# MANGROVE-FRESHWATER SWAMP TRANSITION FOREST LANDSCAPE IN THE NIGER DELTA: SPECIES DOMINANCE AND DIVERSITY

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## Abstract
Transition zones in forest ecosystems are suitable landscapes for understanding species interactions between adjacent ecosystems. This study sought to understand the biodiversity patterns and species dominance of a freshwater-mangrove transition zone in the Niger Delta and likely environmental change concerns. To achieve this, a total of 8 plots that are 1 hectare each were set up randomly across the delimited zone and used to conduct a vegetation inventory. Trees that were ≥ 10cm diameter at breast height (130cm) were identified to species levels and their results were summarized with species importance values and biodiversity indices. In all, 55 plant species within 30 families were found across the plots. More than 50% of the species were dominated by *Rhizophora racemosa*, *Elaeis guineensis, Raphia* spp, and Lannea welwitschii Engl.; with species importance values of 72.94, 64.22, 18.17 and 8.35, respectively. Species diversity ranged from 2.23 to 2.83 and the number of species varied from 29 to 42 across the plots. Though the diversity were lower than what obtains in tropical ecosystems (like lowland rain forests), they were still much higher than what the mangrove ecosystem supports. Environmental conditions in the transition zone enabled mutual species occurrence and supported community coexistence of species more than what would normally be obtainable in single ecosystems. Biodiversity conservation of the landscape is advocated as the zone serves supportive role as important refuge for species in both mangrove and freshwater landscapes currently and more importantly as the effects of environmental change become more glaring across the region.

**Keywords:** biodiversity, conservation, environmental change, tropical, wetlands

## Introduction
Transition zones of forest ecosystems are ecological boundaries that enclose homogenous landscapes. These ecotones are seen between ecosystems or biomes at different spatial scales from global to local scales and are characterized by different boundaries which are normally influenced by natural or anthropogenic factors. Such landscapes are seen to be shaped by physical changes in the environment (environmental ecotones), while its species are also seen to respond to environmental changes (biotic ecotones) (Fortin et al. 2000). Across the Niger Delta swamp forest zone, they are mostly seen between the mangrove swamp and freshwater swamp forest and constitute major landscapes for the migration of flora and fauna between the two ecosystems. The two ecosystems are found in low relief

zones that are prone to annual flooding regimes and are both characterized by alluvial rich soils from the deposition after the flood. Mangrove forests literally live in two worlds at once. Growing in the intertidal areas and estuary mouths between land and sea, mangroves are comprised of salt-tolerant tree and other plant species from a range of plant families. They thrive in intertidal zones of sheltered tropical shores, islands and estuaries. Mangroves may be found as isolated patches of dwarf stunted trees- in very high salinity and/or disturbed conditions- or as lush forests with a canopy reaching 30 – 40 metres in height under suitable environmental conditions (FAO, 2007).

Freshwater swamp forests are found in freshwater environments unlike the mangrove swamp which are found in saline environments. They are not as diverse as other tropical forest ecosystems (especially the lowland forests) due to constraints in dispersal, germination and establishment which its flooded and seasonal extremes dictates (Corlett and Primack, 2011; Igu, 2016). Hence, it is characterized by a strong dominance of few tree species which tends towards monodominance across most of the landscapes (Koponen et al., 2004; Igu, 2016). Site conditions, disturbance regimes water quality and nutrient content of the soil play major roles in the variations seen across the ecosystem. While tree species richness in freshwater swamp forests are lower than what is found in tropical rainforests/lowland forest ecosystems (Igu and Marchant, 2018), they support more composition than the mangroves that are architecturally simple, often lacking an under storey of ferns and shrubs, and are ordinarily less species-rich than other tropical forests (Ajonina, 2008).

Since both ecosystems are distinct from each other, variation in species composition, dominance and community ecology are expected especially at large spatial scales. These variations in species composition and biodiversity indices that characterize tropical landscapes are expected points of inquiry that should precede forest management and conservation designs and implementation. Moving a step further to elucidate the specie characteristics and their spatial variations at the transition zones will help in providing suitable information for their conservation prioritization. Furthermore, since such zone constitutes where vegetation changes are most likely to reflect environmental changes (Jiang et al. 2012), understanding the inherent characteristics and features will help in addressing arising environmental concerns that may affect such landscapes. This work aims to elucidate the species composition, abundance and characteristics of the biodiversity indices in a freshwater-mangrove transition zone. Such landscape scale assessment will help to address conservation implications for which there is dearth in literature for the zone.

