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Population Structure and Regeneration Potential of the most Abundant Timber Tree Species in a Rainforest Reserve in Southeastern Nigeria

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ABSTRACT

Sustainable management of the remaining areas of tropical rainforest is being canvassed globally. Quantitative and qualitative ecological data on the forests are indispensable for the actualisation of sustainable management. Accordingly, this study assessed the population structure and regeneration potentials of the most abundant timber trees in a rainforest reserve in Southeast Nigeria using belt transect and quadrat techniques for data collection on mature trees and regeneration. Data collected were analysed on per/ha basis, stem diameter classification and calculation of regeneration potential indices. A total of 19 species were found to be the most abundant, with *Celtis integrifolia* having the highest population density of 53 per/ha, while *Brachystegia eurycoma, Enantia chlorantha* and *Vitex grandifolia* had the least of 5 per/ha each. Most of the trees are of small stem diameter with the stem diameter-class 20 – 29cm had the highest frequency of 522 trees, while stem diameter-class 90 – 99cm had the least of 31 trees. The highest regeneration density of 418 per/ha was recorded for *Berlinia confuse,* while *B. eurycoma* and *Pterygota macrocarpa* regeneration were not encountered. Only 9 of the 19 tree species showed sustainable natural regeneration capability as indicated by their regeneration potential indices of ≥ 0.10. Limiting timber harvesting to the few big-size trees, and enrichment planting with seedlings of trees of poor natural regeneration potentials would enhance sustainable management of the forest.

Keywords: Rainforest, Timber, Trees, Population, Regeneration, Sustainable Management

INTRODUCTION

The importance of wood to man is enormous. Aside being the most accessible and affordable source of energy in virtually all the tropical region of the world, wood in the form of lumbers of various dimension is a worldwide materials used for construction. The industrial products from wood include furniture items, plywood, tiles, ceiling boards, veneers and papers of varying grades. More often than not, wood, in timber form, is regarded as the most tangible produce of the forest. Huge incomes and foreign exchange earnings are generated through trades in timber and wood products at the local and international markets.

The world tropical rainforest (Nigerian rainforest inclusive) is the major source of the world wood need (ITTO, 2011, Molinos, 2011 & 2013). However, large areas of forest plantations exist, yet the rainforest is of great attraction to timber contractors due to their wide variety of species and sizes (Akindele and Akinsanmi, 2002; Olajide and Akpan-Ebe, 2006 and Agyeman, 2013). Consequent upon the upsurge in human population, pressures have been placed on the tropical rainforest to meet the wood need of man for construction, furniture, packaging and other purposes. The pressures have culminated in widespread degradation, denudation and destruction of rainforest in many regions of the world.

The availability of wood products from the trees in the rainforest ecosystem on sustainable basis is dependent on the sustainable management of the remaining areas of the rainforest. Sustainable natural forest management is predicated on the availability of quantitative and qualitative ecological data on the constituent trees, which include tree population density, stem diameter distribution and population density of tree regeneration. According to Betti *et al.*, (2016), knowledge of the distribution of stems by diameter class is important for the effective management of a given tree species, because it shows the structure of the population and helps in identifying deficiencies in regeneration capacity. Moreover, diameter class distributions provide a basis for designing timber harvesting

CARD International Journal of Agricultural Research and Food Production (IJARFP)
Volume 1, Number 3, December 2016

regime and the adaptation of silvicultural interventions (Olajide and Akinyemi, 2007; Betti *et al.*, 2016).

Thus, this paper is the report of a research on the population structure, stem size distribution and regeneration potentials of the most abundant timber tree species in Oban Forest Reserve (Rainforest Reserve), Southeastern Nigeria. It is hoped that the information gathered would help sustainable management of the forest and totality of biodiversity conservation.

