CANOPY STRUCTURE OF SECONDARY FOREST IN THE FEDERAL UNIVERSITY DUTSE, JIGAWA STATE: COMPOSITION AND IMPORTANCE OF WOODY SPECIES

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K. D. Salami[1]*, K. J. Ilu[1], M. A. Odewale[2], A. H. Gidado[1] and S. U. Umukoro[1]
[1]Department of Forestry and Wildlife Management, Federal University Dutse, Jigawa State, Nigeria
[2]Forestry Research Institute of Nigeria, PMB 5054, Ibadan, Oyo State, Nigeria
*Corresponding author: foristsalam@yahoo.com

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Abstract: The study determined the diversity, distribution and composition of woody species in the Faculty of Agriculture, Federal University Dutse, Jigawa State. Using a systematic sampling technique for plots demarcation, a line transect was laid in the study area. Equal size of 30 × 30 m were laid in the direction along each transect at 100 m interval in other to have four (4) sampled plots which make up a total area of 360 m^2 were covered during the inventory experiment. All woody plants were identified and classified into families while the diameter at breast height (Dbh) > 10 cm were measured and used to extrapolate volume and basal area. Shannon–wieners diversity index (H^1), Simpson's index (D) and Margalef (d), were then computed. Floristic composition identified into seven (7) families, eleven (11) genera with twelve (12) species in the Federal University Dutse. The family of Meliacea had the highest number of frequency occurrence (*Khaya senegalensis* (8) and *Azadiracta indica* (10), while Fabaceae had more prevalent species in the study area (*Acacia nilotica*, *Tamarindus indica*, *Acacia nilotica*, *Parkia biglobosa* and *Pilostgma reticulatum*). Combretaceae, Sapotaceae, Anacardiaceae, Malvaceae and Myrtaceae families had the lowest occurrence of one (1) in the reserve area. The total frequencies of all the species were calculated to be (725) and density (15.5). The total basal area, total volume, mean volume and average diameter at breast height were 438.14, 0.600 0.150 and 8.763 m^2ha^{-1} respectively. The reserve fairly displayed inverted J-shape structure in diameter distribution. The DBH of size class 100 cm and above had highest number of tree in the reserve (40%). Shannon–wieners diversity index (H^1) Simpsons index (D) and Margalef (d) were calculated to be 2.115, 0.640 and 2.812, respectively. Despite the large spacing in the reserve woody plants remain fairly diverse in composition and it has a great potential for restoration if properly managed with silvicultural interventions such as seed supplementation and/or enrichment planting which would encourage the rapid return of the complex forest condition.

Keywords: Forest structure, woody species, restoration, secondary forest, composition

Introduction

Forests contain one of the principles of renewable natural resources for mankind. They are essential in maintaining environmental stability, provision of raw materials for wood-based industries and food, livelihood and employment for millions of people, particularly in the rural areas (Food Agriculture Organisation, 2010). It is worthy to note that in recent times, the concern has been to concentrate on conservation efforts of the savannah because of its relative richness in biodiversity. In forest management operations, inventories on biodiversity are used to determine the nature and distribution of biodiversity. Quantification of tree species diversity is an important aspect that provides resources for many species. To protect forest from declining, it is essential to examine the current status of species diversity as it will provide guidance for management of forest areas, valuable reference for forest assessment and improve knowledge in identification of ecologically useful species as well as species of special concern. Thus identifying conservation efforts are to assess the tree species diversity and stand structure of forest reserve.

However, many savannah forests are under great anthropogenic pressure and require management intervention to maintain and/or to improve their biodiversity conservation, productivity and sustainability (Kumar *et al.*, 2006). Loss of biodiversity has been recognized as one of the main threats to the world forest estates. There are growing concerns for developing new global, regional and national programs for conserving and managing forest biodiversity (Kohl *et al.*, 1998). Species diversity and stand density measures have been widely used as indicators of ecosystem status, and they play critical roles in studies dealing with the assessment of human impact on ecological systems (Leitner and Turner, 2001).

Knowledge of stand density in forest management is an essential apparatus to check crowdedness and competition of trees in a forest stand. Relative stand density measures and size density relationship have been used to developed stand management density diagram for slash pine plantation in coastal plain (Dean and Jokela, 1993). Essential tools for average stand models are graphically characterize by growth, density and mortality at various stages of stand development (Solomon and Zhang, 1998). Stand density management diagram is a useful tool which is not only allows estimation of stand stocking but also serve as a stand monitoring system in which stand development and treatment can be traced through the stand management history (Solomon and Zhang, 1998; Kumar *et al*., 2006). Stocking chart can also be used by forest manager to rapidly design and evaluate alternative density regimes, this practice will help to maximize wood yield (Kershaw and Fischer 1991; Dean and Jokela, 1992) and to create favorable ecological conditions for vegetation (Barbour *et al.*, 1997), Kershaw and Fischer (1991). To develop a stand diagram for sawn timber–sized mixed upland hardwoods, understanding species diversity and density patterns is important for helping forest managers evaluate the complexity and resource of forest. Trees from the major structural and functional basic of savannah ecosystems can serve as robust indicator of changes. This study aimed at utilizing the information derived through ecological assessment to explore floristic composition, structural characterization of the secondary forest and with a view to promoting sustainable conservation and management of the secondary forest.

