

EFFECT OF ANTHROPOGENIC DISTURBANCE ON THE FLORISTIC COMPOSITION OF RAINFOREST ECOSYSTEM OF SOUTHERN NIGERIA

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ABSTRACT

*The original contiguous and luxuriant rainforest in Southern Nigeria has been much degraded owing to different anthropogenic disturbances which include oil exploration; the resultant effects being lost of components and proper functioning of the ecosystem. This study therefore examined the effects of anthropogenic disturbances on flora composition within the oil producing area of Southern Nigeria. Vegetation floristic features of woody tree species were investigated for 15 degraded forests and 15 adjoining rainforest (control) plots. The size of each control plot was adopted for the degraded forest areas from which data were collected for the year 2004 and 2014, so as to determine the rate of forest disappearance and woody tree species loss. Data collected were subjected to both descriptive and inferential statistical tests, as well as Simpson's index of species diversity. The population of trees varied significantly ($p < 0.05$) between the degraded and control forest ecosystems. Population of trees and forest size correlated positively ($r = 0.96$ and $r = 0.84$) within the degraded forest, and ($r = 0.96$ and $r = 0.97$) in the control forest in 2004 and 2014 respectively. *Piptadeniastrum africanum* and *Anthonotha macrophylla* were dominant in the control plots while *Elaeis guineensis* dominated in the degraded forests. Forest areas exposed to oil exploration activities experienced higher rate of degradation thereby leading to reduced forest size, tree populations and tree species diversity. Integrated environmental management is recommended to prevent forest disappearance from the region.*

Keywords: Anthropogenic disturbance, degradation, floristic composition, rainforest ecosystem, Southern Nigeria.

INTRODUCTION AND STATEMENT OF PROBLEMS

Despite the ongoing reduction in forest degradation over the past 30 years, the process of deforestation remains a serious global ecological problem and a major soil and economic problem in many regions (Fuwape, 2004). The species rich rainforest ecosystems of southern Nigeria has been much degraded owing to decades of anthropogenic disturbance such as oil exploration activities; the long term effect being environmental degradation in terms of reduction in forest size and floristic composition (Ndakara, 2012). Despite the importance of trees to man and the environment, oil exploration and other anthropogenic activities remain on the

increase, thereby reducing the proper functioning of the rainforest ecosystem. Indeed, oil exploration activities and oil theft were necessitated by the presence and abundance of carbonaceous rocks deposits within this study area. It can therefore be predicted that if the prevailing rate of anthropogenic activities continues within this region, a certain point will reach where the functioning of the forest ecosystem will no longer be able to support the effective formation of carbonaceous rocks (vegetative rocks).

Degradation is a process that results in permanent destruction of indigenous forest

and woodlands, and constitutes one of the most critical environmental problems facing the world today. In rural areas, the deterioration of natural resources negatively affects the environment and undermines the foundation on which economic growth and long term prosperity depends. The F.A.O (1997) estimated the annual rate of forest degradation in developing countries at 15.5 million hectares from 1980 to 1990 and 13.7 million hectares from 1990 to 1995 respectively. The total forest area lost during the 15 year period was approximately 200 million hectares

The rate of forest degradation varies widely with region and despite a global decline in some regions, particularly in developing tropical nations, the rate of deforestation is increasing and most pronounced in tropical rainforests. For example, study by Fuwape (2004) revealed that Nigeria lost 81% of its old-growth forests between 1990 and 2005. At the global perspective, F. A.O (2005) revealed that 13 million hectares of forests are lost each year, 6 million hectares of which are forests that have been largely undisturbed by man. The process of forest degradation has been on the increase. According to Fuwape (2004) and Osemeobo (2001), deforestation left less than 5% of Nigeria's rainforest ecosystems as undisturbed. This results in a loss of habitat, reduction in tree species composition, and reducing ecosystem services of the rainforest (Gillespie *et al.*, 2004; Ndakara, 2009).

In the Niger Delta region, the rainforest vegetation has been affected by centuries of human impacts (such as agricultural practices, logging activities, bush fire, fuel-wood collection and settlement development), thus leading to forest mosaic consisting of many stages of forest succession that are interspersed with areas of climax forests. The rainforest ecosystem is the most luxuriant and species-rich environment, and between 45% and 53% of all rainforest plants are woody species (Ndakara, 2010). Owing to degradation

impacts, this species-rich ecosystem has been reduced in terms of size and species composition. Relics of the forest ecosystems are now confined to sacred places as sacred groves, where logging and other activities that result in ecosystem degradation are not carried out. There is therefore the need to ascertain the rate of degradation and its effects on woody tree species in terms of floristic composition, species richness and their rate of loss by comparing data from the degraded areas with those from their adjoining sacred groves.

