Original Research Article

Empirical Study of Forest Regeneration Potentiality of Old Afaka Forest Reserve, Kaduna State, Nigeria

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Abstract: Forest Reserve Areas can sustain themselves of their valuable species through an effective regeneration system. At present, most of the preserved forest areas are been vandalized and valuable species are illegally removed. Based on the ecological problems which lead to the extinction of valuable flora and fauna species, it became necessary to study species diversity and their potentiality for regeneration in old Afaka Forest Reserve. Four (4) plots (A–D) of 100m x 100m were laid in each plot. Point centred quadrant method of sampling was used. Transect were selected on pure random basis where data were collected on species diversity and families, density of woody stem, diameter class distribution, regeneration potentials and relative frequency. 21 families with a total of 181 species were obtained on the species diversity at old Afaka Forest Reserve. The densities of woody plant varied between 625.01 - 961.51 per hectare in plots A, B, C and D. While the highest number of trees in diameter-class distribution were apportioned to 10 – 19cm class interval in plots A, B, C and D respectively. Diameter class 50cm and above had the lowest number of trees allocated to it. The regeneration potential of the diversified species was very poor, which has a great implication for regeneration and conservation of the various species encountered. Although *Isoberlinia doka Craib &Stapf.*had the highest regeneration potential from each of the examined plots followed closely by *Acacia senegal, Parkia biglobosa* and *Terminalia avicennoides Gull &Peer.* Important woody plants of economic importance, like *Triplochiton scleroxylon k. schum* had zero regeneration potential. However, it is necessary to understand the phenology of the forest reserve. To study whether seeds or fruits produced are under adequate physiological conditions to germinate and grow into wildlings for regeneration purposes.

Keywords: Conservation, Forest regeneration, Forest reserve, Potentiality, point centred, vandalized.

INTRODUCTION

Biological diversity conservation strategies that include a variety of individual management strategies for specific species are neither feasible nor effective [1-3]. As an alternative, 'coarse-filter' management strategies focus on maintenance of broad patterns of forest age and composition under the assumption that this will provide the necessary habitat to support a wider variety of native species [4, 5]. Native species are assumed to be adapted to the natural disturbance regime of their environment; thus, management that stimulates the natural disturbance regime has become a popular approach to maintaining species diversity as well as ecological integrity [6, 7]. With this approach, natural processes are to be protected, which include forest regeneration after disturbance such as fire or logging [8]. A central component of biodiversity conservation in managed forest landscape is successful regeneration of natural tree species mixes after logging [9, 10]. This often proves to be a substantial challenge. Site preparation and planning of tree seedlings have been widely adopted as strategies to ensure rapid and successful postharvest regeneration. These require a substantial silvicultural and financial investment, however, and are not always successful in meeting legal regeneration standards let alone achieving a natural species mix. Although natural regeneration can be much less expansive and lead to more natural species mixes, its success depends on availability of seed sources, regeneration micro sites and micro environmental and biotic conditions favoring establishment and early survival of tree seedlings [11, 12].

There is necessity to conserve the forest resources because of their economic importance. Several direct as well as indirect benefits are available in the forest such as timber and non-timber products. Apart from timber products in the forest, plant foods such as leaves, seed nuts, fruits, tubers and roots stand as source of food income generation [13, 10]. Also, species of economic importance such as medicinal and aesthetic values can be kept in perpetuity in a well preserved forest. The forests of Nigeria comprise of swamp forest, tropical rainforests and secondary forest regrowth. The lowland tropical rainforest was described by as a complicated mosaic of communities of different status and floristic composition [14]. Structurally, the forests consist of three layers – the tree layer, the shrub layer and the undergrowth. Many of the emergent species in the forest grow slowly and require fair amount of overhead shade in their early life in order to survive and thrive [15, 16]. But it is now recognized that many of them grow very rapidly in full light conditions [17].

