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Evaluation of the Ecological Impact of Human Settlement on Trees in Oban and Okwangwo Forests of Cross River National Park, Nigeria

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Authors' contributions

This work was carried out in collaboration among all authors. Author OIO designed the study, also performed the statistical analysis and wrote the first draft of the manuscript. Author CUA wrote the protocol and managed the literature searches. Author CCI managed the analyses of the study. Author JOO performed the statistical analysis. Author AAA also managed the literature searches. All authors read and approved the final manuscript.

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ABSTRACT

The ecological impacts of human settlement on trees in Oban and Okwangwo Forests of Cross River National Park located in Nigeria was carried out in the park with the view of providing information on the activities of the support zones and enclave communities in both (Oban and Okwangwo) divisions of the park. Surveillance tours were carried out in company of the park rangers in the park and enclave communities. Each division was divided into two (2) zones each (core and peripheral) for ease of coverage. Plots were randomly selected in each study site at regular number of paces (fixed interval) to avoid coincidence.

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Data collections and observations were carried out for a period of four (4) months in both divisions. Random Sampling method was used for the study. Eight (8) plots of size $50\,\mathrm{m} \times 50\,\mathrm{m}$ each were marked out using wooden pegs with red ribbon tied across the pegs in the core zones in both divisions (Oban and okwangwo). Same was applicable to the peripheral zones in both divisions giving a total number of 32 plots. The total number of trees per plot was determined by direct stem count and trees with 30 cm girth and above was considered for the count. The total number of trees counted in the core zones was (Oban 141 and Okwangwo 162) and the peripheral zones (Oban 120 and Okwangwo 127). Descriptive statistics was applied on the data to determine the mean, standard deviation and range. The T-test for tree counted in Oban (Table 3) reveals that $T_{cal}(1.161) \leq T_{tab}(2.365)$ and the difference had a mean of 3.875, $T_{Cal} \leq T_{tab}$ at 5% level of significance. The T-test for tree counts in Okwangwo (Table 6) shows that $T_{cal}(3.040) \geq T_{tab}(2.365)$, $T_{Cal} \geq T_{tab}$ at 5% level of significance. F-statistics (Table 8) revealed a significance level in their differences, F_{tab} ($p=0.05$) df (7,7) = 3.79, F_{Cal} = 5.384.
This calls for fast action on the resettlement of the enclave communities and provision of alternative sources of income for the support zones and enclave communities. Strategies should be adopted and improved upon if biodiversity is to be conserved. These strategies are embedded in increasing staff strength, well equipped and dedicated rangers as well as the absence of surrounding enclave communities.

Keywords: Forest; ecological impacts; human settlement; deforestation.

1. INTRODUCTION

Human settlements are recognized as ecosystems because they are habitat systems for human populations which may be directly comparable with natural ecosystems [1]. Humans are adjudged to be the principal drivers of change on the earth's surface. Such impact may shape the earth in small subtle ways and sometimes in big catastrophic ways. The biodiversity of forest ecosystem are damaged and has been degraded including other ecosystems [1]. Encroachment causes degradation because it disrupts provisioning services and leads to biodiversity loss [2,3]. Man has consciously or unconsciously destroyed with utmost impunity the environment that provides his food, drug, clothing and other essential needs [4].

Ecosystems become degraded when anthropogenic factors adversely affect ecosystem health, functions and services [3]. Encroachment causes degradation because it disrupts provisioning services and leads to biodiversity loss [2,3]. In these systems, hunting, fragmentation and disturbance cause species losses, and selective logging or land conversion for agriculture depletes carbon stocks, effects which clearly degrade the natural value of forests [3]. The major threats to biodiversity that result from human activity is habitat destruction, habitat fragmentation, habitat degradation, overexploitation of species for human use [5].

Deforestation alters the composition, configuration and connectivity of the landscape which results not only in the outright loss of species but can also lead to genetic bottleneck, increased genetic drift and inbreeding depression, which can ultimately result in a loss of genetic variation and increased genetic differentiation between remnant population [6,7]. High rate of forest loss and degradation are on increase as a result of over exploitation, conversion of forest to other land uses, growing demand for food and introduction of plantation agriculture which requires very large expense of land [8,9,7].