Studies by Dzwonko and Loster (1989), Doak and Mills (1994), Jules (1998), Hanski and Ovaskainen (2000), Lindborg and Eriksson (2004), Jongejans and de Kroon (2005) have reported that the results of studies about plant communities are often not clear due to different rates of selective logging in rainforests, which make statistical interpretations quite complicated. Ndakara (2009) offered clearer results by investigating plant communities that were confined to sacred places where logging and other degradation activities are not permitted.

The main objective of this study therefore is to investigate the rate of forest degradation and its effects on the composition and diversity of woody tree species in southern Nigeria. However, as efforts are geared towards preventing further destruction of the tropical rainforests and ensuring the conservation of its rich biodiversity, adequate quantitative and qualitative ecological data on tree species are imperative. Such data are needed for fashioning out realistic and effective conservative measures for sustainable forest ecosystem development.

THE STUDY AREA

The study was conducted in Orogun area of Delta state in the Niger Delta region of southern Nigeria. This study area falls within

the humid sub-equatorial climate of Af Koppen's classification, with annual rainfall above 2000mm, and average temperature of about 26°C (Efe, 2006; Ndakara, 2006). The topography is a low plain with slope of $\leq 2^\circ$. The soils are classified according to the U.S. soil Taxonomy System (Soil Survey Staff, 1994) as alfisols, oxisols/ultisols orders. The natural vegetation is the moist evergreen tropical rainforest with tree forms ranging in strata from shrubs to exceedingly tall members. This rainforest vegetation has been affected owing to several years of human activities, such that the originally contiguous ecosystem now feature as island habitats or sacred groves (Ndakara, 2006; 2009), and confined to sacred places where human induced degradation activities are restricted. The rainforest tree species that featured prominently in the study area include *Piptadeniastrum africanum*, *Ceiba pentandra*, *Albizia adianthifolia*, *Terminalia superba*, *Alstonia boonei*, *Milicia excelsa*, *Ricnodendron heudelotii*, *Musanga cecropioidea* and *Antiaris toxicaria*.

Study Design and Samples Collection

The study area was divided into 5 units using the stratified random sampling technique which was based on the existing 5 quarters of the clan (Umusu, Unukpo, Imodje, Emonu and Ogwa). The quarters were so used in this study to ensure that every part of the study area was covered. In each quarter, 3 degraded sites as well as 3 control sites were selected, making a total of 15 degraded and 15 control sites respectively from which data for this study were collected for the 2004 and 2014. The essence of data collection exercise within the 10-years time interval was to ascertain the level and rate of forest degradation.

The selection of the adjoining sacred groves was to serve as control in the study. The size of each sacred grove was adopted for the respective degraded site closer to the sacred grove chosen. Each of the degraded sites and the adjoining

sacred groves selected was divided into quadrats of 25 meter by 40 meter. Quadrats of this size are considered adequate for sampling tropical vegetation units.

This study was based on the functional characteristics of the plant cover (i.e. plant features that serve an adaptive role for survival in existing environment). Therefore, emphasis was placed on the higher life-forms of the phanerophyte order, which are mostly woody trees and plants of 8 meters and above in height. They represent the true floristic composition of tree species that characterize the tropical rainforest ecosystems.

Data for this study were collected in two phases, the first phase being in the year 2004 while the second phase was in 2014. The 10 years gap was to enable the determination of the rate of degradation within the forest ecosystem. Variables determined in the study were the size of sample sites, tree species populations and their densities in each sample site, and tree species diversity. The size of each site was determined by the use of measuring tape, ranging poles and arrows. Tree species population was determined by counting the number of each species present in each quadrat and added up for each of the sites, while percentage change in population of trees was determined by expressing the change in population between the two dates as a percentage of the population in the first year. Tree density was calculated by dividing the population of trees in each site with the area of the sites. The Pearson's bivariate correlation was tested on the relationship between the population of trees and the size of sample sites at 5% two-tailed levels of probability. Analysis of variance (ANOVA) was tested on the differences in the population of trees between the degraded and the adjoining sacred groves respectively. While tree species diversity was determined as the reciprocal of Simpson's (1949) index as suggested by Odum (1975):

$$\text{Simpson's index (Is)} = 1 - \frac{\sum (ni)^2}{N}$$

Where:

Is = Simpson's index

ni = Importance value of each species

N = Importance value of all species taken together

The rainforest ecosystem is characterized with diverse woody tree species, many of which produce timber products. In this study, only 10 woody tree species were observed in the degraded forest areas while 23 woody tree species were observed in the sacred groves. The degraded sites do not contain many of the rainforest tree species that were observed in the sacred groves owing possibly to degradation resulting from oil exploration, bush fire and farming activities. Also, the population of the tree species varied amongst the sites of the two ecosystems respectively. Table 1 presents the population and population density of trees in each site studied.