The emergent species exist for a long period in a state of suppressed regrowth under shade of the canopy until a gap occurs which allows them to grow up. Forestry growth cycle consists of a mosaic gap-phase, build up phase and mature phase forests as explained by Van der Maarel [18]. At present most of the preserved forest areas are being vandalized and valuable species illegally removed. The only mean by which Forest Reserved Areas can sustain themselves of these valuable species, is through an effective regeneration programmes. NEST [19] indicated that 350,000 ha of forest and natural vegetation were lost in Nigeria. It led to problems such as desertification, soil erosion, declining soil fertility; flooding and extinction of important flora and fauna species [20, 21]. Forests are dynamic, seedlings germinate, grow, and compete with each other and with large trees. Some survive for hundreds of years. Changes will happen which will be predominant in the future forest depends not only on climate and soils but also on management decisions made today. Changes in forest composition will affect the quality and variety of forest resources available to future generations and wildlife [16]. Sustainable management of forest ecosystem is set as a goal by most nations [22, 15], and maintaining biological diversity is one important component of this [23].

High demands for timber and increasing accessibility are leading to increased exploitation of these high elevation forests. They are characterized by slow growth rates of post-disturbance regeneration and established trees. Thus meeting objections for regeneration of natural species mixes and sustainability of fiber and other ecosystem components can prove challenging [24, 25]. The only mean by which Forest Reserved Areas can sustain themselves of these valuable species, is through an effective regeneration programmes. Forest and natural vegetation lost in Nigeria every year due to anthropogenic activities are of great concerned. It led to problems such as desertification, soil erosion, declining soil fertility, flooding and extinction of important flora and fauna species [20]. Hence, necessitate the need to study the natural regeneration potentials of forest reserved areas so that species of economic significance, including non-timber forest products (NTFPs) and aesthetic values, can be maintained in perpetuity. The objective of the study is to assess the species diversity and potentiality for forest regeneration in Old Afaka Forest Reserve.

MATERIALS AND METHODS

Study Area

The study was carried out in Old Afaka Forest Reserve. Afaka is in Igabi Local Government Area. Igabi Local Government Area is located in the Northern Guinea Savanna region of Nigeria on latitude 10^0E 37^1N and 10^0 41^1N and longitude $7^0 47^1$E [26] Igabi local Government Area shares boundary with Kaduna South, Kaduna North, Giwa Local Government and Zaria Local Government areas of Kaduna State. It has an Annual rainfall of about 1000mm -1500mm per annum. Major crops grown in the area include maize, cassava, millet, sorghum, guinea-corn and water-melon. The area consists of different tribes and ethnic groups such as Yoruba's, Hausa, Igbo's, Fulani's, Gbagyi's and Hausa's. The area has an estimated population of about 570,00 people and covers an area of about 4556.95 square kilometers [27].

Sampling Procedure

Four (4) sampling plots of 100m x 100m were laid in Old Afaka Forest Reserve. Technique used was adopted from Cuttam and Curts, 1956 [28]; Oduwaiye *et al.,* 2002 [13]; Sodimu *et al.,* 2017 [29]. Point centred quadrant method of sampling was used in each of the selected plots. Transects were selected using systematic sampling method. The first one was selected on pure random basis. Along the direction of each transect, sampling points were taken at intervals of 5m which helps in getting sufficient sampling points and possible overlapping and duplication of units of measurement were avoided [10]. At each sampling point, the following parameters were assessed. Distance to four nearest woody plants, one in such quadrant.

Height of the tree

This is measured through the use of Haga altimeter.

Diameter of each tree

This is measured through the use of diameter tape.

Analytical Tools

Density

Densities of the woody stem in all the study plots were determined. The distance measured between sample points of each woody plant was used to obtain the density stem. The estimation was based on the formula;

$$D = \frac{10^4 \text{ stem ha}^{-1}}{d^2}$$

Where d^2 = is the average distance in m^2 [28, 10]

Diameter Class Distribution

Diameter class distribution was determined through the measurement of diameter of the woody stand in all the plots at DBH (1.37m height)

Regeneration Potentials

$$\text{Regeneration potential} = \frac{\text{Number of wilding of individual species}}{\text{Density of the woody stem}}$$

Relative Frequency

$$R.F = \frac{\text{Number of individual of the species}}{\text{Number of individual of all species}} \times 100$$

Species Abundance

Species abundance, indicating the number of species contained in the number of individual plants.