**Study area**

This study was carried out in freshwater-mangrove swamp forest ecotone in the Niger Delta. The region is generally a low lying vast sedimentary basin. The locality is characterized by a short dry season (normally between December and February) and a long rainy season which

mainly lasts from March to October. The flooding regime in the locality starts in August and tapers off in December. It is a generally marshy region with mainly medium to coarse unconsolidated sands, silt, clay, shale and peat. It is made up of alluvial soils that are either permanently or seasonally waterlogged (Areola, 1982). The soils across the landscape are fertile and support luxuriant vegetation growth and crops (agricultural activities). Average monthly maximum and minimum temperatures vary between 28$^{o}$C to 33$^{o}$C and 21$^{o}$C to 23$^{o}$C, respectively. The forest sites are located in Akoloma, Ogbia L.G.A, Bayelsa state (Fig 1).

**Vegetation data collection**

The transition zone used for data collection and enumeration were delimited with the vegetation map of Keay (1959). Survey method employed for the work was standard- square based plots that were 1 hectare each. Each of the 100 x 100 cm (1 hectare) plots were arranged in transects that were 1km apart between each transect and 500m between each of the plots. To ensure that none of the stems to be enumerated were omitted, each of the 100 x 100 cm plots were further divided into 20 x 20 cm plots. All the trees that were ≥ 10cm diameter at breast height (130cm) were identified to species levels in the field. Voucher specimen were collected for unidentified species and verified at the herbarium afterwards.

