993).

The line transects were conducted by a team of experienced observers. For each observation, the time, species, number of individuals, habitats, perpendicular distance and sighting distance were recorded. we measured perpendicular distance from the nearest of each animal at first sighting to the nearest metre from the line transect to the position of each detected animal using Nikon(c) rangefinder (Buckland *et al.*, 1993; Rovero and Marshall, 2004; Walter *et al.*, 2006). In order, reduce disturbance effects on mammals, transect were allowed to rest for minimum of 6-7 days before the commencement of census walks on each transect, also transect were allowed to rest for at least 4 days before revisiting previously walked transects. No survey was conducted on rainy days since that could introduce bias (Peres, 2000; Lannoy *et al.*, 2003). Census lines were walked, beginning at 0700 to 1200 hours morning and 19:00 and 21:00 hours for evening survey. The transects were walked at a speed of 1–1.5 km/h (Plumptre, 2000) depending on the topography

2.4. Data Analysis

Data for 48months animal census were compiled and subject data to analysis using Past to estimates species diversity, Species richness and Species evenness (Spellerberg (199; Turyahabwe and Tweheyo, 2010).

Shannon- wiener diversity index equation is stated as:

$$H' = -\sum_{i=1}^{s} p_i \ln p_i$$

Where H′ = species diversity index, pi = the proportion of individuals or the abundance of the ith species expressed as a proportion of the total abundance. The use of natural logs is usual because this gives information in binary digits.

Species richness was computed using Margalef (1951) as cited by Spellerberg (1991) and Magurran (2004) as followed:

$$D = \frac{(S-1)}{\ln N}$$

Where, D = species richness index (Margalef index), S = number of species and N = the total number of individuals.

Species evenness was estimated using Pielou's evenness (equitability) index (Pielou, 1975) as cited by Turyahabwe and Tweheyo (2010) as followed:

$$J' = \frac{H'(observed)}{H_{max}}$$

J′ = Pielou's evenness index. Where H′ (observed) / H_{max}, where H_{max} is the maximum possible diversity, which would be achieved if all species were equally abundant (=Log S)

Animal Density and Abundance

Data from the animal survey were pooled and analysed separately for core, buffer, plantation and farm fallow surveys. Population density and abundance were estimated for each land use type using the formula below:

$$D = \frac{E(n).f(0)}{2L} objects / km$$

Where D =density, n= number of individuals detected, f (0) = detection function, E= perpendicular distance L= length of transect L=length of the transect (Buckland *et al.*, 1993)

One-way ANOVA was used to test for significance of differences between these species composition across land use type.

$$Y_{ij} = \mu + T_i + e_{ij}$$

Where μ = general mean

T = Treatment effect

e_{ij} = experimental error.

3. Results

A total of 1,560 individual sightings were recorded for 37 species in 22 families. Thirty six percent 36% representing 29 of the fauna species in 16 families were recorded in the core, 30% (24) in 16 families were recorded in the buffer, while plantation recorded the least with 11 species representing 13% in 7 families (Table 1). Eight hundred and sixty-eight (868) representing 55% of the sighted individual were made in the core, while only 48 representing 3% of the sighted individual were made in the plantation (Table 1). The highest density of 69.8 individuals per km^2 and abundance of 0.1440E+06 individuals were recorded in the core of the park. The least density and abundance for fauna species were recorded in the plantation 8.3 individuals per km^2 and 2,321.0 individuals respectively. The Mean detection rate with standard error of vertebrates family, indicates that only 4 families were recorded in alll the land use types (Fig.1)

Twenty-six (70.27%) species were found in both core and butter zone of the park, while the remaining eleven (30%) occurred in farm-fallow and plantation outside the park area. A total of 29, 24, 17 and 11 species were encountered in Core, Buffer, Farm-fallow and Plantation (Table 1) respectively. Similarly, buffer and core zone recorded eight family each while farm fallow recorded ten family and seven family recorded in plantation respectively (Table 1)

Table 1. Fauna species composition across land use types in Oban division of CRNP

Variables	Core	Buffer	Farm fallow	Plantation
Species	29 (36%)	24 (30%)	17 (21%)	11 (13%)
Families	16 (80%)	16(80%)	10 (40%)	7 (35%)
Individuals	868 (55%)	519 (33%)	136 (9%)	48 (3%)
Density/ km^2	69.8	64.8	25.7	8.3
Abundance	0.1440E+06	23,726	3,591.0	2,321.0

