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Assessment of Natural Regeneration of African Mahogany Species in Strict Nature Reserve 3, Urhonigbe Forest Reserve, Edo State, Nigeria

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ABSTRACT

Diversity and richness of naturally regenerated juveniles of African mahogany species were assessed in Strict Nature Reserve (SNR) 3 in Urhonigbe Forest Reserve, Edo State, Nigeria. Using the stratified random sampling design, the SNR straddling *ca*. 64 hectares was first sub-divided into four plots made up of 16 ha each. Four (100m x 100m) plots were selected and delineated in each of the 16 ha plots while three (10m × 10m) regeneration plots were then established within the 1 ha plot; thus bringing the total of designated and assessed regeneration plots to 12. Quantitative data which cut across life forms (seedling, sapling and pole) were collected on African mahogany species encountered in SNR 3 using the following plant parameters: family, genus and species (at 0.1875% sampling intensity). Data were subjected to Shannon-Weiner Index of diversity and Analysis of Variance (ANOVA) (P=0.05). Two hundred and forty-nine (249) individuals belonging to five genera and six species, namely *Khaya ivorensis, Guaria cederata, Guaria thompsonii, Entadrophragma angolense, Entadrophragma cylindricum and Lovoa trichiliodes* were recorded while the Shannon Weiner index of diversity was 2.20. *Khaya ivorensis* was the most diverse and dominant (425 stems/ha) among the six species found in the SNR. While there were significant differences among the life-forms (seedlings, saplings and poles), the differences among species were not significant (P > 0.05). Seedlings were most abundant followed by saplings; although they were not significantly different from each other. Despite the relatively abundant seedlings of the mahogany recorded in the SNR, it is uncertain if the mahogany seedlings and juveniles would reach maturity age given the fact that the entire SNR 3 had hitherto been illegally and intensively logged and currently bereft of mature trees.

Keywords: Degraded Forest, Inviolate plot, Meliaceae, Natural Regeneration, Rainforest Ecosystem, Seed/Seedling Bank.

INTRODUCTION

Exploitation of timber in the Forests of southern Nigeria predates the establishment of the Nigerian Forest Department (FD) which dates back to early 19th century (Isikhuemen, 2014) According to Sayer *et al*. (1992), "exploitation of forests for timber in Nigeria began in the 1880s. This was by extracting valuable trees such as African mahogany (mainly those belonging to *Khaya* and *Entandrophragma* genera) that were accessible from river banks – particularly from Bendel and Ondo forests which were mostly reached as they were penetrated by rivers and the terrain was

relatively flat and free from streams." The long term negative effect of the polycyclic management system which encouraged selective exploitation of the rich timber resource in the rainforest region of southern Nigeria is the genetic erosion of important endemic timber species, especially the African mahogany and the concomitant degradation of fragile rainforest ecosystem (Isikhuemen, 2014). But with the forests' disappearance would go not only the varieties of timber species but also several uncharacterized species including wildlife, fruits and variety of leaves, bark and roots that form the vital parts of our culture and ethnomedicine; besides, fertile lands for farming as well as protection of soil and water catchments afforded by the forests would also go (Okali, 1975).

The Benin Forest in southern Nigeria was famous for its richness in mahogany species classified under class I (species of major economic timber importance) by Redhead (1971). These species have multi-utility values – they provide timber and critical mass of non-wood forest products, e.g. bark, root, resin and leaf. These NWFPs bolster the economies and cultural repertoire of the rural populace living in forest reserve enclaves as well as fringing and far flung communities; and serve as raw materials for pharmaceutical industries, practitioners/vendors and users of ethnomedicine (Isikhuemen and Iduozee, 2008; Isikhuemen and Ikponmwonba, 2020). Ironically, these taxa are increasingly facing grave challenges associated with overharvesting and habitats loss leading to extermination of not only the transitory regeneration but their recalcitrant seed and/or transient seedling banks (Isikhuemen and Ola-Adams, 2011). Recent incursions in the use/application of ethnomedicine – a branch of ethno-botany concerned with the study of medicinal systems from the local/native view point otherwise called indigenous knowledge (IK) and explanations of models of illness, including symptoms, causes of sickness and treatments (Kleinman, 1978) – in Nigeria have revealed increasing demands for African mahogany species and concomitant loss of both adults and juveniles. Ionically, not all the species have been thoroughly investigated in the field to establish their conservation status while the few characterized are 'vulnerable' or 'endangered' on the IUCN red list (IUCN, 2015).