According to [10], effective timber mining prevails in many forest areas of global conservation importance. The direct causes of forest depletion include economic policies, rising demand for forest products, poor law enforcement and weak laws [11]. Factors such as rapid urbanization, developmental projects, poaching and ivory, over exploitation of natural resources (fish, game, forest etc), ignorance [7], increased demands for trade in timber and non-timber species have collectively increased deforestation and biodiversity loss in various parts of the country [12,4,7]. The timber cut are not replaced hence sustained yield of the forest cannot be attained [12,4]. These vital resources are threatened by increased population pressure and intensified by human development activities [4].

In establishment of small or large protected areas which are set aside exclusively for wild life,

human activities like timber harvesting, fire wood collection, hunting etc. are restricted so that wild plants and animals could grow and multiply in a natural but protected environment [13]. Forest have been subjected to various human pressures generated by human activities in agriculture, construction of hydroelectric projects, raising monoculture plantations, logging and a host of other developmental projects. These activities have led to a steady depletion of forest areas [14,15]. Livelihood analysis in park-edge communities have also revealed that wide variation exist in socio economic status among the local communities such that poorer households engage in activities such as illegal resources use and extraction while usually households are less dependent on forest resources [16,17]. Degradation therefore arises from somewhat different processes, and is marked by different indicators to those used for forests [18,3].

Ijeomah and Ogbara [19], stated that wildlife management is facing several challenges which shown up informs of encroachment into wildlife habitats through hunting, fishing, grazing, collection of non-timber forest products (NTFPs), logging, seed collection and mining that results in habitat degradation and species migration. It is estimated that in Nigeria, there are more than 4600 plants of which about 205 are endemic that is they cannot be found elsewhere, [4]. [5] pointed out that conservation of biodiversity and its use in sustainable development have been impeded by many obstacles. The need to mainstream the conservation and sustainable use of biological resources across all sectors of the national economy, the society and the policy-making framework is a complex challenge at the heart of the Convention on Biological Diversity (CBD).

Cross River National Park (CRNP) has one of the oldest rainforests in Africa with a total land area of about 4,000 km^2 and has been identified as a biodiversity hot spot [20,21]. Hunting, farming, illegal logging and collection of non-timber products are the major problems park [16,22].

Deforestation and high rate of forest loss are on the increase due to the growing human population. There is need for conservation and protection of the natural ecosystems to ensure the continuous existence of biodiversity for human benefit. Identifying the impacts and the extent of damage on forest trees (forest resources) will help the Government to implement control measures. A better understanding of the impact on protected areas will provide information on the future consequences. However research must be expanded and strengthened to improve our understanding of biodiversity and its potential role in building sustainable human societies. At this stage we need to understand more about how, why and where human activities bring about long-term changes in biodiversity and the environment, in order to provide accurate information to decision makers. This study therefore aims at evaluating the activities of the enclave and border communities on the park. The result could help in understanding the effect of the human activities.

2. MATERIALS AND METHODS

2.1 Study Area

The Cross River National Park (CRNP) is located in Cross River State, Nigeria and contiguous to both the Korup and Takamanda National Parks, in Cameroun and it covers a total area of about 4,000 km^2. The Park was established in 1991 from the erstwhile Oban group forest and Okwangwo Reserve, Boshi and Boshi extension. The Cross River National Park is divided into two (2) divisions (Oban and Okwangwo). The Oban Division is 3,000 km^2 in area, centered on coordinates 5°25′0″N 8°35′0″E. The division shares a long border with Korup National Park in the Republic of Cameroon, forming a single protected ecological zone and has a rugged terrain, rising from 100 m in the river valleys to over 1,000 m in the mountains. The Okwangwo division is centered on coordinates 6°17′00″N 9°14′00″E. It is made up of the former Boshi, Okwangwo and Boshi Extension Forest Reserves. The division has an area of about 640 km^2 and shares a border with the Takamanda Forest Reserve in the Republic of Cameroon to the east. It is separated from the Oban division to the south by about 50 km of disturbed rainforest. The Park is border by different communities peopled mostly by the Ejagham, Dusanga-Iyong, Boki and Obanliku ethnic groups in Cross River State who are predominantly farmers with exciting illuminating cultural environment as amply expressed in their songs, dance, cuisine, crafts and dressing. The Park is reputed as Nigeria last great rain-forest, one of the oldest forests in Africa and part of the 25 biodiversity hot spots in the world. It is the richest part of Nigeria's biodiversity home to the famous Cross

River Gorilla (Gorilla gorilla diehli), *Prunus africana* plant and *Anceistocladus korupensis* plant reputed to have potency against prostate cancer and HIV/AIDS respectively and new varieties of butterflies are discovered recently in the park.