MATERIALS AND METHODS

Study Area

The study was carried out in Oban Forest Reserve, Cross River State, Southeastern Nigeria. The Forest Reserve is a tropical rainforest, and one of the very few expanse tracts of rainforest remaining in Nigeria. The forest reserve covers an area of 245.48km^2. The area lies between latitudes 5°00' and 5°57'N and longitudes 8°10' and 8°55'E. The annual rainfall of the area varies between 2,500mm and 3,500mm, mean minimum and maximum annual temperature are 23°C and 30°C respectively. The average relative humidity is 85% at 12.00 hour (Offiong and Iwara, 2011). The soil is known to be formed from rocks of pre-Cambrian complex especially granite, Gneisses and Schist (Offiong and Iwara, 2011). The forest reserve has been subjected to logging over the years and about six years ago, logging is officially prohibited in the forest.

Data Collection

Belt transects and quadrant techniques were adopted for the enumeration of the trees. The technique entailed the laying of one kilometer (1km) baseline across the access route at 20m away from the border of the buffer zone of the Forest Reserve. Five points of 200m apart from one another were marked along the base-line, and thereafter three points were randomly selected for the laying of belt transects. Accordingly, three 1km belt transects were laid from the three randomly selected points on the base-line into the forest.

All adult trees with stems ≥ 20 cm diameter at breast height (Gilman, 2011) that were within 10m away from both sides of each belt transect were identified, enumerated and measured for diameter at breast height. It therefore translated to an area of 20,000m^2 assessed around each belt transect, and gross total of 60,000m^2 (6ha) enumerated for adult trees. Forty 5m x 5m quadrats were randomly alternately laid on both sides of each belt transect, and subsequently enumerated for regeneration or juvenile trees (< 20cm dbh). Thus, a total area of 3,000m^2 (0.3ha) was enumerated for tree regeneration. The data collections were made from 2013 to 2015.

Data Analysis

The population density of adult stands of individual tree species per hectare was calculated from the population in the whole sampled area (6ha). Only the tree species with population density of 5 stands per hectare and above were considered the most abundant species. The population density of regeneration or juvenile stand of each tree species in the total sampled area (0.3ha) was computed and extrapolated to density per hectare. The stem size distribution was analysed by classifying the stems diameters into nine (9) diameter-classes and coded as follows: 20 – 29cm (class 1), 30 – 39cm (class 2), 40 – 49cm (class 3), 50 – 59cm (class 4), 60 – 69cm (class 5), 70 – 79cm (class 6), 80 – 89cm (class 7), 90 – 99cm (class 8) and ≥ 100 (class 9).

Natural regeneration potential index on per/ha basis was determined for each tree species using the modified function of Osho (1996) in Olajide *et al.,* (2010). The modified function is expressed as:

$$R_p = \frac{\left(\frac{r_i}{r_t} X \ T_a\right)}{100}$$

Where,

R_p = regeneration potential index

r_i = number of regeneration of species i encountered.

r_t = total number of regeneration of all the species.

T_a = total number of all the adult trees

CARD International Journal of Agricultural Research and Food Production (IJARFP)
Volume 1, Number 3, December 2016

RESULTS

A total of nineteen (19) tree species were identified as the most abundant species in the forest (Table 1). The highest number of 53 stands per/ha was recorded for *Celtis integrifolia,* while *Brachystegia eurycoma, Enantia chlorantha* and *Vitex grandifolia* had the least of 5 stands apiece per/ha (Table 1). The majority of the trees are of smaller diameters (Table 2). The stem diameter-class 1 (20 – 29cm) had the highest population of 522 trees, while stem diameter-class 8 (90 – 99cm) had the least of 31 trees (Table 2). The highest regeneration density of 418 per/ha was recorded for *Berlinia confuse,* while the regeneration of two species, viz; *Brachystegia eurycoma* and *Pterygota macrocarpa* were not encountered (Table 3). It was found that only 9 of the 19 tree species had sustainable natural regeneration capability as indicated by their natural regeneration potential indices (Table 4).