The quantitative study of how tree populations work is known as plant demography (Harper and White, 1974; cited in Peters, 1996). The pattern of seed disposition, seedling demography and adult tree recruitment are critical to making sound conservation decisions regarding tropical rainforest habitats (Hubbel and Forster, 1983). Natural regeneration is a biological process that can be assisted and managed to increase forest cover and achieve the recovery of the native ecosystem or some of its functions (Chazdon *et al*, 2017). Records of height growth of regeneration of valuable tree species in natural forest have been mainly restricted to the sapling and pole (*ca*.100 cm height) stages of their growth cycle (Mervart, 1972), while diagnostic assessments only focused on economic species (Okali and Onyeachusim, 1991). This paper evaluates the lifeforms – seedling, sapling and poles – of naturally regenerated African mahogany species in Strict Nature Reserve (SNR) 3, Urhonigbe Forest Reserve, Edo State, Nigeria.

MATERIALS AND METHODS

Study Area

This study was carried out in Urhonigbe Forest Reserve (UFR) in Edo State, Nigeria (Lat. 5º 57´ to 5º 59´N and Long. 6º 5´ to 6º 06´E). The crescent-shape protected area located on the southeastern fringe of Edo State was constituted in the early 1920s. The climate of the area is typical humid tropical rainforest type, with an average annual temperature of 27ºC. Rainfall is heavy for about 9 months of the year, from March to November, with average rainfall of 2286 mm, well distributed within the rainy season (Shell, 2006). With a mean annual rainfall of 2300mm, it experiences bi-modal rainfall distribution pattern; with two peaks, July and September. The mean relative humidity is 84%, rarely falling below 80%. Minimum and maximum temperatures in the forest reserve range from 23^0C to 36^0C. The average elevation is 75m above sea level while the geological formation is the coastal plains sand and lignite group, which is of late tertiary age otherwise called 'Benin sands' (Oguntala, and Soladoye, 2000),

There are over twenty-three enclave and fringing communities in and around Urhonigbe Forest Reserve whose livelihoods are dependent in one way or the other on the forest and allied resources. Save for the vestiges of relic rainforest or semblance of regrowth vegetation (with obvious decline in height, structure and physiognomy) which currently exist in the two inviolate plots – PSP 82 and SNR 3; the entire landscape has reached a tipping point having lost magnificent and lush rainforest vegetation to a medley of farm fallows and forest-regrowth interspersed with fire-climax savanna species (Isikhuemen and Iduozee, 2008).

The Strict Nature Reserve (SNR) 3 (size: *ca.* 2.8 km^2) is located in Urhonigbe Forest Reserve between Evboesi and Urhonigbe towns in Orhiomwon Local Government Area (Figure 1). SNR 3 was established in 1956 by the Forest Research Institute of Nigeria (FRIN). Its aim was to "conserve adequate samples of undisturbed vegetation types and endangered plants in perpetuity in order to preserve a wide genetic diversity existing within the natural forest to serve as a reservoir for the collection of plant materials at all times".