2.2 Sampling Techniques

Surveillance tours were carried out in company of the park rangers to the enclave communities, peripheral and core zones of the park.

Plots were randomly selected in each study site at regular number of paces (fixed interval) to avoid coincidence.

Eight (8) plots (of size 50 $\mathrm{m} \times 50\ \mathrm{m}$ each) were marked out using wooden pegs with rope and red ribbon tied across the pegs at the core zones of the park in both divisions (Oban and Okwangwo).

Another 8 (eight) plots (of size 50 m x 50 m each) were also marked out using wooden pegs with rope and red ribbon tied across the pegs at the peripheral zones in all sampling locations. This gave a total number of 32 plots.

The total number of trees per plot was determined by direct stem count and trees with 30 cm girth and above were considered for the count.

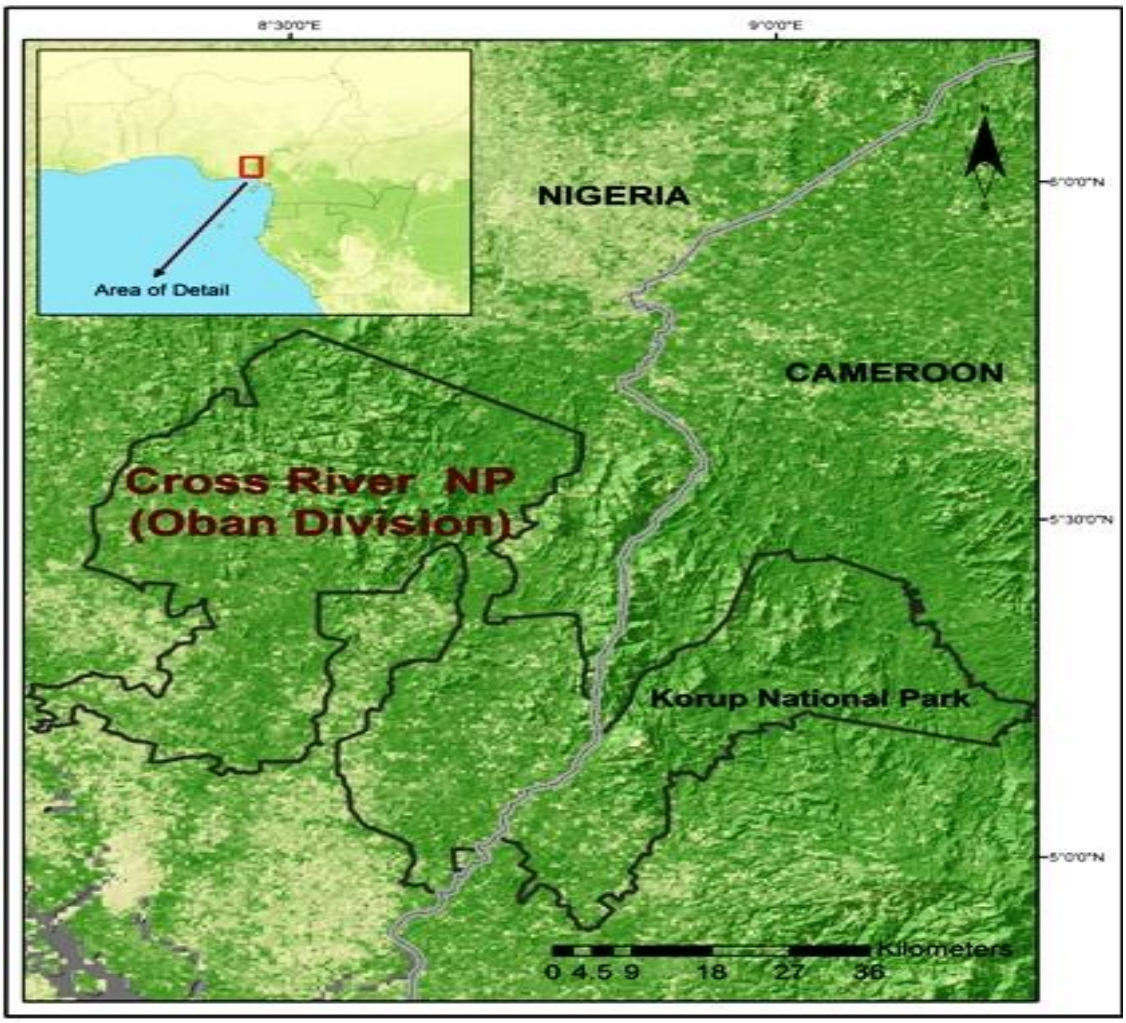


Fig. 1. Map showing the location of Cross River National Park (Oban division)
Source: Wildlife Conservation Society of Nigeria; http://www.wcsnigeria.org/portal/139/Maps/Map