RESULTS AND DISCUSSION

i. Woody Tree Species Composition

Table 1: Size of sites, population and population density of woody trees

Sites	Area (m ²)	Degraded forests				Sacred groves			
		2004		2014		2004		2014	
		pop	p.d / m ²	pop	p.d / m ²	pop	p.d / m ²	Pop	p.d / m ²
1	108×282 = 30456	56	0.00184	33	0.00108	264	0.00867	230	0.00755
2	176 ×386 = 67934	102	0.00150	41	0.00060	605	0.00891	557	0.00820
3	128× 380 = 48640	89	0.00183	36	0.00074	358	0.00736	332	0.00683
4	162 ×274 = 44388	91	0.00205	43	0.00097	336	0.00757	305	0.00687
5	118× 216 = 25488	62	0.00243	28	0.00110	218	0.00855	197	0.00773
6	130× 190 = 24700	63	0.00255	32	0.00130	208	0.00842	176	0.00713
7	120× 220 = 26400	61	0.00231	31	0.00117	225	0.00852	203	0.00769
8	110 ×200 = 22000	54	0.00246	22	0.00100	206	0.00936	187	0.00850
9	120× 180 = 21600	65	0.00301	28	0.00130	204	0.00944	183	0.00847
10	114× 285 = 32490	77	0.00237	30	0.00092	287	0.00883	263	0.00810
11	116× 481 = 55796	81	0.00145	34	0.00061	387	0.00694	343	0.00615
12	202× 416 = 84032	134	0.00160	43	0.00051	702	0.00835	600	0.00714
13	165× 320 = 52800	83	0.00157	29	0.00055	374	0.00708	326	0.00617
14	125 ×380 = 47500	87	0.00183	28	0.00059	256	0.00539	244	0.00514
15	192× 516 = 99072	146	0.00147	55	0.00056	718	0.00725	638	0.00644

Pop = population; p.d = population density

The populations of trees were much lower in the degraded forests than in the sacred groves. Between 2004 and 2014, there was an observed reduction in the population of trees contained in the degraded sites than in the sacred groves. Also, the sacred groves had higher population density and ranged

between 0.00539-0.00944 and 0.00514-0.00850 in 2004 and 2014, while in the degraded sites it ranged between 0.000145-0.00301 and 0.00051-0.00130 in 2004 and 2014 respectively. The presence and population density of woody tree species in the rainforest area is greatly influenced by the

reduced population of tree species. For instance, if tree species that do not regenerate fast are cut down and their seeds subjected to burning, such tree species may not be found in that site again, thus affecting the population of trees and their densities.

The population of trees varies with the size of sites. Tables 2 and 3 present the

relationship between the size of sites and the population of trees contained in 2004 and 2014 for the two ecosystems. However, strong positive correlations exist between population of trees and the size of sites. Therefore changes in the size of forests have direct impact on the population of trees contained.

Table 2: Pearson's correlation between forest size and the population of trees in degraded forests areas.

Year	Variables	N	Mean	SD	correlation	Decision
2004	Size of site	15	45553.1	23527	0.96	Significant
	Population	15	83.4000	27.1		
2014	Size of site	15	45553.1	23527	0.84	Significant
	Population	15	34.2	8.3		

P > 0.01 (Significant); SD = standard deviation

Table 3: Pearson's correlation between forest size and the population of trees in sacred groves

Year	Variables	N	Mean	SD	correlation	Decision
2004	Size of site	15	45553.1	23527	0.96	Significant
	Population	15	356.5	177.6		
2014	Size of site	15	45553.1	23527	0.97	Significant
	Population	15	318.9	155.8		

P > 0.01 (Significant); SD = standard deviation

Table 4 below shows the differences in the population of trees between 2004 and 2014 as tested with ANOVA statistics. Results show that significant differences exist in the population of woody trees contained in the degraded sites, while no difference was observed in the sacred groves for the two years.