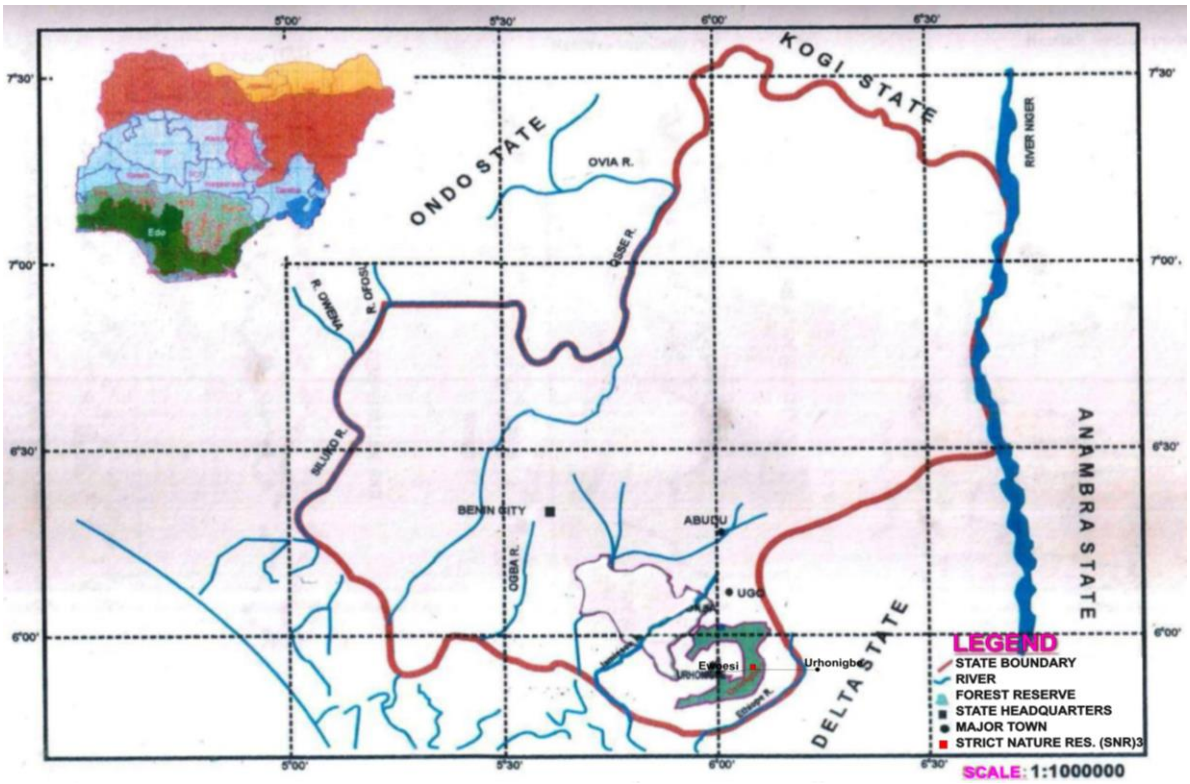

Fig.1. Map of Edo State showing Strict Nature Reserve (SNR) 3, Urhonigbe Forest Reserve. Inset (top left) is Map of Nigeria.

Sampling Design and Data Collection

Prior to the enumeration of the mahogany species in the study area, reconnaissance visits were made to locate and identify the original boundaries of the *ca*. 64 hectares Strict Nature Reserve (SNR 3) in Urhonigbe Forest Reserve. The boundaries were thereafter re-opened and the SNR sub-divided into four 16 ha sub-plots using a prismatic compass, ranging poles, chain and a map (containing SNR 3 geo-reference information) obtained from the Forest Research Institute of Nigeria (FRIN), Ibadan. Within each 16 ha plot, a one hectare plot (measuring 100m x 100m) was randomly selected from the core and leaving the remaining outer plots as surround (to take care of edge effect). Using a table of random numbers, three (10m × 10m) regeneration plots were then selected/established bringing the total number of enumerated sub-plots to 12 (i.e. sampling intensity of 0.1875%).

Within the regeneration plots, quantitative data on lifeforms of all African mahogany species encountered were collected using the following plant parameters: family, genus and species. Plant lifeform (i.e. growth and development stages) was determined using minimum and maximum height/girth thresholds: seedling (point of emergence - 90cm height), sapling (90cm - 305cm height) and Pole (>305cm height - 30cm girth) (Whitmore, 1998; Isikhuemen and Oyibotie (2017). Species identification followed Keay (1989).

Data Analysis

The data collected on the species lifeforms were analyzed using simple descriptive

statistical tools and Analysis of Variance (ANOVA) while means were separated using Duncan Multiple Range Test (DMRT) (p=0.05). Relative density of life forms was calculated following Philips (1994):

$$\text{Relative density of life forms (R.D.L.F)} = \frac{\text{Total number of individual of life form} \times 100}{\text{Total number of life forms}}$$

Overall species diversity was computed using Shannon-Wiener diversity index (H') (Kent and Coker 1992):

$$H' = -\sum_{i=1}^{s} pi\,ln(pi);$$

where H' = Shannon-Wiener diversity index

s = total number of species in the community

pi = proportion of s made up of the ith species

ln = natural logarithm.