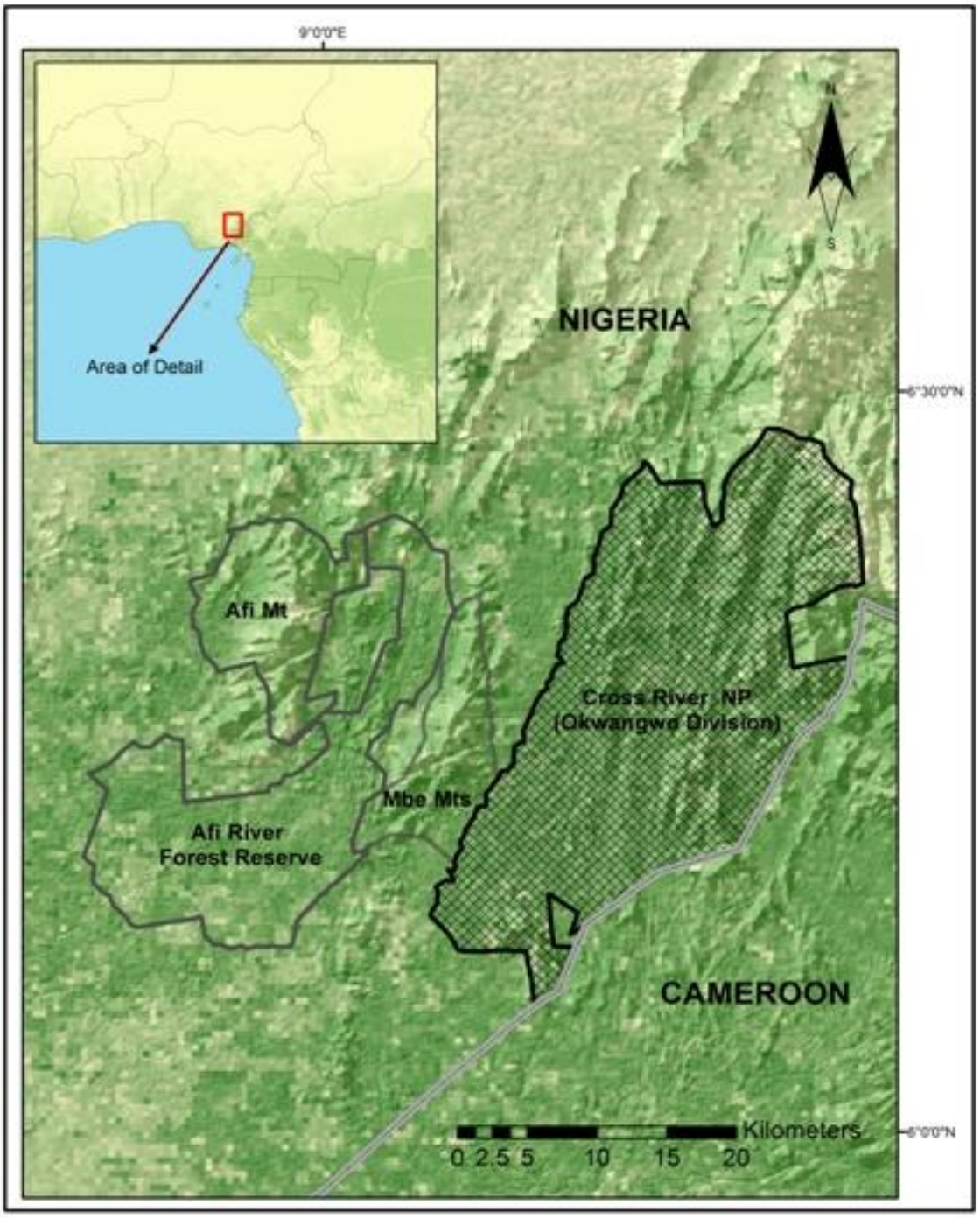


Fig. 2. Map showing the location of Cross River National Park (Okwangwo division)
Source: Wildlife Conservation Society of Nigeria; http://www.wcsnigeria.org/portal/139/Maps/Map

3. RESULTS AND DISCUSSION

Table 1 shows the tree counts of the core and peripheral zones in Oban division. It revealed that 8 (eight) plots of the core zone (CZ) had a total of 141 trees with plot 4 (four) having the highest number of 25 (twenty five) trees and plot 1 (one) had the lowest number of 10 (ten) trees. While the 8 (eight) plots of the peripheral zone (PZ) had a total of 120 trees lower than that of

the CZ, and plot 5(five) had the highest number of 20 (twenty) trees and plots 2 (two) and 3 (three) had the lowest numbers of 10 (eight) trees each.