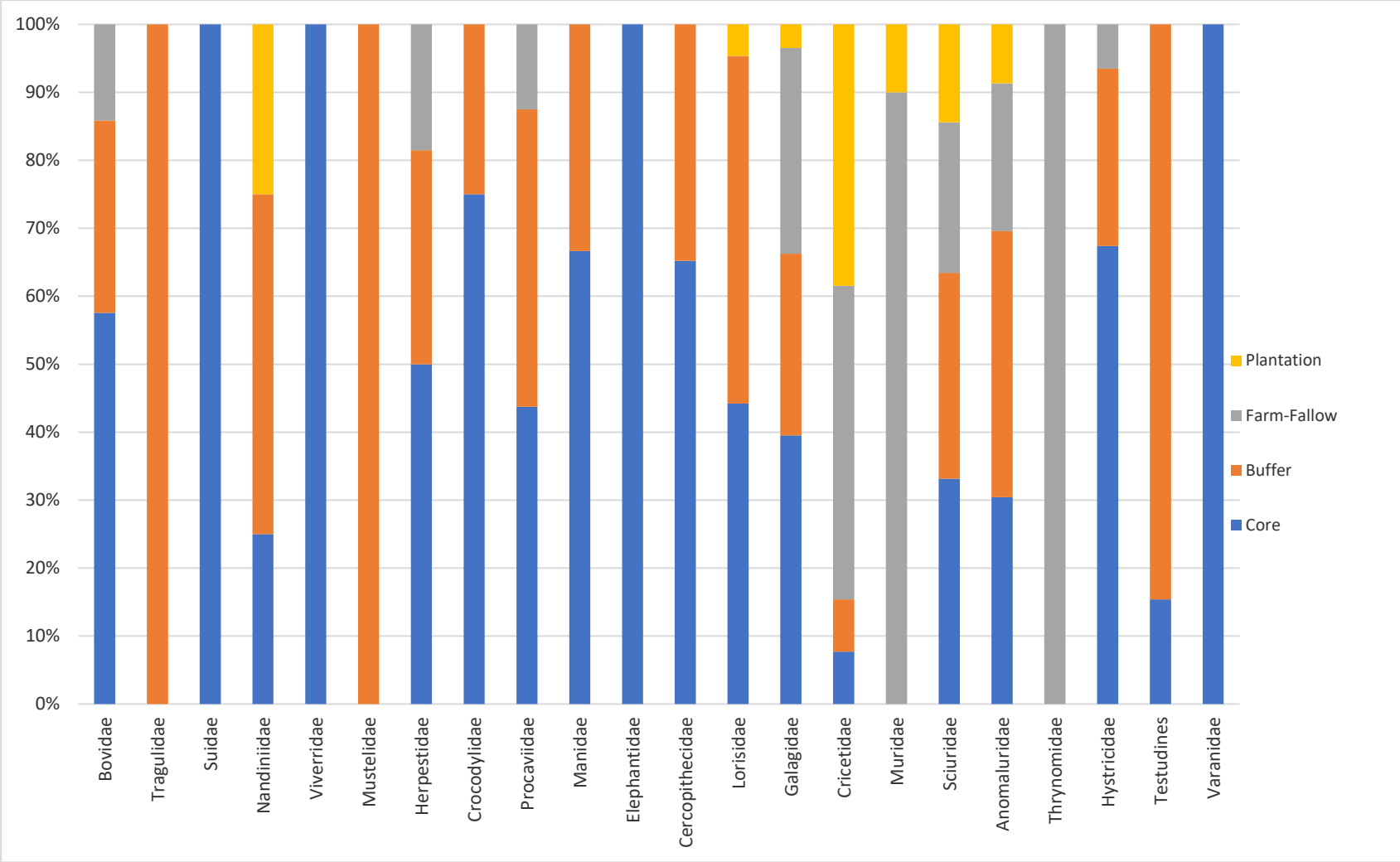

Figure 2: Mean detection rate with standard error of vertebrates family in the core, buffer, farm-fallow and Planatation in Oban sector of CRNP between 2010 and 2015.

