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Original Article

Structural Characterization of Island Rainforests and Secondary Groves in Southern Nigeria

Emmanuel Ofudjaye Ndakara, PhD[1*] *& Odafivwotu Ohwo, PhD*[2]

[1] Delta State University, PMB 1 Abraka, Delta State, Nigeria.
[2] Niger Delta University, PMB 071 Wilberforce Island, Bayelsa State, Nigeria
[*] Author for Correspondence ORCID ID: https://orcid.org/0000-0001-8622-7342; email: ndakaraoe@delsu.edu.ng

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Keywords: *Biodiversity Conservation, Ecosystem Management, Island Rainforest, Rainforest Attributes, Tree Species Diversity.*

ABSTRACT

This study characterized the structural attributes of island rainforests and secondary groves within Orogun region in southern Nigeria. The quasi-experimental design was used, and the vegetation structural characteristics were determined in both secondary groves (experimental sites) and island rainforests (control sites). The randomized systematic sampling was employed in dividing the study area into 6 zones which were selected upon the presence of mature rainforest islands and secondary groves respectively. Six plots were sampled in each ecosystem. Tree heights, tree girths, and plot sizes were the data collected. Both secondary groves and island rainforest plots were measured to first determine uniformity in the area covered by the trees, after which, size of 200 ft X 100 ft was chosen as the uniform area of plot from which data were gathered. Tree girths at breast height were determined using measuring tape; while tree heights were determined by the use of Abney level and measuring tape. The 15.0 version of the Statistical Package for the Social Sciences (SPSS) was used in the statistical tests of the stated hypotheses. Statistical results showed that t-value = 7.05, P(0.001) > 0.05 for tree heights; and t-value = 3.122, P(0.026) > 0.05 for the tree girths. The mean differences in the structural characteristics between the secondary and mature island rainforest were significant at 0.05 alpha level. This implies that trees within island rainforests are significantly taller and bigger. The higher structural attributes of the island rainforest revealed that over time, conservation of rainforest trees could positively impact on its structural attributes. Therefore, ecosystem-based management approach was recommended for the management and conservation of the rainforest trees and covers.

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INTRODUCTION

The rainforest ecosystem forms a veritable basis from which a considerable part of human populations draw their livelihood (Ndakara, 2016). Despite the immense importance of this ecosystem, different human and natural activities like farming, lumbering, bush burning, fuel-wood harvesting and resources exploitation over the years, have negatively affected the structural features of the vegetation thus, reduced the contiguous evergreen multi-layered rainforest cover to discontinuous pattern (Okwuokei & Ndakara, 2022) while reserved sacred areas now feature as rainforest islands (Ndakara, 2012a).

Environmental importance of the rainforest trees have been relegated to the background owing to rapid human population growth and urbanization leading to resultant effect on reduced tree heights, girths and extent of native species of trees in the adjacent mature rainforest, giving room for secondary re-growth (Ndakara, 2012b). This, according to Efebeh (2017) has effect on regional development. The trees are no longer there to serve as wind breakers, desert encroachment is on the increase, soil erosion becomes rapidly accelerated, while the mutual interrelationships maintained between humans and trees in terms of oxygen – carbon (IV) oxide exchange is also affected (Salami & Jibo, 2019; Fashing, Forrestel, Scully & Cords, 2004). The possibility of re-forestation would have been a panacea but for the difficulty in regeneration of indigenous rainforest tree species, the practice of their re-growth has become so negligible, owing to the long period it probably takes for an indigenous rainforest tree species to grow to maturity and attain equilibrium with the regional climate (Ndakara, 2012c).

When a part of the rainforest is cut down for any use, the trees hardly regenerate (Amiolemen, Iwara, Ndakara, Deekor & Ita, 2012). However, after certain time range, fallows begin to set in, which further develop into secondary re-growth without the original structural characteristics of a typical rainforest (Okwuokei & Ndakara, 2022; Ndakara, 2009). The trees take a very long period of time to grow into maturity, which in the process, affects both the tree heights and girths as their measures of biomass parameters. The resource values of the secondary re-growth are never at equilibrium with the original rainforest cover that depicts multi-layer and multi-species bound ecosystem (Peng, Hu & Yu, 2014; Adekunle, Adewole & Akindele, 2013). When trees are deliberately not allowed to grow to mature stage before they are cut down for timber purpose, the resource value is reduced because of the limited size of the trunks which are essential for the timber production. As shields and habitat to organisms, many of the animals which inhabit the typical rainforest are now reported to be scarce because the trees which originally protect them as shelter are no longer there. In another vain, the resource importance of trees with respect to mineral production is highly affected amongst other factors (Obi & Ndakara, 2020).