Table 1. Tree count in Oban division

S/N	CZ	PZ
1	10	16
2	13	10
3	17	10
4	25	14
5	14	20
6	18	19
7	23	12
8	21	19
Total	**141**	**120**

Key: CZ = Core zone, PZ = Peripheral zone

Table 2 shows that the two zones of Oban had equal sample size, and the core zone (CZ) had mean 17.6250, standard deviation 5.18066 and range 15. While the peripheral (PZ) had mean 15.0000, standard deviation 4.10575 and range 10.

The T-test for tree counts in Oban (Table 3) shows that $T_{cal}(1.161) \leq T_{tab}(2.365)$ and the difference had a mean of 3.875. It shows that there is significance and the two zones did not give the same result.

The tree counts of the core and peripheral zones in Okwangwo division are displayed in Table 4. It revealed that 8 (eight) plots of the core zone (CZ) had a total of 162 trees with plot 4 (four) having the highest number of 24 (twenty four) trees and plots 5 (five) and 8 (eight) had the lowest number of 17 (seventeen) trees each. While the 8 (eight) plots of the peripheral zone (PZ) had a total of 127 trees lower than that of the CZ, with plot 4 (four) having the highest number of 20 (twenty) trees and plot 6 (six) had the lowest number of 8 (eight) trees. However, Table 5 shows that the two zones had equal sample size, and the CZ had mean value of 20.2500, standard deviation 2.49285 and range 7. While the PZ had mean value of 15.8750, standard deviation 3.94380 and range 13.

Table 2. Descriptive statistics tree count in Oban

	N	Mean	Std. deviation	Range	
				Minimum	Maximum
CZ	8	17.6250	5.18066	10.00	25.00
PC	8	15.0000	4.10575	10.00	20.00

Key: N = Sample size, CZ = Core zone, PZ = Peripheral zone

Table 3. T-test for tree count in Oban

S/N	CZ	PZ	D
1	10	16	-6
2	13	10	3
3	17	10	7
4	25	14	9
5	14	20	-6
6	18	19	-1
7	23	12	23
8	21	19	2
Total	**141**	**120**	**31**
Mean			**3.875**

Key: CZ = Core zone, PZ = Peripheral zone. D = Difference; T_{tab} (0.025) df (8-1) = 2.365, T_{Cal} = 1.161, $T_{Cal} \leq T_{tab}$ at 5% level of significance

The T-test for tree counts in Okwangwo (Table 6) shows that $T_{cal}(3.040) \geq T_{tab}(2.365)$ and the difference had a mean of 4.375. It shows that there is significance and the two zones do not give the same result.

Table 4. Tree counts in Okwangwo division

S/N	CZ	PZ
1	19	15
2	20	16
3	22	21
4	24	20
5	17	15
6	22	8
7	21	17
8	17	15
Total	**162**	**127**

Key: CZ = Core zone, PZ = Peripheral zone

Table 5. Descriptive statistics for tree count in Okwangwo division

	N	Mean	Std. deviation	Range	
				Minimum	Maximum
CZ	8	20.2500	2.49285	17.00	24.00
PZ	8	15.8750	3.94380	8.00	21.00

Key: N = Sample size, CZ = Core zone, PZ = Peripheral zone

Table 7 reveales that the calculated differences of plots in the core zone (CZ) and peripheral zone (PZ) of Oban (A) had a sum-up difference of 31 and while those of Okwangwo (B) had 35.

Table 8 shows that Oban has a variance of 89.125, while Okwangwo had 16.554. F-statistics revealed a significance level in their differences. $F_{cal}(5.384) \geq F_{tab}(3.7)$.