Materials and Methods

Study area

The Study was carried out in Forest Reserve at Faculty of Agriculture, Federal University Dutse, Jigawa State. It is located within the University farm, situated in the North-Western geopolitical zone of the town. It lies between latitudes 11.00ºN to 13.00ºN and longitudes of 8.00ºE to 10.15ºE. The study area covered by Sudan Savannah, also area characterized by hot wet summer and cool dry winter

with average raining season of 3-5 months (644 mm) Jigawa State Ministry of Agriculture and Natural Resources, 2016). Sunshine hours indicate that the town enjoys 10-11 hours of sunshine depending on the season (JARDA Metrological data, 2015)

Sample plots demarcation and design

Systematic sampling design (Systematic line transect) was employed for the laying of plots in the forest. A line transect was laid at the centre of the forest. Sample plots of equal size (30 × 30 m) were laid in along a line transect at 100 m interval to have four (4) sample plots for transect. A total area of 3600 m^2 was sampled. It was based on model used by Onyekwelu (2007) and Salami (2017). Total area of land surveyed was 3,600 m^2 and sampling intensity was 7.2%. Within each selected plots, information on total number of species per plot and relative abundance of all living trees were recorded

Data collection

Floristic survey

The vegetation of the study site was surveyed in order to document patterns of species diversity in the study site. Systematic sampling method was adopted to generate data on the floristic composition of the study sites. Samples (leave /bark) of unidentified trees were taken to Forestry Research Institute of Nigeria Herbarium for proper identification.

Measurement of tree growth variables in the forest reserve

Identification and Measurement of all woody plants with diameter at breast height of 10 cm and above were measured. Vascular plants measured were plants with Dbh between 10 cm and above. The tree growth variables measured include diameter at breast height measured with girth tape and basal area was calculated using appropriate formula.

Tree species identification

The botanical name of every living tree encountered in each sample plot was recorded. Where a tree botanical name is not known immediately, such a tree will be identified by its commercial or local name. Such commercial or local names were translated to correct the botanical names using Gbile and Soladoye (2002). Trees that could not be identified will be tagged unknown specimens of such unknown trees was collected, pressed, preserved and taken to forestry herbarium, Ibadan (FHI) of Forestry Research Institute of Nigeria for identification. Each tree species was recorded individually in the field forms and possible effort was made not to omit any eligible stem in a sample plot. After the floristic survey of the study sites, the trees encountered will be sorted into species and families, species richness and abundance of each species in the ecological community will be establish using Shannon-Wiener diversity index given by Price (1997).

Tree species classification and community structure study

All the trees encountered were assigned to families and number of species in each of the family was obtained for tree species diversity classification. Frequency of occurrence was obtained for species abundance/richness. This was repeated for all trees encountered in the sample plot for the site. The following biodiversity indices were used to obtain tree species richness and evenness within the forest. They were also used as indices for comparing biodiversity as indication of biodiversity loss. Species relative density (RD) which is the number of individuals per hectare was obtained using the formula given by Oduwaiye *et al.* (2002).

Data analysis

Shannon diversity index

Species diversity is the number of different species in a particular area and number of individuals in each species. This was obtained using a mathematical formula that takes into account the species richness and abundance of each species in the ecological community. The equation for the Shannon-Wiener diversity index given by Price (1997) was used;

$$H^1 = -\sum_{i=1}^{S}(p_i Lnp_i).....(eqn.1)$$

Where: H^I = Shannon diversity index; S = Total number of species in the community; P^i = Proportion of a species to the total number of plants in the community; Ln = Natural logarithm

Species evenness (E)

Species evenness (E) measures the distribution of the number of individual in each species. It was determined using Shannon's equitability (EH) as stated by Kent and Coker (1992);

$E = H\frac{1}{Ln(S)}$..... (eqn. 2)

Where: S = Total number of species; N =Total number of individuals; *Ln* = Natural logarithm

Simpson's dominance index

Simpson's dominance index is weighted towards the abundance of the commonest species;

Simpson index (C) = $\sum P_i^2$ ……. (eqn. 3)

Where: P_i is the proportional abundance of the ith species $\left(P_i = \frac{n_1}{N}\right)$

Simpson's index varies from 0 to 1 and gives the probability that two individuals drawn at random from a population belong to the same species. If the probability is high, then the diversity of the community sample is low. The higher the dominance index the lower the Shannon diversity.