Similar to the significant importance that water (Awaritefe & Nwabuishi, 2023; Ohwo & Ndakara, 2022a; Nwabuishi & Awritefe, 2022), and agriculture play in human cultures, lumber and fuel-wood have also played significantly prominent roles (Ukoji & Ndakara, 2021). Rapidly growing economies have an impact on anthropogenic disturbances as well. In 1995, the economy of developing nations rose by almost 6% compared with the 2% growth rate of industrialized nations. New neighbourhoods, cities, and city expansions will all arise as the world's population rises (Ohwo & Ndakara, 2022b; Funkami, 2015).

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Different studies have investigated the rainforests attributes in different regions of the world. Some of such studies were conducted by Fashing et al. (2004), Ndakara (2009), Adekunle et al. (2013), Peng et al. (2014), Fukami (2015), Salami and Jibo (2019), Ndakara and Ofuoku (2020), Okwuokei and Ndakara (2022), Ndakara and Okwuokei (2022). However, from these studies, the aspect of characteristics analysis of structural attributes within the secondary and island rainforests covers have not been adequately documented, hence this study. This will further re-affirm or reject the findings from several studies carried out on rainforest islands.

Study Hypotheses

The following hypotheses were tested in this study:

- There is no significant difference in the height of trees between the secondary groves and island rainforests within Orogun region of southern Nigeria.
- There is no significant difference in the girths of trees between the secondary groves and adjoining mature island rainforests within Orogun region of southern Nigeria.

MATERIALS AND METHODS

Study Area

This study was conducted within Orogun region of Southern Nigeria. This region is geographically located between latitudes $5^0$20'N and $5^0$36'N as well as between longitudes $5^0$30'E and $6^0$06'E (*Figure 1*). This study area falls within the humid equatorial climate of AF Koppen's classification (Ndakara & Eyefia, 2021; Ndakara, 2014). The vegetation of Orogun region comprises the moist lowland evergreen rainforest, riparian cover, and derived savannah landscape. The natural rainforest which used to be continuous in distribution is now discontinuously degraded, while remnants of the few original forest cover feature as islands within restricted areas (Ndakara, 2012a). According to Ndakara (2012b), the soils are mainly of oxisols, ultisols and psalments in line with the United States soil classification taxonomy; while in the regional grouping, the soils of this region are classed into mesomorphic and hydromorphic soils, in line with the United States Department of Agriculture Taxonomy (Ndakara, 2012c).

Methodology

The study made use of quasi experimental design, with focus on the secondary re-growth rainforest area as experimental sites, using the island rainforest as control sites. The randomized systematic sampling was used in dividing the study area into 6 zones. The selection of these zones was based on the presence of mature island rainforests within conserved areas where human exploitations have not impacted on; as well as the presence of mature secondary groves that have attained over 80 years from history. Six (6) plots each were chosen from the secondary rainforest and the island rainforest respectively, giving a total of 12 plots sampled in the 2 ecosystems. The rainforest structural characteristics (tree girths and heights) which represent the biomass parameters of the standing trees, as well as the size of rainforest areas were collected from the secondary and island rainforests. Within the ecosystems, secondary rainforest and island rainforest covers were measured to first determine uniformity in the areas covered by the trees, after which, size of 200 ft x 100 ft (60 m x 30 m) was chosen as the uniform area from which data for the study were collected using 20 m x 10 m quadrats. Tree girths at breast height (GBH) were determined using measuring tape; while tree heights were determined by the use of abney level, measuring tape, ranging poles and arrows. The principle of trigonometry was applied to get tree heights through the angles of elevation of the top of trees using abney level. The exact heights of the trees were determined using the formula: Tan Θ^0 = Opposite / Adjacent; Where: Θ^0 represents the measured angle.