Thirty-seven terrestrial mammals species representing 22 families within ten orders were recorded, of which 10 (27%) are listed as listed as threatened by the IUCN. Threatened species include three Endangered (EN) mammal (2.7% Drill: *Mandrillus leucophaeus*; 5.4% Giant Ground Pangolin: *Smutsia gigantea and* White-bellied Pangolin: *Phataginus tricuspis*), three Vulnerable mammal species (2.7%, Redcapped Mangabey*: Cercocebus torquatus, 2.7%* African Forest elephant*: Loxodonta cycloti;* African Dwarf Crocodile: *Osteolaemus tetraspis; 2.7%%,* African Spurred Tortoise: *Centrochelys sulcate 2.7%*) and three Near Threatened (%;Calabar Angwantibo: *2.7%%, Arctocebus calabarensis,* 2.7%%, Puttynose Monkey: *Cercopithecus nictitans* and 2.7%% Cape Clawless Otter: *Aonyx capensis*) species. The remaining (63%) mammals species comprised of Least Concern (LC) (Table 2). Rodentia were the most diverse group, represented by 11 species (29.7%). There were seven (18.9%) Primates species, five (13.5%) Carnivores, Two (5.4%) Pholdita species, five (13.5%) Cetartiodactyla species, One (2.7%) Squamata species, One (2.7%) Reptilia, one (2.7%) Proboscidae, one (2.7%) Hyracoidea, one (2.7%) Crocodylia. In term of trophic categories, there were 18 (48.65%) Herbivores, nine (24.32%) carnivores, eight (21.62%) Omnivore, and two (5.40%) Insectivore species (Table 2)

Table 2. Synopsis of mammal species sighted in different land use types in Oban Division of CRNP from 2011 to 2013, and their current conservation status as per International Union for Conservation of Nature (IUCN) red list criteria (CR = Critically Endangered; EN = Endangered; VU = Vulnerable; NT = Near Threatened and LC = Least Concerned)

								Species Relative abundance				
Order	**Family**	**Scientific name**	**Common name**	**IUCN**	**Tropic**	**Size**	**N**	**C**	**B**	**FF**	**P**	Overall Occurrence (%)
Cetartiodactyla	Bovidae	*Cephalophus monticola*	Blue duiker	*LC*	H	M	87	50	24	13	0	5.25
Cetartiodactyla	Bovidae	*Cephalophus ogilbyi*	Ogilby's duiker	*LC*	H	M	15	8	5	0	2	0.90
Cetartiodactyla	Bovidae	*Tragelaphus scriptus*	Bush Buck	*LC*	H	L	6	3	1	2	0	0.36
Cetartiodactyla	Tragulidae	*Hyemoschus aquaticus*	Water chevrotain	*LC*	H	M	1	0	1	0	0	0.06
Cetartiodactyla	Suidae	*Potamochoerus porcus*	Red River Hog	*LC*	H	L	2	2	0	0	0	0.12
Carnivora	Nandiniidae	*Nandinia binotata*	African Palm civet	*LC*	C	M	4	1	2	0	1	0.24
Carnivora	Viverridae	*Genetta genetta*	Common genet	*LC*	C	M	1	1	0	0	0	0.06
Canivora	Mustelidae	*Aonyx capensis*	Cape-Clawless Otter	*NT*	C	M	1	0	1	0	0	0.06
Canivora	Herpestidae	*Herpestes ichneumon*	Egyptian mongoose	*LC*	C	S	3	0	0	3	0	0.18
Canivora	Herpestidae	*Crossarchus obscurus*	Common Cusimanse mongoose	*LC*	C	S	51	27	17	7	0	3.08
Crocodylia	Crocodylidae	*Osteolaemus tetraspis*	African Dwarf Crocodile	*VU*	C	M	4	3	1	0	0	0.24
Hyracoidea	Procaviidae	*Dendrohyrax dorsalis*	Western Tree hyrax	*LC*	C	S	16	7	7	2		0.97
Pholidota	Manidae	*Phataginus tricuspis*	White-bellied Pangolin	*EN*	C	M	1	1	0	0	0	0.06
Pholidota	Manidae	*Smutsia gigantea*	Giant Ground Pangolin	*EN*	C	M	5	3	2	0	0	0.30
Proboscidea	Elephantidae	*Loxodonta cyclotis*	Forest elephant	*VU*	H	L	18	18	0	0	0	1.08
Primates	Cercopithecidae	*Cercopithecus mona*	Mona Monkey	*LC*	O	M	674	391	283	0	0	39.02
Primates	Cercopithecidae	*Cercopithecus nictitans*	Puttynose Monkey	*NT*	O	M	172	152	20	0	0	10.37