RESULTS

Abundance and diversity of naturally regenerated species of African mahogany in Urhonigbe Forest Reserve

Overall, 249 individuals consisting of seedlings, saplings and poles were recorded among four genera and six species encountered in SNR 3 (Table 1). *Khaya ivorensis* had the most abundant stems (or 20.6%). The species Shannon Weiner Index of diversity was 2.20 (Table 1).

Table 1: Six naturally regenerated species of African mahogany in SNR 3, UFR

Sample Plot	Meliaceae Species						TOTAL
	Khaya ivorensis	*Guarea cederata*	*G. thompsonii*	*Entadrophragma angolense*	*Entadrophragma. cylindricum*	*Lovoa thrichiliodes*	
1	4	0	3	1	0	2	10
2	0	7	0	0	3	4	14
3	8	2	1	5	0	3	19
4	2	1	0	0	1	2	06
5	6	5	2	4	8	7	32
6	3	4	1	3	1	2	14
7	3	6	6	0	3	6	24
8	5	2	4	7	7	6	31
9	7	4	3	5	4	0	23
10	2	1	7	1	6	0	17
11	4	3	5	7	0	7	26
12	7	5	7	6	4	4	33
Richness	**51**	**40**	**39**	**39**	**37**	**43**	**249**
Relative Density	**20.48**	**16.07**	**15.66**	**15.66**	**14.86**	**17.27**	**100**
Shannon Weiner index of diversity							**2.20**
Mean	**4.25**	**3.33**	**3.25**	**3.25**	**3.08**	**3.58**	
Std Error of Mean	**0.698**	**0.632**	**0.740**	**0.799**	**0.811**	**0.702**	

Distribution of species and stems among lifeforms in SNR 3

The number of individuals (richness) recorded among species within the defined growth classes are shown in Table 2. Although seedlings were most abundant among the lifeforms, they were however not significantly different from the saplings ($P<0.05$).

Table 2: Life Forms of the African mahogany Species in Urhonigbe Forest Reserve

Species	Seedling	Sapling	Pole	Total
Khaya ivorensis	25	16	10	**51**
Guaria cederata	16	18	6	**40**
Guaria thompsonii	16	12	11	**39**
Entadrophragma angolensis	17	13	9	**39**
Entadrophragma cylindricum	15	14	8	**37**
Lovoa trichiloides	21	12	10	**43**
Total	**110**	**85**	**54**	**249**
Mean	**18.33[a]**	**14.17[a]**	**9.00[b]**	

Means with same letters are not significantly different ($P>0.05$).

Figure 2 shows the numbers of stems obtained in each plot and distribution of individuals among lifeforms in all the sub-plots assessed. Seedlings were least in plot 1 and most abundant in plot 12; saplings recorded least in plot 4 and highest number in plot 8 while occurrence of poles was least in plot 4 and highest in plot 8 (Figure 4).