RESULTS AND DISCUSSION

Species Diversity and Families

Members of the families in acceding order include *Fabaceae>Combretaceae, Sterculiaceae>Verbanaceae* dominated the permanent protected area followed by members of *Annonaceae >Rhamnaceae> Anacardiaceae >Meliaceae* and to a lesser extent, some other families include *Sapotacea>Euphorbiaceae> Ochnaceae*and so on. The species that are most common in acceding order are *Isobanilia doka>Parkia biglobosa>Prosopis africana>Vitex doniana> Acacia senegal > Lawsonia inermis* Table-1). This result is in agreement with the work of Sodimu *et al.,* [10] that the first four (4) families dominated Old Afaka and Buruku forest Reserve with high percentages spread.

Density

The density of the woody stem as indicated in Table-2, revealed that plot C in permanent protected area had 961.51stem/ha which was the highest when compare to plot A, plot B and plot D with 857.64stem/ha, 760.72stem/ha and 625.01stem/ha respectively.

Diameter Class Distribution

Diameter class distribution of woody stems assessed in plot A, B, C and D; however, the number of trees assessed for diameter was 80, 125, 85and 80 respectively. The highest number of trees was apportioned to diameter class 10 – 19cm for each of the plots A, B, C and D, that was 40 trees, 60 trees, 75trees and 40 trees respectively, followed by diameter class 20 – 29cm (Fig-1). Diameter class 50cm and above had the lowest number of trees allocated to it. Perharps, this might be due to over exploitation and activities of illegal fellers in the reserve hunting for trees with bigger girth for conversion into sizeable wood. The above observation was in agreement with the work of Sodimu *et al.,* [10] who also noted that diameter class of trees between 10cm-19cm are commonly found in most forest reserves around Kaduna Northern Guinea Savanna eco-zones.

Table-1: Species Diversity and Families in Old Afaka Forest Reserve

S/No	Families	Number of Species	Percentage (%) Spread
1	*Fabaceae*	28	15.4
2	*Ebenaceae*	6	3.32
3	*Annonaceae*	8	4.42
4	*Anaccardiaceae*	7	3.87
5	*Combretaceae*	15	8.28
6	*Longaniaceae*	5	2.76
7	*Meliaceae*	7	3.87
8	*Rhamnaceae*	7	3.70
9	*Rubiaceae*	6	3.87
10	*Sapotaceae*	8	4.42
11	*Sterculiaceae*	10	5.53
12	*Verbanaceae*	7	3.87
13	*Papilioceae*	8	4.42
14	*Casalpiniaceae*	6	3.32
15	*Myristicaceae*	7	3.87
16	*Ochnaceae*	8	4.42
17	*Irvingiaceae*	10	5.53
18	*Chysobaniaceae*	6	3.32
19	*Euphorbiaceae*	8	4.42
20	*Lythraceae*	8	4.42
21	*Myrtaceae*	6	3.32
	TOTAL	***181***	***100***

Table-2: Density of Woody Plants at Various Plots in Old Afaka Forest Reserve

S/N	Site	Stem (ha^{-1})
1	Plot C	961.50
2	Plot A	857.64
3	Plot B	760.72
4	Plot D	625.01