Primates	Cercopithecidae	*Cercopithecus ascanius*	Red tail Monkey	*LC*	O	M	12	12	0	0	0	0.72
Primates	Cercopithecidae	*Cercocebus torquatus*	Redcapped Mangabey	*VU*	O	M	10	10	0	0	0	0.60
Primates	Cercopithecidae	*Mandrillus leucophaeus*	Drill	*EN*	O	L	3	3	0	0	0	0.18
Primates	Lorisidae	*Arctocebus calabarensis*	Calabar Angwantibo	*NT*	O	M	43	19	22	0	2	2.59
Primates	Galagidae	*Galagoides demidoff*	Demidoff's Dwarf Galago	*LC*	O	M	86	34	23	26	3	5.19
Rodentia	Cricetidae	*Cricetomys gambianus*	Giant rat	*LC*	H	S	13	1	1	6	5	0.78
Rodentia	Muridae	*Rattus rattus*	black rat	*LC*	H	S	8	0	0	7	1	0.48
Rodentia	Muridae	*Lemniscomys striatus*	Typical striped grass moused	*LC*	H	S	2	0	0	2	0	0.12
Rodentia	Sciuridae	*Heliosciurus rufobrachium*	Red Legged Squirrel	*LC*	H	S	51	14	18	11	8	3.07
Rodentia	Sciuridae	*Funisciurus anerythrus*	Redless Trees Squirrel	*LC*	H	S	104	40	30	18	16	6.27
Rodentia	Sciuridae	*Xerus erythropus*	Ground Squirrel	*LC*	H	S	10	0	0	8	2	0.60
Rodentia	Sciuridae	*Protoxerus stangeri*	Giant Forest Squirrel	*LC*	H	S	40	15	12	9	4	2.41
Rodentia	Sciuridae	*Paraxerus poensis*	Green Bush squirrel	*LC*	H	S	3	0	3	0	0	0.18
Rodentia	Anomaluridae	*Anomalurus derbianus*	Lord Derby's Scaly-tailed Squirrel	*LC*	H	S	46	14	18	10	4	2.77
Rodentia	Thrynomidae	*Thryonomy's swinderianus*	Grass cutter/Cane rat	*LC*	H	M	8	0	0	8	0	0.48
Rodentia	Hystricidae	*Atherurus africanus*	African Brush-tailed Porcupine	*LC*	H	M	46	31	12	3	0	2.77
Reptilia	Testudines	*Centrochelys sulcata*	African Spurred Tortoise	*VU*	H	S	13	2	11	0	0	0.78
Squamata	Varanidae	*Varanus niloticus ornatus*	Monitor Lizard	*LC*	C	M	1	1	0	0	0	0.06
							1668	904	548	154	52	

C= core, B=buffer, FF= farm fallow and P= plantation

Fauna Species Richness and Diversity

The core of the park had the highest fauna species richness (D=4.138). This was followed by the buffer (D=3.674). Analysis of Fauna species evenness and species diversity revealed that, farm fallow had the highest values (J′= 0.7536) and (H′= 2.55) respectively and was followed by plantation for species evenness (J′= 0.7037) and core for species diversity (H′= 2.063) (Table 3).

Table 3: Fauna Species Diversity Indices Across Land Use Types in Oban Division of CRNP

Stratum	Diversity index (H′)	Speceies evenness (J′)	Species richness (D)
Core	2.063	0.2714	4.138
Buffer	1.93	0.287	3.674
farm fallow	2.55	0.7536	3.257
Plantation	2.046	0.7037	2.583

Note: H′= diversity index, J′= species eveness, D= species richness,

One-way analysis of variance for fauna species composition across the land uses types for fauna at p≤0.05 reveals that there were significant differences in the composition of fauna species across land use types in the area (Table 4 and 5).