Table 6. T-Test for Tree Count in Okwangwo Division

S/N	CZ	PZ	D
1	19	15	4
2	20	16	4
3	22	21	1
4	24	20	4
5	17	15	2
6	22	8	14
7	21	17	4
8	17	15	2
Total	**162**	**127**	**35**
Mean			**4.375**

Key: CZ = Core zone, PZ = Peripheral zone. D = Difference; T_{tab} (0.025) df (8-1) = 2.365, T_{Cal} = 3.040; $T_{Cal} \geq T_{tab}$ with 5% level of significance

Table 7. Differences of Oban and Okwangwo core and peripheral zones

S/N	A	B
1	-6	4
2	3	4
3	7	1
4	9	4
5	-6	2
6	-1	14
7	23	4
8	2	2
Total	**31**	**35**

Key: A = Oban differences, B = Okwangwo differences, N=8

Table 8. F-test

	N	df	∑	SS	Range	Variance (S)
A	8	7	31	744	29	89.125
B	8	7	35	269	13	16.554

Key: A= Oban difference, B = Okwangwo difference, SS = Sum of squares, ∑ = summation $= \frac{Variance\ A}{Variance\ B}$; *$F_{tab}$ (p=0.05) df (7,7) = 3.79, F_{Cal} = 5.384*

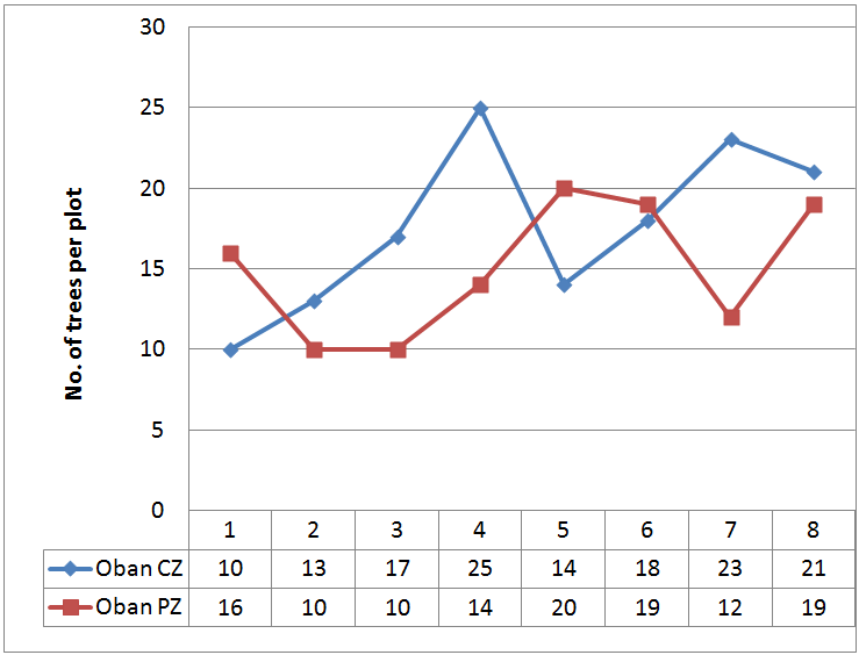


Fig. 3. Comparism of tree counts trees per plot in the core and peripheral zones in Oban

The tree counts in the core zones (CZs) and peripheral zones (PZs) of Oban and Okwangwo revealed that the CZs had a higher number of tree counts between the CZs and PZs as shown in Tables 1 and 4. These could be attributed to the disturbance from human activities since the PZ are easily accessible by the support zones and enclave communities and is in conformity with the findings of [23] that considerable forest destruction is within walking distance of all the