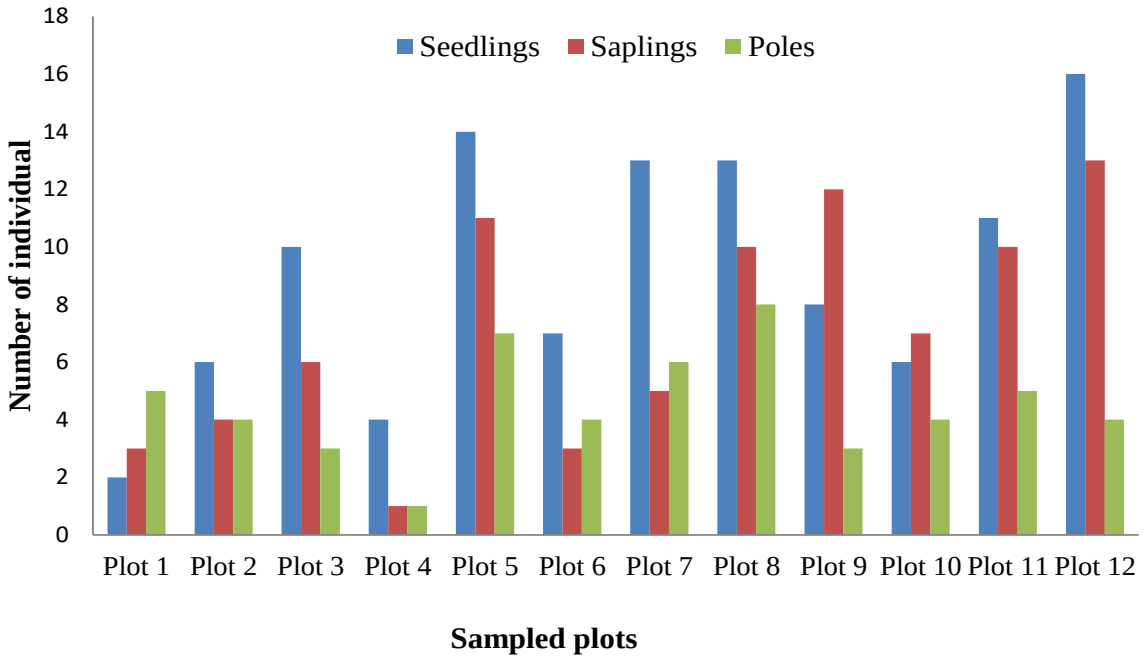

Fig.2. Allotment of stem among lifeforms in sample plots

DISCUSSION

All the six mahogany species encountered in SNR 3 in Urhonigbe Forest Reserve have hitherto been classified under Class I (species of major economic timber importance) by Redhead (1971). The results obtained in this study are in agreement with earlier works carried out by several authors (e.g. Kio, 1978; Bada, 1982; Shell, 2006; Isikhuemen and Ola-Adams, 2011) which assert that most Benin forests, including Sakponba and Urhonigbe Forest Reserves were rich in African mahogany species. From the study results, it is apparent that a major discernible change had occurred in the physiognomy of the vegetation in SNR 3 given the apparent disappearance of the emergent - and to some extent - canopy layers, which were earlier dominated by the leguminosae and meliaceae families (*cf.* Keay, 1952; Redhead, 1971; Kio, 1978). The tropical rainforest ecosystem of Southwest Nigeria is dominated by members of meliaceae, sterculiaceae and moraceae families (Isichei, 1995; Adekunle, 2006; Onyekwelu *et al.* (2008; Adekunle *et al.* 2010).

When results of the study of lifeforms were pooled for all species, the outcome revealed overall average species density of 623 stems/ha; implying relatively rich natural regeneration regardless of the high

level of logging damage wrought on the experimental plot designated originally as 'inviolate plot'. However, the palpable rarity of naturally regenerated seedlings and juveniles of African mahogany species in SNR 3 might not be unconnected with the paucity of adult trees which have been repeatedly exploited by illegal loggers over the years. According to Plumptre (1994), mahogany species produce seeds when the mother tree attains ≥ 80cm dbh and that there is a high correlation between large size trees and the logarithm of seedling density in Budongo Forest Reserve.

Among the three life forms investigated, seedlings were most abundant. This might be adduced to the fact that majority of African mahogany species have rich seedling banks presumably because they exhibit both 'gambler' and 'struggler' regeneration strategies (*cf*. Bazzaz and Pickett, 1980; Oldeman and van Dijk, 1986) to shore-up resilience and longevity in the shaded forest floor region. But the outcomes of this study differ significantly from Bahati, (2005), who reported very low results: 19/ha, 12/ha and 7/ha for seedling, sapling and pole stages respectively in a logged over forest reserve.

Most African mahogany species common to the rainforest region of southern Nigeria fall within the ecological guild called 'non-pioneer light demander' (NPLD) (*cf*: Hawthorne, 1993; Whitmore, 1998) Jones (1956) classified *Guarea cedrata, Lovoa trichilioides* and *Khaya ivorensis* as shade tolerant species. According to Onyeachusim (1985), 'spatial arrangement and distribution of juveniles, including seedlings of most rainforest species – ranging from pioneers, climax species to non-pioneer light demanders – are influenced by forest structure, ecological requirements of seedlings in their early life, location of parent trees and their seed dispersal mechanism'.

Khaya ivorensis, Guaria cederata and Guaria thompsoni recorded the highest number of seedlings, saplings and poles respectively. This could be attributed to the lush rate of survival or life expectancy of the seedlings during the transitory phase preceding establishment. Jones (1956) observed that the seeds of the Nigerian *Khaya ivorensis* and *Lovoa trichilioides* had no dormancy*;* while *Triplochiton scleroxylon and Entandrophragma angolense* had four to six weeks normal storage lives. In Sakponba Forest Reserve, Nigeria, Lancaster (1960) recorded large quantities of young seedlings of L*ovoa* but many of them died at an early age while large amounts of seedlings of *Guarea spp were* established and persisted for several seasons in the same plot.