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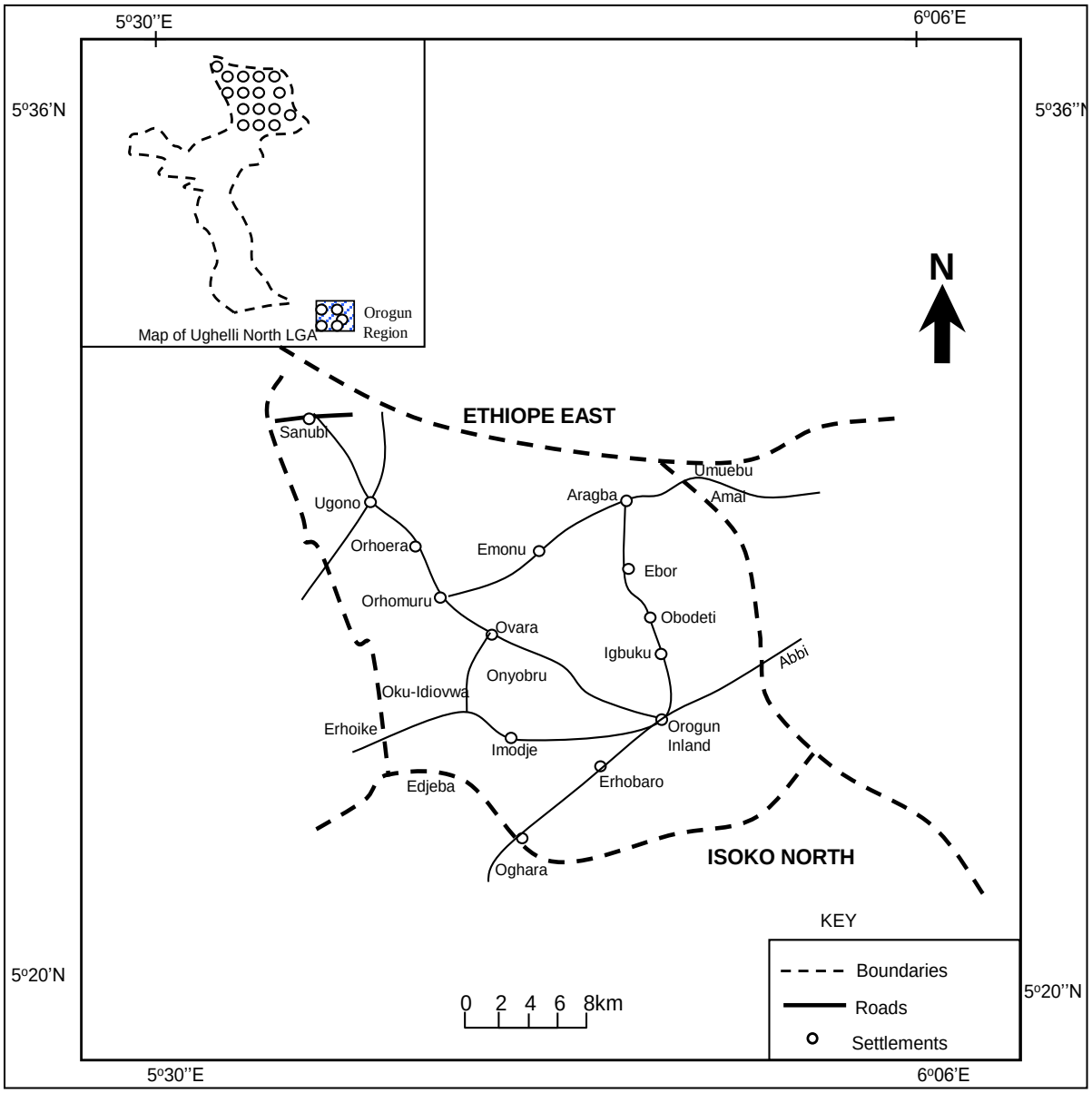
Figure 1: Map of Orogun region



Source: Modified after Ndakara, 2014

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Figure 2: Map of Ughelli North Local Government Area

Source: Adopted from Delta State Map, Ministry of Lands and Survey, Asaba, 2014

RESULTS AND DISCUSSION

Tree Heights (TH) in Secondary Groves and Island Rainforests

The THs in secondary groves and island rainforests varied across the region, as well as between the secondary re-growth and island rainforests. This is because the adjoining island rainforests are mature forest covers within restricted areas. The island rainforests represent the typical natural rainforest with tall trees which are structurally stratified. The THs are presented in *Table 1* below.