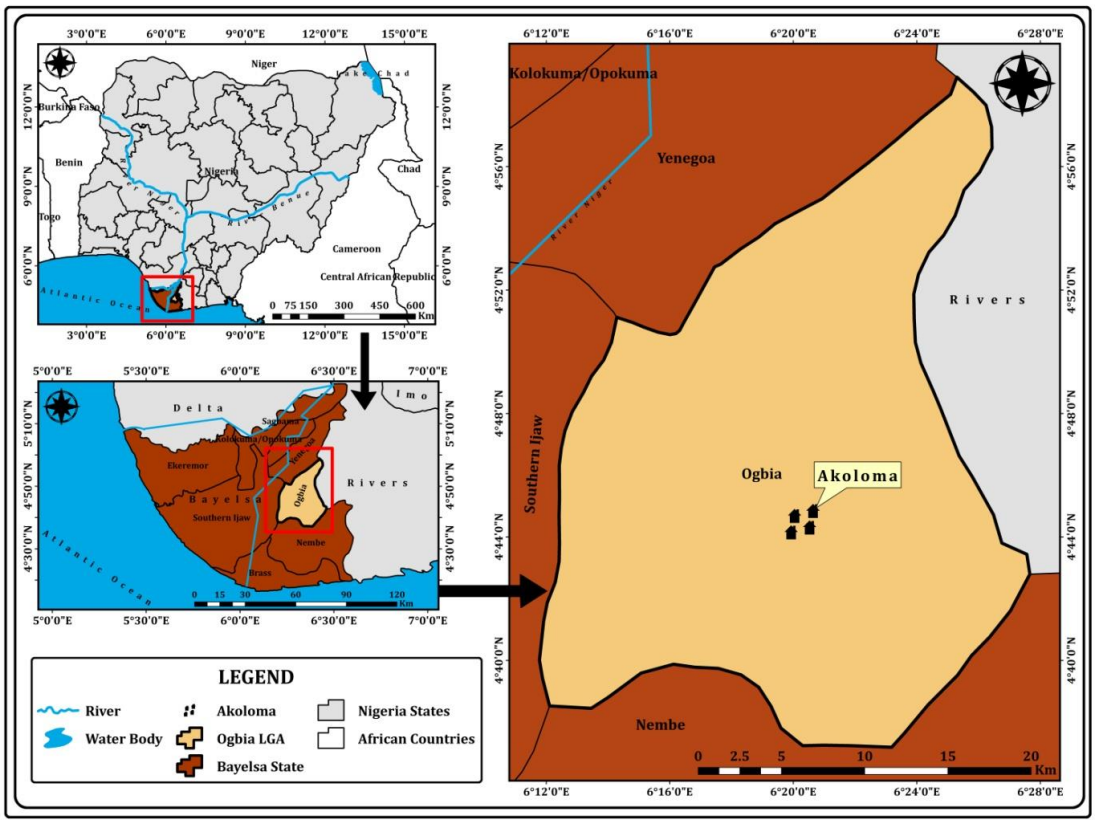



**Fig 1 Map of the study area with Bayelsa state and map of Nigeria inset**

**Data analysis**

Species importance values and biodiversity analysis were used to calculate and characterize the ecosystem as follows:

Species importance values (SIV) = Relative density + Relative frequency + Relative dominance ……. Equation 1

Where:

Relative Density = 100 X Number of stems of a species / Total number of stems

Relative frequency = 100 X Frequency of a species / Sum of all species

Relative dominance = 100 X Total basal area of a species / Total basal area of all species

Biodiversity indices were calculated as follows:

Shannon-Wiener index:

$$H' = -\sum_{i=1}^{s} pi \ln pi$$

Where $H^{l}$ is the Shannon-Weiner index, s is the total number of species, pi is the proportion of individuals in the ith species, and ln is the natural logarithm.

Pielou's evenness index:

$$E = \frac{\sum_{i=1}^{s} pi \ln pi}{\ln(S)}$$

Margalef's species richness index:

$$M = \frac{(S-1)}{lnN}$$

Where S is the total number of species in a community, N is the number of individuals and ln is the natural logarithm.

**Results**

**Species composition and abundance**

The sites across the forest location are made up of 55 plant species and 30 families. Species that were found across the plots in the forest location ranged from 29 to 42 (table 1). The abundant floristic composition of the forest are: *Rhizophora racemosa*, *Elaeis guineensis, Raphia* spp, and Lannea welwitschii Engl. (Fig 2); with species importance values of 72.94, 64.22, 18.17 and 8.35, respectively.

**Table 1 Biodiversity indices of the forest plots**

| Plot number | Stem abundance | Species richness index | Diversity | Evenness | Species number |
|---|---|---|---|---|---|
| 1 | 359 | 4.75 | 2.23 | 0.66 | 29 |
| 2 | 394 | 5.85 | 2.52 | 0.7 | 36 |
| 3 | 315 | 4.86 | 2.36 | 0.7 | 29 |
| 4 | 402 | 5.16 | 2.48 | 0.72 | 32 |
| 5 | 318 | 5.38 | 2.32 | 0.67 | 32 |
| 6 | 481 | 6.63 | 2.83 | 0.76 | 42 |
| 7 | 334 | 5.67 | 2.58 | 0.73 | 34 |
| 8 | 506 | 6.42 | 2.82 | 0.76 | 41 |