Table 1: Population density of the most abundant timber trees in Oban Forest Reserve, Southeastern Nigeria

S/N	Trees species	Population in sampled area (6ha)	Population (per/ha)
1.	*Berlinia confuse*	49	8
2.	*Berlinia grandiflora*	265	44
3.	*Brachystegia eurycoma*	31	5
4.	*Celtis brownie*	92	15
5.	*Celtis integrifolia*	323	53
6.	*Coelocaryon preussii*	48	8
7.	*Coula edulis*	287	47
8.	*Diospyros mespiliforms*	232	38
9.	*Enantia chlorantha*	31	5
10.	*Irvingia gabonensis*	52	8
11.	*Pausinystelia johimbe*	48	8
12.	*Pterygota macrocarpa*	50	8
13.	*Pycnanthus angolensis*	118	19
14.	*Staudtia stipitata*	46	7
15.	*Tabernaemontana pachysiphon*	93	15
16.	*Uapaca guineensis*	49	8
17.	*Uapaca staudtii*	54	9
18.	*Vitex ferruginea*	43	7
19.	*Vitex grandifola*	30	5

Table 2: Stem diameter distribution of the most abundant timber trees in Oban Forest Reserve, Southeastern Nigeria

S/N	Species	Diameter class								
		1	2	3	4	5	6	7	8	9
1.	*Berlinia confuse*	12	15	10	5	4	2	-	1	-
2.	*Berlinia grandiflora*	53	63	55	34	12	12	9	7	23
3.	*Brachystegia eurycoma*	4	5	7	5	3	4	-	-	9
4.	*Celtis brownie*	31	26	23	6	5	1	-	-	-
5.	*Celtis integrifolia*	115	81	71	26	13	10	2	3	2
6.	*Coelocaryon preussii*	12	14	5	2	2	1	3	1	8
7.	*Coula edulis*	82	75	64	28	17	7	8	4	5
8.	*Diospyros mespiliforms*	77	68	59	15	9	2	-	-	2
9.	*Enantia chlorantha*	5	6	10	-	5	2	3	-	-
10.	*Irvingia gabonensis*	4	14	10	6	2	5	1	2	8
11.	*Pausinystelia johimbe*	15	18	6	3	3	-	2	-	1
12.	*Pterygota macrocarpa*	9	10	9	4	2	3	1	2	12
13.	*Pycnanthus angolensis*	33	24	19	7	7	4	1	5	20
14.	*Staudtia stipitata*	7	11	16	2	2	1	1	-	6
15.	*Tabernaemontana pachysiphon*	29	26	23	9	4	2	-	-	-
16.	*Uapaca guineensis*	5	12	12	10	4	4	-	1	2
17.	*Uapaca staudtii*	12	8	10	15	2	4	1	2	1
18.	*Vitex ferruginea*	6	12	4	6	3	3	-	3	7
19.	*Vitex grandifola*	7	6	8	5	2	1	-	-	1
		522	**498**	**424**	**188**	**101**	**68**	**32**	**31**	**107**

Table 3: Regeneration density of the most abundant timber trees in Oban Forest Reserve, Southeastern Nigeria

S/N	Species	Regeneration density in sampled area (0.3ha)	Density (per/ha)
1.	*Berlinia confuse*	126	418
2.	*Berlinia grandiflora*	4	12
3.	*Brachystegia eurycoma*	-	-
4.	*Celtis brownie*	62	207
5.	*Celtis integrifolia*	2	6
6.	*Coelocaryon preussii*	38	125
7.	*Coula edulis*	20	65
8.	*Diospyros mespiliforms*	113	377
9.	*Enantia chlorantha*	15	48
10.	*Irvingia gabonensis*	10	32
11.	*Pausinystelia johimbe*	2	6
12.	*Pterygota macrocarpa*	-	-
13.	*Pycnanthus angolensis*	34	113
14.	*Staudtia stipitata*	46	152
15.	*Tabernaemontana pachysiphon*	37	123
16.	*Uapaca guineensis*	3	8
17.	*Uapaca staudtii*	39	128
18.	*Vitex ferruginea*	2	6
19.	*Vitex grandifola*	16	53