Table 4: One –way Analysis of Variance for Fauna Composition Across Land Use Types in Oban Division of CRNP

	SS	Df	MS	F	P
Between groups:	5.0473	3	1.68243	7.662	8.704E-05**
Within groups:	31.6216	144	0.219595		
Total:	36.6689	147			

** Significant at 0.05%

Table 5: Tukey's Pairwise Comparisons for Fauna: p>0.05

	Core	Buffer	Farm fallow	Plantation
Core		0.6011 ns	0.01544**	5.355E-05**
Buffer	0.6011 ns		0.3047ns	0.006912**
Farm fallow	0.01544**	0.3047ns		0.4445 ns
Plantation	5.355E-05**	0.006912**	0.4445 ns	

** ** Significant at 0.05%

ns not significant at 0.05%

4. Discussion

Fauna Composition and diversity

The study indicates that, the core of the park was a better habitat for fauna species as majority of the animals were only found there. The similarity in species richness level between the core and buffer zones in this study is consistent with the result of Barlow et al. (2007). The decrease in species richness from core to plantation revealed the effect of other land uses such as arable farm and plantation on animal composition and distribution; similar patterns were documented by other studies (Barlow et al., 2007; Fitzherbert et al., 2008; Wanger et al., 2009).

This suggests that vertebrate (particularly large mammals) may react particularly adversely to monocultures, plantations (Fitzherbert et al., 2008; Persey and Anhar, 2010). This view is supported by a study in Sumatra which recorded only 10% of the medium to large mammal species present in other habitats that comes regularly into oil palm plantation (Maddox et al., 2007). The absence some species such as pangolins in plantation in this study agrees with Maddox et al. (2007).

The presence of more squirrels and rats in the plantation agreed with the reports that only least endangered species could thrive well in plantations (Maddox et al., 2007, Bernard et al., 2009, Ikyaagba *et al.,* 2017). Also, Poulsen *et al.,* (2013) submitted that when land use intensity increases, fauna composition gradually change from large mammals to small animals like squirrels and rats. Comparison of the composition of

fauna species across the land use types shows significant differences at p≤0.05. This further demonstrates negative impact of land use intensity on large and small mammals (Barlow *et al.,* 2007). The records of elephants, an endangered species, in this study suggest that the area still hold some species of serious conservation concern.

Density and Abundance of Fauna Species

The abundance and density varied considerably across land use types, except for core and buffer. This agrees with the observation of Lwanga (2006) and Remis and Kpanou (2010). This is the demonstration of the effect of land use on the population of large and small animals which decreases with increasing human activities (Schulze *et al.,* 2004; Van Vliet and Nasi, 2008).

This further demonstrated the fact that human presence impact negatively on the fauna population, Blom *et al.,* (2004) found that population of monkey species in the Dzanga –Sangha National Park in Central African Republic tends to increase with increasing distance from the Village of Bayanga as human pressure reduces. Similarly, Van Vliet and Nasi (2008) submitted that some of the most hunted species for consumption by local people occur mainly far from areas with significant human activities. This explains why the study recorded 29 fauna species in the core and only 18 and 11 in farm fallow and plantation respectively

Conclusion and Implication for conservation

The results of the study suggest that, at least on a local scale, fauna richness was high along the core and buffer habitats respectively. This is an indication that rainforest habitats in the region habour species rich assemblages. This was probably due to the conservation attention received by these habitats. However continue expansion of farm land and plantation in the area is making the area insecure with most of the species with large range under threat (Bergl *et al.,* 2006; Ikyaagba *et al.,*2017). The present of some threatened species like forest elephants, Cape-Clawless Otter, Calabar Angwantibo, Drill, Puttynose Monkey and others in the area has heighten the need to

improve on the monitoring and enforcement of conservation laws in the area.. Attention on core of the park does not in any way diminish the uniqueness and importance of other land use types (buffer, farmfallow and plantation) in the surrounding Oban Hills environment, but simply acknowledges that core of the park occupies the tiny fraction of the overall landscape compared with the farmfallow and buffer, these areas should also be given conservation attention. We recommend that continuous population monitoring of the park with high priority giving for the core of the park for possible detection of population change, this will help safeguard the area against hunting pressure and other forms of threats to continue existence the species rich area.

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Author Contribution

Conceived and designed the experiments: IET, AAA, OJK, UIJ. Performed the Fieldwork and experiments: IET, OJK. Analysed the data: IET, AAA. Contributed materials/analysis: IET, AAA, OJK, UIJ. Wrote and contributed to the manuscript: IET, AAA, OJK, UIJ

Reference

[1] Barlow, J., Mestre, L. A. M., Gardner, T. A. and Peres, C. A. 2007. The value of primary, secondary and plantation forests for Amazonian birds Biological Conservation doi:10.1016/j.biocon.2006.11.021

[2] Bergl, R. A, Oates, J. F. and Fotso, R. 2006. Distribution and protected area coverage of endemic taxa in West Africa's Biafran forests and highlands Biological Conservation13 4:1 9 5 –2 0 8

[3] Bernard, H., Fjeldså, J., and Mohamed, M. 2009. "A case study on the effects of disturbance and conversion of tropical lowland rainforest on the non-volant small mammals in north Borneo: Management implications." Mammal Study 34: 85-96.