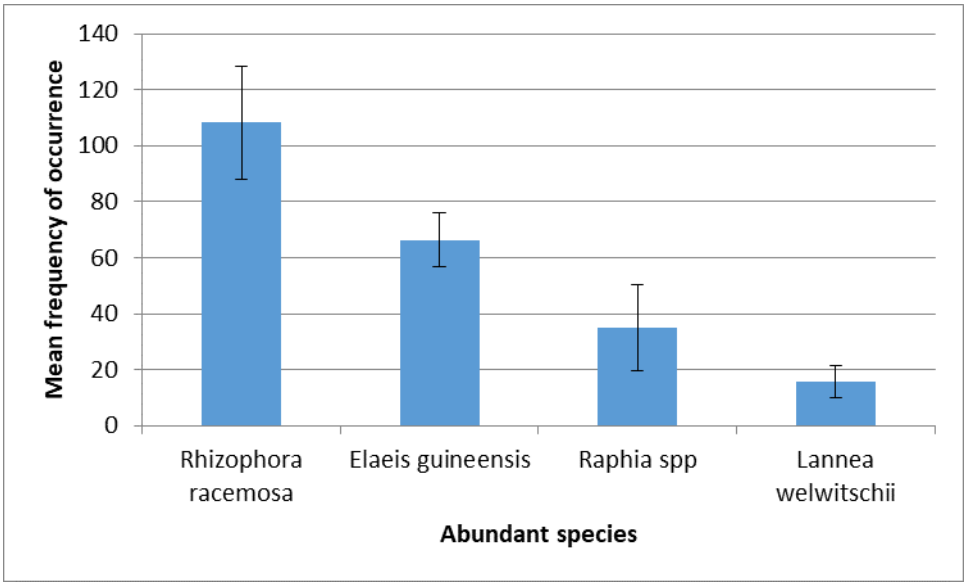



**Fig 2 Mean species abundance of the four most abundant species across the forest site (at 95% confidence intervals)**

## Biodiversity indices

Species richness was varied across the forest sites. This ranged from its highest index of 6.63 in the sixth plot to its least value of 4.75 in the first site, and a mean value of 5.16 ± 0.50. Species evenness ranged from 0.66 in the first plot to 0.76 in the sixth and eighth plots; with a mean value of 0.70 ± 0.03. Species diversity equally ranged from 2.23 to 2.83 in the first and sixth plots respectively (table 1).

## Discussion

Tropical ecosystems are epicentres of biodiversity and hosts to a wide array of species when compared to other ecosystems across the globe. However, within tropical ecosystems, swamp forests have lesser species generally; with mangrove ecosystem having the least (Igu, 2016). Mangrove ecosystems across the country are dominated by mangrove species as expected (FAO, 2005) and due to the high saline nature of the environment,

much of the other species that can thrive in the water logged soil strata (as is the case with freshwater terrain) still find it difficult to survive in the environment. While such constraining environmental conditions are largely responsible for its few species richness, this is different for the (mangrove-freshwater) transition zone which had considerable higher species richness (table 1). Transition zones are normally more heterogenous (internally) than the adjacent ecosystems (Danz et al. 2012) and so will accommodate more species than would be seen in the mangroves. This attribute enables species that are found in adjacent ecosystem (mangrove and freshwater swamp) to mutually coexist in the same ecological community. Such coexistence enhances better ecosystem stability and enables the zone to be more resilient and resistant to disease outbreak. The ecosystem is characterized by 55 species, but had the bulk of the species occurrence dominated by two notable species: *Rhizophora racemosa*, *Elaeis guineensis* (Fig 2). *Rhizophora racemosa* showed the highest occurrence and dominance in the transition zone since the saline conditions needed to promote it is found in the transition zone. Similar conditions apply for *Elaeis guineensis* species which had suitable environment in the transition zone as well as the disturbed state that was needed for reproduction and establishment (Igu, 2016).

Stem abundance and density across the forest sites (table 1) were within the range of what obtains in other tropical landscapes (Igu and Marchant, 2018). The stem abundance in the area were much since it is a secondary forest that had not attained a climax and so permitted the initial competition seen in forest ecosystems. Conversely, since the transition zone favoured some species presence more than others (dominant species; Fig 2), it meant that the stem abundance were actually concentrated in those species; which then had more frequency of occurrence than others. As the forest continues to grow, much of the mangrove species will grow and become established, dominating the landscape as is seen in mangrove ecosystems. As mangrove ecosystems in the Niger Delta continues to decline due to over-dependence on it for rural livelihood and resources (Mmom and Arokoyu, 2010), this zone will likely provide some resources for the region. On the other hand, the zone could be counted on to provide tangible biomass for regulating regional climatic processes and sequestering carbon at least at the landscape scale.

Swamp forests are natural habitats and suitable for the growth of species in the Arecacea family, mainly *Elaeis guineensis* and *Raphia spp*. These species which are among the dominants in the zone can be found in both the mangrove and freshwater ecosystems, hence they are found to have much occurrence in the transition zone. On the other hand, since the sites studied were both disturbed ecosystems and had sufficient moisture, it supported the Arecacea family. While *Elaeis guineensis* is best found in drained zones, *Raphia spp* thrives more in swampy areas (which is characterized by different durations of inundation with flood water). Such marshy zones are found in many landscapes across the Niger Delta (not just in the transition zones) and do not normally have much flora on them

compared to the better drained zones. This ability of *Raphia spp* to grow well in marshy zones could be harnessed properly in reforestation/forest regeneration of degraded marshy zones in the region. Moving a step further to ensure that other indicator species suitable for the transition zone are utilized alongside the aforementioned in restoring its degraded ecosystem, will promote better community ecology and reduce erosional processes associated with the landscape.