Table 4: ANOVA results for the differences in the populations of trees between 2004 and 2014

Ecosystem	Sources of variables	Sum of squares	D/F	Variance estimates	F	Decision
Degraded sites	Between	10490.7	1	10490.7	5.34	Significant
	Within	549960.56	28	19641.5		
	Total	560451.26	29			
Sacred groves	Between	9006.433	1	9006.433	2.09	N.S
	Within	120970.167	28	4320.4		
	Total	10303.600	29			

P > 0.05 (Significant); N.S = Not significant

The level of significance in the degraded sites reveals the levels of tree species reduction, and it was at variance with that observed in the sacred groves. Woody tree species were highly lost within the 10 years interval. The reduced stands of rainforest tree species results from ecosystem degradation due mainly to different anthropogenic disturbances. This can be accounted for by the very small population of woody trees encountered in the degraded sites.

ii. Tree Species Diversity

The diversity of tree species and their levels of dominance in both degraded and the adjoining sacred groves were ascertained using the Simpson's index as presented in tables 5 and 6 respectively.

Table 5: Simpson's Index results for degraded forests

Sites	2004		2014	
	Index of diversity	Dominant tree species	Index of diversity	Dominant tree species
1	0.62	<i>Elaeis guineensis</i>	0.60	<i>Elaeis guineensis</i>
2	0.57	<i>Elaeis guineensis</i>	0.56	<i>Elaeis guineensis</i>
3	0.61	<i>Elaeis guineensis</i>	0.54	<i>Elaeis guineensis</i>
4	0.59	<i>Anthonotha macrophylla</i>	0.58	<i>Elaeis guineensis</i>
5	0.60	<i>Elaeis guineensis</i>	0.56	<i>Elaeis guineensis</i>
6	0.63	<i>Elaeis guineensis</i>	0.61	<i>Elaeis guineensis</i>
7	0.61	<i>Anthonotha macrophylla</i>	0.63	<i>Elaeis guineensis</i>
8	0.58	<i>Anthonotha macrophylla</i>	0.56	<i>Elaeis guineensis</i>
9	0.57	<i>Elaeis guineensis</i>	0.54	<i>Elaeis guineensis</i>
10	0.60	<i>Elaeis guineensis</i>	0.59	<i>Elaeis guineensis</i>
11	0.58	<i>NS</i>	0.55	<i>Elaeis guineensis</i>
12	0.58	<i>Elaeis guineensis</i>	0.57	<i>Elaeis guineensis</i>
13	0.60	<i>Elaeis guineensis</i>	0.60	<i>Elaeis guineensis</i>
14	0.59	<i>Elaeis guineensis</i>	0.60	<i>Elaeis guineensis</i>
15	0.62	<i>Elaeis guineensis</i>	0.59	<i>Elaeis guineensis</i>

NS = where more than one tree species dominate in a site

Most of the tree species which dominated some of the degraded sites in 2004 were no longer dominant in 2014. *Elaeis guineensis* now feature prominently as the dominant species in 2014. This shows a marked reduction in the population of those tree species that were dominant at the initial study in the degraded sites. However, the dominance of *Elaeis guineensis* could be attributed to their preservation because of their economic importance to the people. When tree species of the secondary forest dominates in the rainforest zone, it is an indication of tree species loss.

Table 6: Simpson's Index results for sacred groves

Sites	2004		2014	
	Index of diversity	Dominant tree species	Index of diversity	Dominant tree species
1	0.72	<i>Piptadeniastrum africanum</i>	0.71	<i>Piptadeniastrum africanum</i>
2	0.68	<i>Cordia millenii</i>	0.66	<i>Cordia millenii</i>

3	0.69	<i>Albizia adianthifolia</i>	0.68	<i>Albizia adianthifolia</i>
4	0.65	<i>Anthonotha macrophylla</i>	0.64	<i>Anthonotha macrophylla</i>
5	0.68	<i>Anthonotha macrophylla</i>	0.71	<i>Anthonotha macrophylla</i>
6	0.75	NS	0.74	<i>Anthonotha macrophylla</i>
7	0.71	<i>Anthonotha macrophylla</i>	0.69	<i>Anthonotha macrophylla</i>
8	0.70	<i>Anthonotha macrophylla</i>	0.72	<i>Anthonotha macrophylla</i>
9	0.67	<i>Anthonotha macrophylla</i>	0.66	<i>Anthonotha macrophylla</i>
10	0.74	<i>Ceiba pentandra</i>	0.73	<i>Ceiba pentandra</i>
11	0.65	<i>Ceiba pentandra</i>	0.68	NS
12	0.78	<i>Piptadeniastrum africanum</i>	0.76	<i>Piptadeniastrum africanum</i>
13	0.64	NS	0.65	NS
14	0.64	<i>Albizia adianthifolia</i>	0.62	<i>Albizia adianthifolia</i>
15	0.76	<i>Piptadeniastrum africanum</i>	0.73	<i>Piptadeniastrum africanum</i>