villages and also with the work of [16] that the villagers in the support zones and enclave communities derive significant proportion of their income from the collection of forest products. The intensity of this disturbance due to the derivation of income has significant effect on the trees in CRNP forest. The descriptive statistics in Table 2 and 5 revealed that the core zones (CZs) of Oban and Okwangwo had mean, standard deviation and range higher than the peripheral zones (PZs) of Oban and Okwangwo. The T-test for tree counts in Oban (Table 3) revealed that T-calculated (1.161) is less than T-tabulated (2.365) at degree of freedom 7 with 5% level of significance, that is [T_{cal}=(1.161)≤T_{tab}(0.025) (8-1)=2.365]. It shown that there is significance and the two zones (CZ and PZ) do not have the same results. While the T-test for tree counts in Okwangwo (Table 6) revealed that T- calculated (3.040) is greater than T-tabulated (2.365) at degree of freedom 7 with 5% level of significance, that is [T_{cal}=3.040≥T_{tab}(0.025)(8-1)=2.365]. It shown that there is significance and the two zones do not have the same result. These can be as a result of human impacts on the zones and is in line with the findings of [4] which highlighted that high depletion of fuel wood and timber species have now moved into forest reserves and tree cut for timber, food and non-timber forest products are not replaced which leads to biodiversity loss and also the work of [23] that the rural economy in remote villages is almost entirely forest based. The differences between plots of Oban (A) and Okwangwo (B) in Table 7 revealed that the calculated differences of plots in the core zone (CZ) and peripheral zone (PZ) of Oban (A) had a sum-up difference of 31, while those of Okwangwo (B) had 35 higher than A. The F-test revealed that Oban had a variance of 89.125 and Okwangwo had 16.554. F-statistics revealed that F-calculated (5.384) is greater than F-tabulated (3.79) at degree of freedom (7,7) P(0.05) [that is: F_{cal}=(5.384)≥F_{tab}(0.05)(7,7)=3.79] and there is variability in their differences. These can be attributed to human population pressure on the forest and is in line with the findings of [4], that forest resources are threatened by increased population pressure and intensified by human development activities. During the course of this work, it was observed that is on increase in both divisions of Cross River National Park (CRNP) and the parts of the park within trekable distance are prone to disturbance by the support zones and enclave communities and this is in agreement with the findings of [23] that within walking distance of all the villages, there is a considerable forest destruction. It was also discovered that the work strength of the park especially the rangers is low and lacks motivation and this results to poor protection of the park and is in conformity with the works of [17,9] that both divisions of Cross River National Park are poorly protected and are threatened by illegal logging, slash and burn farming, sanctuaries for poachers and expanding farmlands are gradually eroding the park from within. It clearly indicates that human settlements nearer to evergreen forests have a direct impact on forest. Plants are vital to ecological processes hence deforestation has a

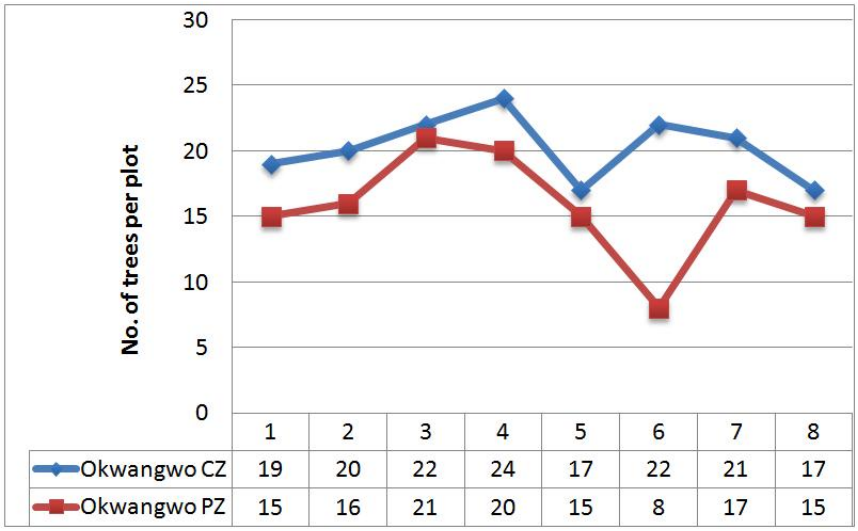
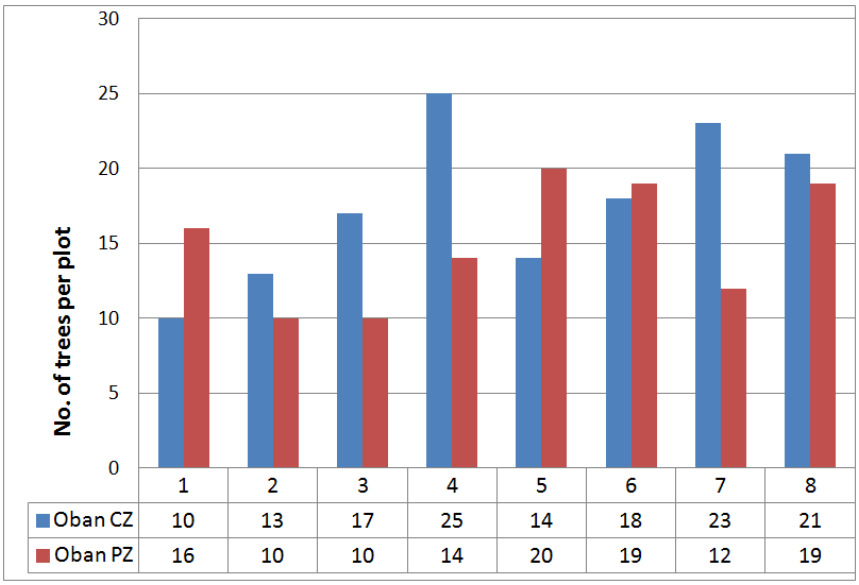
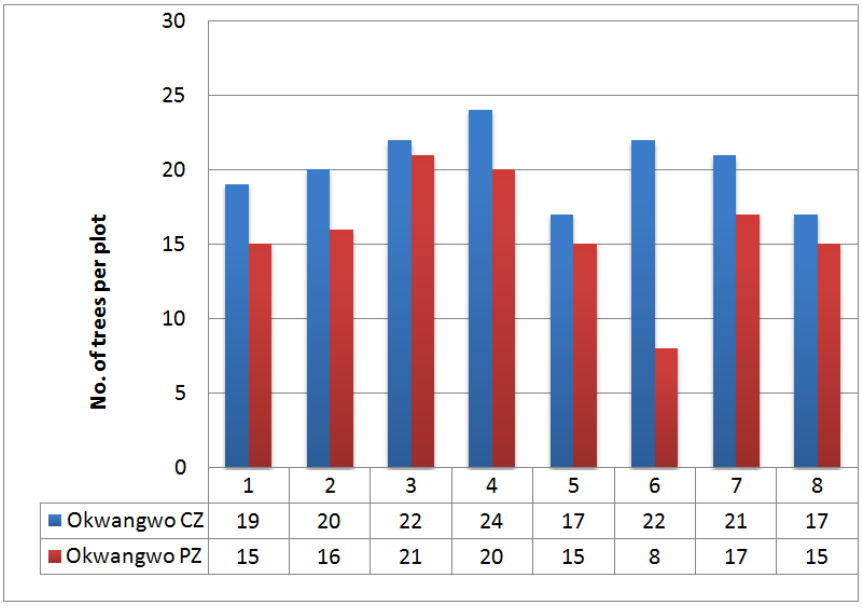