Transition forests provide good basis for understanding ecological processes of adjacent ecosystems and how future environmental scenarios might affect them. While the edaphic determinants of species occurrence and dominance will barely change over time, climatic factors will be more easily affected with environmental change. With the transition forest being characterized by the dominance of *Rhizophora racemosa*, the (vegetation) zone seems able to cope with likely climatic scenarios (becoming more wet and more flooded or maintaining same or similar current precipitation status). Furthermore, since the dominant species both thrive in freshwater and mangrove swamp forests, future climatic patterns are likely to only affect the (species composition in) transition zone slightly; since the transition line for adjacent ecosystems will likely remain unaltered or only advance or retreat within accommodating scales.

## Conclusion

Transition zones are ecologically diverse and good landscapes for suitable community ecological interactions. Across the forest plots, much species abundance and stem density were facilitated. Species diversity was low as seen in swamp ecosystems, but higher than what exists in mangrove ecosystems. Within the zone, species dominance concentrated on four species which exists in both freshwater and mangrove landscapes. The dominance pattern for the species show that they can cope with environmental change in the region and could be counted on to provide needed ecosystem services and functions for the zone.

## References

Ajonina, G.N. (2008). Inventory and modeling mangrove forest stand dynamics following different levels of wood exploitation pressures in the Douala-Edea Atlantic coast of Cameroon, Central Africa. PhD thesis, Albert-Ludwigs University, Germany.

Corlett, R. T. and Primack, R. B. (2011). Tropical rain forests: an ecological and biogeographical comparison (second edition). Wiley-Blackwell.

Danz, N. P., Frelich, L. E., Reich, P. B. and Niemi, G. J. (2012). Do vegetation boundaries display smooth or abrupt spatial transitions along environmental gradients? Evidence from the prairie-forest biome boundary of historic Minnesota, USA. Journal of Vegetation Science, Doi: 10.1111/jvs. 12028.

FAO. (2005). Global forest resources assessment. Thematic study on mangroves, Nigeria country profile. Forest resources division, Rome.

FAO. (2007). The world's mangroves. FAO forestry paper, Rome.

Fortin, M. J., Olson, R. J., Ferson, S., Iverson, L., Hunsaker, C., Edwards, G., Levine, D., Butera, K. and Klemas, V. (2000). Issues related to the detection of boundaries. Landscape Ecology 15: 453-466.

Igu, N. I. (2016). Freshwater swamp forest ecosystem in the Niger Delta: Ecology, Disturbance and Ecosystem services. PhD thesis, University of York, UK.

Igu, N.I. and Marchant, R. (2018). Floristic composition and diversity of freshwater swamp forests in the Niger Basin of Nigeria. Open Journal of Forestry, 8: 567-584

Jiang, J., Gao, D. and DeAngelis, D. L. (2012). Towards a theory of ecotone resilience: coastal vegetation on a salinity gradient. Theoretical Population Biology 82: 29-37.

Keay, R.W. (1959). An outline of the Nigerian vegetation. Federal Department of Forest Research. Federal Ministry of Information, Lagos.

Koponen, P., Nygren, P., Sabatier, D., Rousteau, A. and Saur, E. (2004). Tree species diversity and forest structure in relation to microtopography in a tropical freshwater swamp forest in French Guiana. Plant Ecology 173, 17-32. Kluwer Academic Publishers, Netherlands.

Mmom, P.C. and Arokoyu, S.B. (2010). Mangrove forest depletion, biodiversity loss and traditional resources management practices in the Niger delta, Nigeria. Resource journal of Applied sciences, Engineering and Technology 2(10: 28-34. ISSN: 2040-7467. Maxwell scientific organization.