NS = where more than one tree species dominate in a site

The same species of trees were found dominant in the studies conducted on the sacred groves for the two different years. However, in some of the sites, more than one tree species dominated. Comparing the level of dominance by the tree species in the two ecosystems, the degraded sites have lost most of the tree species which characterize the tropical rainforest ecosystem. The much reduced number of tree species in the degraded sites is an indication of loss of woody tree species owing to the impact of anthropogenic disturbances. Therefore, effective conservation approach is necessary

to preserve the few stands of woody tree species remaining, and therefore encourage the development of other tree species so as to achieve sustainable ecosystem development.

iii. Rate of Woody Tree Species Loss

The rate with which the woody tree species are reduced in the rainforest ecosystem is quite alarming. Between 2004 and 2014, the percentage rate of loss ranged from 41.1% to 67.9%, while in the same period it ranged between 4.7% and 15.4% for the sacred groves (see table 7).

Table 7: Rate of Change in the Population of Trees

Sites	Degraded forests			Sacred groves		
	Population of trees		% change	Population of trees		% change
	2004	2014		2004	2014	
1	56	33	41.1	264	230	12.9
2	102	41	59.8	605	557	7.9

3	89	36	59.6	358	332	7.3
4	91	43	52.8	336	305	9.2
5	62	28	54.8	218	197	9.6
6	63	32	49.2	208	176	15.4
7	61	31	49.2	225	203	9.8
8	54	22	59.3	206	187	9.2
9	65	28	56.9	204	183	10.3
10	77	30	61.0	287	263	8.4
11	81	34	58.0	387	343	11.4
12	134	43	67.9	702	600	14.5
13	83	29	65.1	374	326	12.8
14	87	28	67.8	256	244	4.7
15	146	55	62.3	718	638	10.6

The rate of change in the populations of woody tree species is higher in the degraded ecosystem than in the sacred groves. The high rate of change in the degraded sites shows that tree species contained are at a high risk of being endangered. This can be deduced from the population of individual tree species contained in each site as shown in appendices 1 and 2. In contrast with the rate of change observed in the sacred groves, woody tree species are much preserved thus the presence of more tree species than in the degraded ecosystem. The much larger number of tree species contained in the sacred groves is an indication that if the rainforest ecosystem is left undisturbed, the true floristic and physiognomy of the ecosystem will be achieved. Therefore conservation of the ecosystem is possible through the Ecosystem-based Management approach.

CONCLUSIONS AND RECOMMENDATIONS

The species rich rainforest ecosystems of southern Nigeria has been much degraded owing to decades of anthropogenic disturbances such as oil exploration activities, bush fire and agricultural practices; the long term effect being environmental degradation in terms of forest size and flora composition. Although the importance of trees and forest cover with respect to carbonaceous rock formation thereby leading to oil deposits has

been established, anthropogenic disturbances remain on the increase, thereby reducing the proper functioning of the rainforest ecosystem.

This study has shown that anthropogenic disturbances resulting from oil exploration activities, bush fire and agricultural practices have affected the floristic composition of the rainforest ecosystem in Southern Nigeria. The degradation effects have resulted in high rate of loss in forest cover, reduced flora composition, increased environmental degradation, species diversity and reduced functioning of the forest ecosystem.

Indeed, man's increasing knowledge of the ecological implications of anthropogenic disturbances led to the ideas of conservation of forest and its resources for the future generations. Consequent upon these implications, the following measures are here recommended to conserve and manage the rainforest ecosystem of southern Nigeria.

- An integrated ecosystem-based management approach should be adopted to conserve and manage the relics of the rainforest tree cover. This approach is geared towards ensuring the management of the ecosystem by collective efforts of all inhabitants of the region. Conserving the rainforest ecosystem will result in the preservation of wildlife habitats and

prevention of biodiversity. If deforestation is properly controlled, rainforest products such as rubber latex, medicinal plants, fruits and nuts can be exploited without damaging the ecosystem. Therefore the following measures are recommended in line with the Ecosystem – Based Management approach.

- There should be elaborate public education and awareness of the negative

impacts of activities such as oil exploration, bush fire and agricultural practices which result to ecosystem degradation in this study area.

- There should be a review of government policy on the forest and forest resources. Such review should take cognizance of the ecological, economic and social importance of the region's rainforest ecosystem.

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