Table 1 shows the mean, SD and CV for the height of trees in secondary groves and island rainforests within Orogun region. Trees in the island rainforest plots are taller than trees in the secondary rainforest areas. The mean THs of the tallest tree is 36.0 M within the mature rainforest, while the mean THs of the shortest tree is 28.9 M as observed in the secondary rainforest. Trees within secondary rainforest are shorter possibly due to anthropogenic disturbances, while trees within mature rainforest are taller because they were not exposed to frequent disturbances like the secondary rainforest areas. These findings are in

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tandem with the results reported by Okwuokei and Ndakara (2022).

Test of hypothesis was carried out to ascertain if there was any significant difference in THs between the secondary and island rainforests using the paired student's t-test statistics at 0.05 alpha level.

Table 1: The Mean, Standard Deviation (SD) and Coefficient of Variation (CV) of Tree Heights in the Secondary Groves and Island Rainforests

Sites	Tree Heights in Secondary Groves			Tree Heights in Island Rainforests		
	Mean	S.D	C.V (%)	Mean	S.D	C.V (%)
1	30.0	13.3	44.3	35.0	14.2	40.6
2	32.4	13.7	42.3	35.1	14.2	40.5
3	28.9	13.1	45.3	33.7	14.1	41.8
4	30.2	13.3	44.0	34.6	14.2	41.0
5	29.3	13.2	45.1	36.0	14.6	40.6
6	31.1	13.5	43.4	33.8	14.0	41.4

Authors Field work, 2023

From *Table 2*, the t-value = 7.05, degree of freedom (df) = 5 and P(0.001) < 0.05. The mean difference in THs between the secondary groves and island rainforests is significant at 0.05 alpha level. Therefore, the null hypothesis which states that there is no significant difference in the height of trees between the secondary groves and island rainforests within Orogun region of southern Nigeria is rejected. This is as to be expected since trees in the secondary re-growth rainforest are shorter in mean heights than those in the adjoining mature island rainforest areas, as also observed in the study carried out by Ndakara (2009). Significant difference in biomass parameters of trees between natural and degraded forest covers were reported in the studies by Adekunle et al, (2013), Ndakara (2012b). The much taller trees observed in the adjoining island rainforests could be attributed to the impact of conservation of the forest which were not exposed to degradation activities of man within the region.

Most of the island rainforests were areas conserved as sacred groves where native and traditional rules disallow the practice of human activities that could lead to ecosystem degradation within the region. Conversely, the much lower mean height of trees within the secondary regrowth could be accounted for, by the earlier human activities that reduced the tree heights, while attainment of equilibrium with regional climate by indigenous rainforest tree species takes a very long period of time. The implication of the reduced tree height to wood resource importance is that forest degradation leads to reduction of wood resources and biomass within the rainforest ecosystem.

Table 2: Paired Samples T-Test Output for the Differences in the Mean Height of Trees between the Secondary Groves and Island Rainforests

Biomass Parameter	Paired Samples	Mean	Paired S.E.M	Paired Differences (95% CI)		t-value	df	Sig (2-tailed)
				Lower	Upper			
Tree Height	Secondary groves Island rainforest	30.3167 34.7000	0.6215	5.9810	2.7857	7.053	5	0.001

Tree Girths (TGs) in Secondary Groves and Island Rainforests

The TGs in secondary groves and island rainforests in Orogun region are not the same. They varied between the secondary rainforest and the island rainforest. This is because the island rainforests contain trees with bigger girths than the secondary re-growth rainforest. The TGs are presented in *Table 3*.