Table-3: Regeneration Potential of Species in Old Afaka Forest Reserve

S/N	Species	Plot A	Plot B	Plot C	Plot D
1	*Prosopis africana*	0.00	*0.00*	*0.00*	*0.03*
2	*Entada Africana Gull &Perr.*	*0.01*	*0.00*	*0.00*	*0.00*
3	*Vitex doniana Linn.*	*0.00*	*0.00*	*0.00*	*0.01*
4	*Terminalia avicennoides Guill &Perr.*	*0.05*	*0.02*	*0.01*	*0.02*
5	*Macaranga hurifolia*	*0.00*	*0.00*	*0.00*	*0.00*
6	*Triplochiton scleroxylone K.Schum*	*0.00*	*0.00*	*0.00*	*0.00*
7	*Isoberlinia doka Craib&Stapf.*	*0.44*	*0.75*	*0.76*	*0.68*
8	*Annona senegalensis Pers.*	*0.00*	*0.05*	*0.00*	*0.00*
9	*Carissa adolia Linn.*	*0.01*	*0.00*	*0.00*	*0.00*
10	*Pilostigma thornningii (schum)*	*0.00*	*0.00*	*0.03*	*0.00*
11	*Acacia senegal (Houtt)*	*0.03*	*0.02*	*0.04*	*0.01*
12	*Lophira lanceolata Banks ex Gaertn.*	*0.01*	*0.00*	*0.00*	*0.00*
13	*Combretum ghasalense Engl.& Diels*	*0.01*	*0.00*	*0.01*	*0.00*
14	*Parkia biglobosa (Jacq) Benth*	*0.02*	*0.04*	*0.01*	*0.02*
15	*Parinari curatellifolia Planch.*	*0.00*	*0.02*	*0.00*	*0.00*

Table-4: Relative Frequency of Species in Old Afaka Forest Reserve

S/N	Species	Plot A	Plot B	Plot C	Plot D
1	*Terminalia avecinnoides Guill &Perr.*	5.850	8.492	6.462	8.739
2	*Khaya senegalensis Ders.*	0.278	0.450	0.303	0.000
3	*Vitellaria paradoxa C.F. Gaertn*	0.543	1.046	1.256	1.817
4	*Pilostigma thonningii(schum)*	4.403	2.063	5.229	2.008
5	*Annona senegalensis Pers.*	8.951	3.487	7.757	0.000
6	*Acacia Senegal(Houtt)*	67.208	56.010	46.644	45.372
7	*Lannea barteri (Oliv)*	1.733	0.699	0.000	1.205
8	*Gardenia imperialis(K .Schum)*	1.338	5.846	0.000	1.012
9	*Carissa adolia Linn.*	4.703	1.848	5.687	2.460
10	*Sterculia setigera Del.*	1.538	7.946	0.000	6.422
11	*Isoberlinia doka Craib&Stapf.*	8.188	20.541	7.653	14.879
12	*Entada Africana Gull & Perr.*	0.349	0.320	0.000	0.904
13	*Diospyros mespiloformis Hochst.*	0.368	0.000	0.000	0.304
14	*Prosopis Africana (Gull & Perr) Taub*	0.412	0.000	0.000	0.000
15	*Combretum ghasalens Engl.& Diels*	0.288	1.139	0.000	0.000
16	*Anogeisus liocarpus(DC) Gull &Perr*	6.850	0.000	0.000	0.501
17	*Parkia biglobosa(Jacq) Benth*	5.465	0.000	0.00	0.000
18	*Triplochiton scleroxylon K.Schum.*	0.890	0.000	1.711	0.000
19	*Vitex doniana Linn*	0.890	0.000	1.811	1.306
20	*Strychnos spinosa Lam.*	0.418	0.000	2.005	0.000
21	*Tectona grandis L.f.*	2.256	0.000	0.000	1.605
22	*Macaranga hurifolia Beille.*	0.000	9.692	1.247	6.745
23	*Parinari curitellifolia Planch.*	0.000	0.460	0.000	0.604
24	*Lophira lanceolata Banks ex Gaertn*	0.000	0.560	2.467	0.000
25	*Lawsonia inermis L.*	0.000	0.256	7.242	0.000
26	*Psidium guajava L.*	0.000	0.350	0.303	1.705
27	*Irvingia gabonensis(Bail)*	0.000	1.089	1.543	1.309
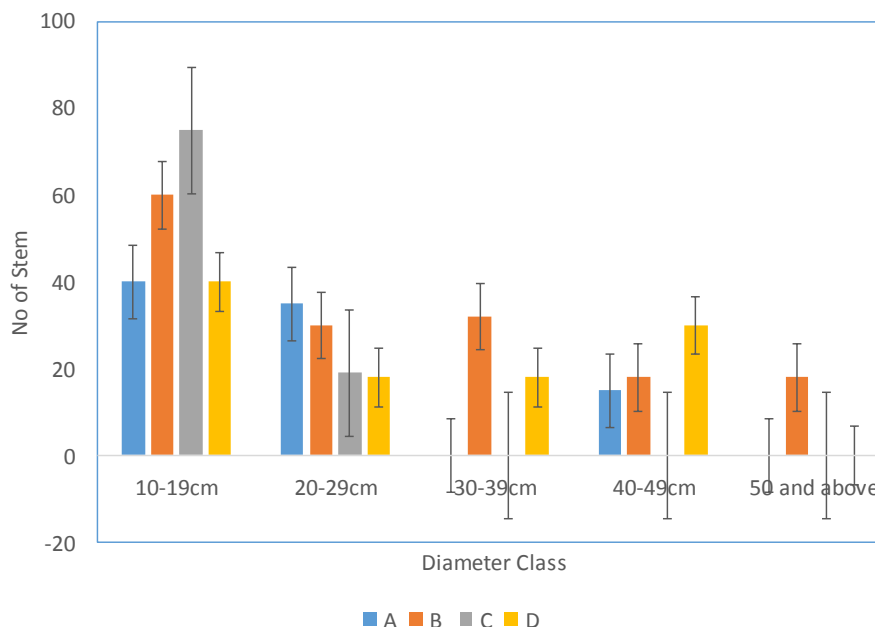
Fig-1: Diameter Class distribution of woody stem in plot A, B, C and D of Old Afaka Forest Reserve