The fact that six African mahogany species were encountered during the study in SNR 3, Urhonigbe Forest Reserve, aptly demonstrates that, despite the high level of perturbations in the fragile rainforest ecosystem in SNR 3, the ecosystem still exhibit some semblance of the original rainforest vegetation when the inviolate was established in 1956. However, it is uncertain if the fairly abundant juveniles recorded in this study would have the opportunity of growing to maturity given the pressure of unauthorized logging and the fact that it is the only relic rainforest regrowth located in the center of a degraded agricultural landscape.

REFERENCES

Adekunle, V. A. J. 2006. Conservation of tree species diversity in tropical rainforest ecosystem of southwest Nigeria. *Journal of Tropical Forest Science* 18, 91-101.

Adekunle, V. A. J., A.O. Olagoke and L.F. Ogundare 2010. Rate of timber production in a

tropical rainforest ecosystem of southwest Nigeria and its implications on sustainable forest management. *Journal of Forestry Research* 21, 225-230.

Aigbe HI, Akindele SO, Onyekwelu JC 2014. Tree species diversity and density pattern in Afi River Forest Reserve, Nigeria. *International Journal of Scientific and Technology Research* 3(10), 178-185.

Bada, S.O. 1986. Predicted basal area growth of *Guarea cedrata* (A. Chev.) Pellegr, in a Wet lowland rain forest. *Journal of tropical forest resources*, 2, 1-8.

Bahati J.B. 2005. Effect of logging on Environmental factors, Natural Regeneration and Distribution of selected mahogany species in Budongo forest reserve, Uganda. Thesis submitted in candidature for the degree of Doctor of Philosophy of Makerere University of Kampala. 231pp.

Bazzaz, F. A and Pickott, S. T. A. 1980. Physiological ecology of tropical succession. A Comparative Review. *Ann. Rev. Ecol. Syst*. 11, 287-310.

Dike, M. C. 1992. Tree regeneration, recruitment and mortality in Nigerian tropical moist forest. PhD Thesis University of Ibadan, Nigeria.

D'Hoore, J. L. 1964. Soil map of Africa. Scale 1:5,000,000 (explanatory monograph). Publ. 93. Commission Technical Cooperation in Africa, Lagos, Nigeria. University Press, Ibadan.

FAO/UNESCO 1988. Soil map of the world: Revised legend. World Soil Resources Report No. 60.

Hawthorne, W. D. 1993. Forest Regeneration after logging. Funding of a study in the Bia South Game Production Reserve, Ghana. ODA Forestry series No. 3. 52 pp.

Isichei, A. O. 1995. Omo biosphere reserve, current status, utilisation of biological resources and sustainable management. UNESCO South-South Cooperation Programme. Paper 11.

Isikhuemen, E. M. and Ikponmwonba, O. S. 2020. Okomu plateau forest and associated wetlands in southern Nigeria: Status, threats and significance. *International Journal of Hydrology*, 4(1), 31 – 40. DOI: 10.15406/ijh.2020.04.00223.

Isikhuemen, E. M. and Oyibotie, G. O. 2017. Impact of Tropical Shelterwood System on the Heterogeneous Forests of South-Western Nigeria. *Journal of Environment & Sustainable Development* 3 (2), 8 – 17.

Isikhuemen, E. M. 2014. Rainforest in Southern Nigeria: Role of Forestry Institutions. *UNU-INRA Working Paper* United Nations University-Institute for Natural Resources in Africa, Accra, Ghana. 64p. http//: www.inra.unu.edu

Isikhuemen, E. M. and Edore, A. A. 2016. Assessment of Tree Diversity and Floristic Composition in a Planted Forest in University of Benin, Benin City, Nigeria. *Journal of Forest Science and Environment*, 1 (2), 37 – 43.

Isikhuemen, E.M and Iduozee, O.F. 2008. Degraded Forest in Protected Landscapes: prospect of Biodiversity Rehabilitation in Urhonigbe Forest Reserve, Edo State, Nigeria. In: Parrottai J.A; A. Oteng-Yeboah, and J. Cobbinah (eds.) Vol. 23: p. 220. Traditional Forest Related Knowledge and

Sustainable Forest Management in Africa l. IUFRO World Series.