Fig. 4. Comparism of tree counts trees per plot in the core and peripheral zones in Okwangwo



	1	2	3	4	5	6	7	8
Oban CZ	10	13	17	25	14	18	23	21
Oban PZ	16	10	10	14	20	19	12	19

Fig. 5. Comparism of tree counts trees per plot in the core and peripheral zones of Oban



	1	2	3	4	5	6	7	8
Okwangwo CZ	19	20	22	24	17	22	21	17
Okwangwo PZ	15	16	21	20	15	8	17	15

Fig. 6. Comparism of tree counts per plot in the core and peripheral zones of Okwangwo

devastating impacts on climate, water and nutrient cycles. However research must be expanded and strengthened to improve our understanding of biodiversity and its potential role in building sustainable human societies. At this stage we need to more understand about how, why and where human activities bring about long-term changes in biodiversity and the environment, in order to provide accurate information to decision makers.

4. CONCLUSION

Forest reserves are gradually threatened by the global needs of forest products and the derivation of income from the collection of forest products by the rural communities which clearly indicates that human settlements nearer to evergreen forests have direct impacts on forests, Cross River National Park inclusive. Forests are vital to ecological processes hence deforestation

has devastating impacts on climate, water and nutrient cycles. At this stage, we need to understand more on how, why and where human activity brings about long-term changes in order to provide accurate information to decision makers. Research should be expanded and strengthened to improve our knowledge and understanding of the benefits of forest and its potential role in building a sustainable human society. In the course of this study, it was discovered that the staff strength of CRNP, especially the rangers, is poor and lacks motivation. These may be the cause of poor protection of the park.

5. RECOMMENDATIONS

The park boundaries should be well marked and demarcated from the community forests.

Strategies should be adopted to protect the park locations if wildlife is to be sustained. These strategies are embedded in the presence of numerous, well trained, motivated and dedicated rangers.

The enclave communities should be resettled outside the park to prevent further disturbance of the forest as the population increases. Palliative measures and alternative sources of income should be provided through establishment of skill acquisition centers, scholarship programs and free medical treatment when villagers are resettled.

Public enlightenment campaign on the future consequences of forest destruction should be carried out in the enclave and support zone communities.

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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