CARD International Journal of Agricultural Research and Food Production (IJARFP)
Volume 1, Number 3, December 2016

Table 4: Natural regeneration potential indices of the most abundant timber trees in Oban Forest Reserve, Southeastern Nigeria

S/N	Species	Regeneration potential index
1.	*Berlinia confuse*	0.66*
2.	*Berlinia grandiflora*	0.02
3.	*Brachystegia eurycoma*	-
4.	*Celtis brownie*	0.33*
5.	*Celtis integrifolia*	0.01
6.	*Coelocaryon preussii*	0.12*
7.	*Coula edulis*	0.10*
8.	*Diospyros mespiliforms*	0.59*
9.	*Enantia chlorantha*	0.07
10.	*Irvingia gabonensis*	0.05
11.	*Pausinystelia johimbe*	0.01
12.	*Pterygota macrocarpa*	-
13.	*Pycnanthus angolensis*	0.18*
14.	*Staudtia stipitata*	0.24*
15.	*Tabernaemontana pachysiphon*	0.19*
16.	*Uapaca guineensis*	0.01
17.	*Uapaca staudtii*	0.20*
18.	*Vitex ferruginea*	0.01
19.	*Vitex grandifola*	0.08

*capable sustainable natural regeneration.

DISCUSSION AND CONCLUSION

The abundance or rarity, stem size distribution and population structure (mature stands and regeneration) of a tree species in a tract of tropical rainforest are functions of the degrees of intensity of perturbation of the forest and exploitation of such tree species, and availability of favourable micro-climate for its regeneration and growth. It was observed in this study that the majority of the trees are of smaller stem diameters of between 20cm and 49cm, which indicates intense exploitation of many big trees for timber. This finding agrees with Etigale *et al.*, (2014) that most of the trees in a reserved rainforest, which has been subjected to timber exploitation in the eastern bloc of Nigerian rainforest are of small stem diameters of between 10cm and 40cm. Moreover, similar findings had earlier been reported by Ogbonnaya (2002), Adekunle *et al.* (2002) and Newin (2014). The high population density of regeneration of some of the tree species is an indication of prevalence of canopy-gaps with favourable micro-climate which include infiltration of sunlight into the forest floor and availability of needed temperature for tree regeneration.

Agyeman (2013) reported that, there was a preponderance of regeneration of many popular timber tree species in a logged rainforest in Ghana. According to Nwoboshi (1982) and Parthasarathy and Karthikeyan (1997), on tree species that has a regeneration potential index of not less than 0.1 is deemed to have sustainable natural renewal capability. This implies that ten regeneration individuals out of 100 regeneration individuals of a tree species in an hectare will make it to the mature stage. Accordingly, only nine of the tree species (Table 4) have regeneration potential indices indicating sustainable natural regeneration capability.

The poor sustainable natural regeneration potentials of some of the tree species may be ascribed to the paucity of good microsites for the germination of their seeds and survival of their regeneration. Moreover, the seeds of some of the tree species might be food items for human and wild animals, and therefore caused great reduction in their regeneration population. Olajide *et al.*, (2010) reported poor regeneration potential indices for *Brachystegia eurycoma* and *Irvingia gabonensis* as also found in this present study. The two tree species' seeds are widely consumed food items in Southeast Nigeria.

In conclusion, logging should be drastically minimized in the forest and by strictly limiting timber harvesting to the trees of higher diameter-classes (60cm ≥). Enrichment planting of the wide canopy-gaps with the seedlings of timber trees, particularly those with poor natural regeneration potentials, should be carried out to enhance the ecological integrity and overall biodiversity conservation of the forest.

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CARD International Journal of Agricultural Research and Food Production (IJARFP)
Volume 1, Number 3, December 2016

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