[4] Bisong, F. E and Mfon, P. Jnr. 2006. Effect of logging on stand damage in rainforest of sourth- eastern Nigeria. West African Journal Applied Ecology. 10:119-12

[5] Blom, A., Van Zalinge, R., Mbea, E., Heitkonig, I. M. A. and Prins, H. H. T. 2004. Human impact on Wildlife population within a protected Central African forest African Journal Ecology. 42:23-3

[6] Buckland, S. T., Anderson, D. R., Burnham, K. P. and Laake, J. L. 1993. Distance Sampling: Estimating Abundance of Biological Populations. London: Chapman and Hall;1-90pp

[7] Eniang, E. A., Eniang, M. E. and. Akpan, C. E. 2008. Bush meat trading in the Oban Hills Region of South- Eastern Nigeria: Implication for sustainable Livelihoods and Conservation. Ethiopian Journal of environmental studies and management 1.1:70-83.

[8] Ezebilo, E. E. and Mattsson, L. 2010b. Socio-economic benefits of Protected area as perceived by local people around Cross River National Park, Nigeria. Forest Policy and Economic 12: 189-193

[9] Fa, J. E., Seymour, S., Dupain, J., Amin, R., Albrechtsen, L. and Macdonald, D. 2006. Getting to grips with the magnitude of exploitation: Bushmeat in the Cross-Sanaga river region, Nigeria and Cameroon. Biological Conservation 129: 497-510.

[10] Fitzherbert, E. B., Struebig, M. J., Morel, A., Danielsen, F., Bruhl,C.A., Donald, P.F. and Phalan, B. 2008. "How will oil palm expansion affect biodiversity?." Trends in Ecology and Evolution 23: 538-45

[11] Gardner, T. A., Barlow, J., Chazdon, R., Ewers, R. M., Harvey, C. A., Peres, C. A., Sodhi, N. S. 2009. Prospects for tropical forest biodiversity in a human-modified world. Ecology Letters 12: 561–582.

[12] Gillespie, T. W., Brock, J. and Wright, C. W. 2004. Prospects for quantifying structure, floristic composition and species richness of tropical forests. International Journal Remote Sensing 25.4: 707–715.

[13] Ikyaagba, E.T. Jimoh, S. O, and Amonum, J. I. 2015. Effect of Land use Changes on Flora Diversity in Oban Division of Cross River National Park Nigeria. Ghana Journal of Forestry Vol. 31:62-77

[14] Ikyaagba, E.T., Jimoh, S.O, Dagba, B.I., Tee, T. N., Ancha, P. U. and Tume, C. 2017. Oil Palm Plantation Development: An Emerging Threat to Biodiversity Conservation in Oban Division of Cross River National Park, Nigeria. Journal of Agricultural and Forestry 4(5):5-11

[15] Jimoh,S.O., Ikyaagba, E.T., Aralape,A. A., Adeyemi, A. A. and Waltert, M. 2012a. Local depletion of two larger Duikers in the Oban Hills Region, Nigeria Afr. J. Ecol. 51, 228–234

[16] Jimoh, S.O., Adesoye, P.O., Adeyemi, A.A and Ikyaagba ,E.T**.** 2012b. Forest Structure Analysis in the Oban Division of Cross River National Park, Nigeria. Journal of Agricultural Science and Technology B 2.5:510-519

[17] Kingdon. J, Lahm, S.A. 2013. Cephalophus silvicvultor Yellow-backed Duiker. In: Kingdon J, Hoffmann M (eds) The mammals of Africa. Vol VI (Hippopotamuses, pigs, deer, giraffe and bovids). Bloomsbury Publishing, London, pp 288, 680 pp–293

[18] Lannoy, L., Gaidet, N., Chardonnet, P. and Fangouinoveny, M. 2003. Abundance estimates of duikers through direct counts in a rainforest, Gabon. African Journal of Ecology 41:108–110.