Isikhuemen, E. M. and Ola-Adams, B. A. 2011. Tree Population Dynamics in a Protected Rainforest Ecosystem in Urhonigbe Forest Reserve, Edo state, Nigeria. *Nigerian Journal of Forestry* 41 (1&2), 40 – 52.

IUCN 2015. Red List of Threatened Species. Version 2015-4. <www.iucnredlist.org>. Downloaded on 30 November 2015.

Jones, E.W. 1956. Ecological studies on the rainforests of southern Nigeria IV. The plateau forest of Okomu Forest Reserve. Part 2: The regeneration and history of the forest. *Journal of Ecology* 44(1), 83-117.

Keay, R. W. J. 1989. Trees of Nigeria. Clarendon Press, Oxford. 476 pp.

Kio, P.R.O. 1978**.** Stand development in naturally regenerated forest in South Western Nigeria. Ph.D. Thesis. University of Ibadan, Nigeria.

Kleinman, *A.* 1978. Concepts and a model for the comparison of medical systems as cultural systems. Social Science & Medicine, 12(2-B), 85–93.

Kent, M. and Coker, P. 1992. Vegetation Description and Analysis: A Practical Approach. Belhaven Press, London.

Lancaster, P. C. 1960. Investigation into the methods of obtaining and encouraging the growth of natural regeneration after exploitation in tropical high forest in Southern Nigeria. *Nigeria Forest Information Bulletin (New series)* No. 8 Fed. Govt. Printer, Lagos.

Mervart, J. 1972. Growth and mortality rates in the natural high forest of western Nigeria. *Nigeria Information Bulletin,* No. 28.

Michael. S. Philips 1994. Tree and Forest. 2nd Edition, 56pp.

Oguntala, A. B. and Soladoye, M. O. 2000. Endangered forest ecosystems. Okomu Forest Reserve: Its ecology and Management. Forestry Research Institute of Nigeria. National Agricultural Research Project (World Bank Assisted) PRP. No 105.

Okali D. U. U and Onyeachusim, H. D. 1991. The ground flora and rain forest regeneration At Omo Forest Reserve, Nigeria. pp. 273-283. *In:* Rainforest regeneration and management (Ed.) A. Gomez Pompa, T.C. Whitmore and M. Hardley UNESCO / Parthenson, Paris.

Okali D. U. U., 1975. The case of conservation of our forest wealth. *Obeche* 11, 8-11.

Oldeman, R. A. A. and Dijk van, J. 1986. Tree characteristics silvigensis and architectural diversity. Pp. 18-20. *In:* Malcoln Hardley (ed). Rain forest regeneration and management, workshop. Special issue 18. Biology International/UNESCO. .

Onyeachusim, H. D. 1985. Ecological studies in Omo Forest Reserve, South Western Nigerian with particular reference to tree seed germination patterns, ground flora dynamics and litter standing crop, M. Phil. Thesis. University of Ibadan. 495 pp.

Onyekwelu J.C., Mosand l R. and Stimm B. 2008. Tree Species Diversity and Soil Status of Primary and Degraded Tropical Rainforest Ecosystems in South-Western Nigeria. *Journal of Tropical Forest Science* 20(3), 193–204.

Plumptre, A.J., 1994. The importance of ''seed trees'' for the natural regeneration of selectively logged tropical forest. *Comm. For. Rev*. 74, 253–258.

Redhead, J. F. 1971. Timber resources of Nigeria. The Nigeria Journal of Forestry 1(1), 1-11.

Richards, P. W. 1952. The tropical rainforest. Cambridge University Press. 450 pp.

Sayer, J. A.; Harcourt, C. S. and Collins, N. N. 1992. The conservation atlas of tropical forest. Africa. IUCN. 239 pp.

Shaffer, M. L. (1981). Minimum population sizes for species conservation. *Bioscience*, 31, 131 – 134.

Shell. 2006. SPDC/NCF/Edo State Biodiversity Action Plan Project for Urhonigbe Forest Reserve, Edo State, Nigeria, 182pp.

Whitmore, T. C. 1998. An introduction to tropical rain forests. 2nd Edition. Oxford University Press. 282pp.