Regeneration Potentials

The regeneration potential of the diversified species as indicated in Table-3 is very poor. It therefore, has a great implication for regeneration and conservation of the various species encountered. *Isoberlinia doka* had the highest regeneration potential from each of the examined plots in Old Afaka Forest Reserve; followed by *Acacia senegal*, *Parkia biglobosa* and *Terminalia avicennoides*. However, most of the important woody plants of economic importance like

Triplochiton scleroxylon, had zero regeneration potential. Regeneration potential of the most species is zero, owing to complete absent of mother trees which would have produced the wildlings within the assessed area. The results are in consonance with the works and observations of Oduwaiye *et al.,* [13]; Sodimu *et al.,* [29]; Sodimu *et al.,* [10].

Relative Frequency
In Table-4 plots A, B, C and D, 21, 19, 16 and 18 species were observed. In plot A, *Acacia senegal* showed the greatest occurrence with relative frequency of 67.2%, the species had some spread in plot B, plot C and plot D with relative frequency of 56%, 46.6% and 45.4%. This was followed by *Isoberlinia doka* in plots B and plot D with relative frequency of 20.5% and 15.9% respectively. However, in plot C *Acacia senegal* was closely followed by *Annona senegalensis* with relative frequency of 7.56% respectively. This is in agreement with the work of Sodimu *et al.,* 2020 [10] who observed that *I. doka* and *A. senegal* have better spread in Northern Guinea Savannah eco-zone.

CONCLUSION AND RECOMMENDATION
Conclusion
None of the tree species in protected area of Old Afaka Forest Reserve was observed flowering during the period of assessment. However, it could not be ascertained whether most of the diverse species had undergone generative phase or were still undergoing vegetative phase. From the analysis, it would be observed that most of the woody species were not regenerating themselves. There were cases when mother trees of the wildlings observed were absent from the plots or the wildlings of woody species were absent. This situation poses a great threat to conservation of the diverse species in the Forest Reserve.

Recommendation
Based on the findings, it is recommended that it is of paramount importance to understand the phenology of the forest reserve and, to study whether seed or fruits produced are under adequate physiological conditions to germinate and grow into wildlings for regeneration purpose. Otherwise, it will be very necessary to find means of regenerating the reserve either artificially or naturally for sustainability of the forest reserve.

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