[19] Lwanga, J. S. 2006. The influence of forest variation and possible effects of poaching on duiker abundance at Ngogo, Kibale National Park, Uganda. African. Journal. of Ecology, 44: 209–218.

[20] Maddox, T., Priatna, D., Gemita, E. and Salampessy, A. 2007. "The conservation of tigers and other wildlife in oil palm plantations, Jambi Province, Sumatra, Indonesia (October 2007)." ZSL Conservation Report 7: 1-62.

[21] Myers, N., Mittermeier, R. A., Mittermeier, C. G., Da Fonseca, G. A. B. and Kent, J., 2000. Biodiversity hotspots for conservation priorities. Nature 403: 853–858.

[22] Norris, K., Asase, A., Collen, B., Gockowksi, J., Mason, J., Phalan, B. and Wade, A. 2010. Biodiversity in a forest-agriculture mosaic – The changing face of West African rainforests. Biological Conservation143:2341-2350

[23] Oates, J. F., Bergl, R. A. and Linder, J. M., 2004. Africa's Gulf of Guinea Forests: Biodiversity Patterns and Conservation Priorities: Advances in Applied Biodiversity Science, number 6. Conservation International, Washington D.C.

[24] Ogar, D, Agbor, C, Eyamba, F and Adeleke, W. 2005. The Significance of Bush-meat and Timber trade in Local and State Economies of Cross River State. SPACE Study Report – 3rd Draft.

[25] Oguntala, A. B, Soladoye, M. O and Ugbogu, O. A. 2000. Endangered trees species of Nigeria. Nigerian journal of forestry 30.(1and 2): 15-21.

[26] Onadeko, A. 2006. An amphibian survey of the Oban hill division of cross river National park, NCF- WCS Biodiversity research programme. 1-23pp

[27] Peres, C. A 2000. Effects of subsistence hunting on vertebrate community structure in Amazonian forest; Conservation. Biology. 14.1: 240-253.

[28] Peryes, S. and Anhar, S. 2010.Biodiversity Information for Oil Palm International Conference on Oil Palm and Environment 2010, Bali, INDONESIA

[29] Plumptre, A. 1994. The effects of long-term selective logging on blue duikers in the Budongo Forest Reserve. Gnusletter 13: 15-16.

[30] Poulsen, J. R., Clark, J. and Palmer, T. M. 2013. Ecological erosion of an Afrotropical forest and potential consequences for tree recruitment and forest biomass Biological conservation 163:122-130

[31] Reid, J.C. 1989. Flora and Fauna Richness of the Oban Division of the CRNP. Appendix 7 CRNP (Oban Division) Plan for Developing the Park and its Support Zone, WWF, Gland Switzerland

[32] Remis, M. J. and Kpanou, J. B. 2010. Primate and Ungulate abundance in response to multi-use zoning and human extractive activities in a central African reserve. African Journal Ecology. 40 (1): 70-80.

[33] Richards, P. W. 1996. The Tropical Rainforest. Cambridge: Cambridge University

[34] Schmit, K. 1996. Botanical survey in the Oban Division of CRNP –Technical Report on Oban Hill progamm Calabar 1-55pp

[35] Schulze. C. H., Waltert, M., Keßler, P. J. A., Pitopang, R., Shahabudd, Veddeler, D., Mu¨hlenberg M., Gradstein, S. R., Leuschner, C., Steffan-Dewenter, I. and Tscharntke, T. 2004. Biodiversity indicator groups of tropical land-use systems: comparing plants, birds and insects. Ecological Applications 14: 1321–1333.

[36] Spellerberg, I. F. 1991. Monitoring Ecological Change. New York USA, Cambridge University.112-140pp

[37] Turyahabwe, N. and Tweheyo, M. 2010. Does Forest tenure influence forest vegetation characteristic? A comparative analysis of private, local and central government forest; International Forestry Review 12(4):320-338

[38] Van vliet, N. and Nasi, R. 2008. Mammal distribution in a Central African logging Concession area. Biodiversity Conservation 17: 1241-1249

[39] Walter, M., Heber, S., Riedelbauch, S., Lien, J. L. and Muhlenberg, M. 2006. Estimates of blue Duiker (Cephalophus monticola) densities from diurnal and nocturnal line transects in the Korup region, south-western Cameroon. Afr. J. Ecol., 44, 290–292.