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Table 3: The Mean, SD and CV for the TGs in Secondary Groves and Island Rainforest

Sites	Tree Girths in Secondary Groves			Tree Girths in Island Rainforest		
	Mean	S.D	C.V (%)	Mean	S.D	C.V (%)
1	3.02	3.19	105.6	3.28	2.20	67.1
2	2.89	3.06	105.9	3.37	2.28	67.6
3	2.97	3.09	104.0	3.15	2.18	69.2
4	3.00	3.11	103.7	3.19	2.26	70.9
5	2.98	3.04	102.0	3.40	2.17	63.8
6	2.86	3.03	105.9	3.95	2.27	57.5

Authors Field work, 2023

Table 3 shows the mean, SD and CV for the TGs in secondary rainforest and mature island rainforest in Orogun region. Trees within island rainforest were bigger than trees within secondary rainforest areas. The mean girth of biggest tree is 3.95 M within the island rainforest plots, while the smallest mean girth of 2.86 M is found in the secondary re-growth rainforest plots. This finding is in line with findings reported in the study by Ndakara (2009). Trees in the secondary rainforest were smaller in girths because of anthropogenic disturbances, while trees within mature island rainforest were bigger because they were not exposed to frequent disturbances like the secondary rainforest areas that were tampered with before conservation efforts. These results are in tandem with the results presented in the studies by Fahrig (2013). Another hypothesis was tested to ascertain the difference in the TGs between the secondary and adjoining mature island rainforests in Orogun region at the 0.05 alpha level.

Table 4: Paired Samples T-Test Output for the Differences in the Mean Girths of Trees between the Secondary Groves and Island Rainforests

Biomass Parameter	Paired Samples	Mean	Paired S.E.M	Paired Differences (95% CI)		t-value	df	Sig (2-tailed)
				Lower	Upper			
Tree Girth	Secondary groves Island rainforest	2.9533 3.3900	0.1399	0.7962	0.0771	3.122	5	0.026

From *Table 4*, the t-value = 3.122, degree of freedom (df) = 5 and P (0.026) < 0.05. The mean differences in the TGs between the secondary and mature island rainforest is significant at 0.05 level of confidence. Therefore, the hypothesis which states that there is no significant difference in the girths of trees between the secondary groves and adjoining mature island rainforests within Orogun region of southern Nigeria is rejected. Therefore, there is a significant difference in the TGs between the secondary groves and the adjoining mature island rainforests within Orogun region of southern Nigeria. This finding is in line with findings reported in the study by Ndakara (2009).

The much bigger trees observed in the adjoining island rainforests could be attributed to the impact of conservation of the forest which were not exposed to degradation activities of man within the region. Most of the island rainforests were areas conserved as sacred groves where native and traditional rules disallow the practice of human activities that could lead to ecosystem degradation within the region. Conversely, the much smaller mean girths of trees within the secondary regrowth areas could be accounted for by the earlier human activities that reduced the tree girths, while attainment of equilibrium with regional climate by indigenous rainforest tree species takes a very long period of time. The implication of the reduced tree girth, like that of the reduced tree heights to wood resource importance is that, forest degradation leads to reduction of wood resources and biomass within the rainforest ecosystem.

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CONCLUSION AND RECOMMENDATIONS

This study was based on the analysis of the structural characteristics of island rainforests and the secondary groves in southern Nigerian rainforest environment. Tree heights and girths were examined to ascertain the levels of influence on the structural characteristics of the rainforest relics dominating and featuring prominently as rainforest islands, and the mature secondary groves. Trees in the secondary rainforests were observed to be shorter, obviously due to earlier anthropogenic disturbances before being conserved, while trees within mature island rainforests were taller because they were not exposed to disturbances and exploitations like the secondary groves. Also, trees within mature island rainforests were observed to be bigger than trees within secondary groves. Trees within secondary groves are smaller in girths because of anthropogenic disturbances, while trees within mature island rainforest are bigger because they were not exposed to frequent disturbances like the secondary groves. Statistical analyses on the differences in the vegetation structural characteristics revealed that the mean differences in the heights and girths of trees between the mature secondary and island rainforests were significant at 0.05 alpha levels.

The higher structural attributes of the island rainforest reveal that conservation of the rainforest area can highly improve its attributes. Therefore, ecosystem-based management approach is recommended for the management and conservation of the rainforest covers.

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