Species Richness …… (eqn. 4)

Margalef' index (d) = $\frac{S-1}{In(N)}$

Where: S is the total number of species, 'N' is the total number of individuals and '*ln'* is the natural logarithm.

Community structure study analysis

Basal area calculation

The basal area of all the trees in the sample plots was calculated using formula:

$BA = \frac{\pi D^2}{4}$..... (eqn. 5)

Where: BA = Basal Area (m^2), D = diameter at breast height (cm) and π = (3.142)

The total basal area for each of the sample plots was obtained by adding the BA of all trees in the plot while the mean BA for the plot (BAP) was obtained by dividing the total BA by the number of sample plots. Basal area per hectare was obtained by multiplying mean basal per plot with the number of 30 × 30 m plots in the four hectares.

$BA\ ha^{-1} = BAP \times 4$..... (eqn. 6)

Where BA ha-1 = Basal area per hectare

Relative density (P)

$RD = \{\frac{ni}{N}\} \times 100$..... (eqn. 7)

Where RD = Relative density; ni = Density of a particular species; N = Density of all species.

Volume calculation

The volume of each tree was calculated in every plot using the newton's formular (Adopted by FOMECU, 1999)

$V = e^{-8.433+2.331Ln(D)}$ …….. (eqn. 8)

Where V = Volume of tree (m^3); D =dbh (cm); e = Euler's constant= 2.71

Total plot volume was obtained by adding the volume of individual trees encountered in the plots. Mean volume for sample plots was calculated by dividing the total plot volume by the number of sample plots.
Volume per hectare was obtained by multiplying mean volume per plot VP with the number of 30×30 m plots in a hectare (4).
Vha =VP x 4

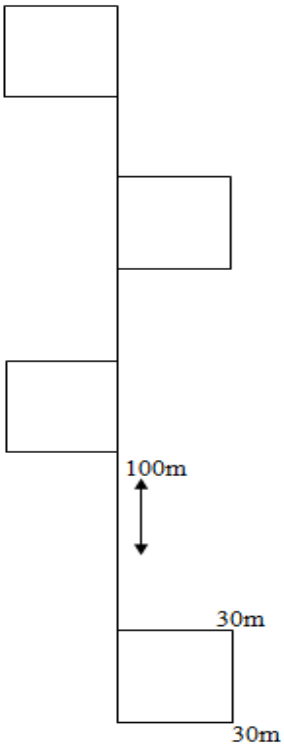

Fig. 1: Plot layout with systematic line transects sampling technique

Results and Discussion

Floristic composition of the study area

A designed assessment for exploratory checklist inventory of biodiversity species genus and their families in Natural Forest, Faculty of Agriculture, Federal University Dutse, Jigawa State were presented in the Table 1. A total of twelve (12) species distribution into eleven (11) genera were identified in Forest Reserve, Faculty of Agriculture, Federal University Duste. The following tree species of *Azadirachtaindica* had more frequency occurrences ten (10) in the four sampled plots, followed by *Khaya senegalensis* that appeared eight (8) times in the sampled area. *Eucalyptus camaldulensis* occurred six (6) *times* in the study area during the sampled measurement, while *Poupartia birrea* had five (5) numbers of frequency occurrences in the sampled plots. *Parkia biglobosa* and *Pilostigma reticulum* has the same frequency of four (4) trees in the inventory measurement. *Acacia albida* and *Vitellaria paradoxa* had the frequency occurrences of three (3) while *Tamarindus indica, Anogeisus species* and *Adansonia digitata* had the same occurrences of two (2) and *Acacia nilotica* had the lowest frequency occurrences of one (1) in the study area. From the research that was carried out in the study area, it was observed that *Azadirachta indica* (Meliaceae) had more prevalent dominant species in the whole four sampled plots because the species is more suitable for the geographical area in terms of survival rate and reproduced more frequency by natural means (through the dispersal of seedlings by wind, birds and rodents and by natural agents) which makes it to be in more abundances than the other tree species. Salami, (2017) reported the dominance of Fabaceae and Meliaceae in Omo Forest Reserve because of easy wind dispersal which enhanced their spread in the study location.

Table 1: Families distribution of genera and species in the University

	Family Names	Species Names	No of Genera	No of Species	Total no of species
1.	Meliaceae	*K. senegalensis* *A. indica*	2	2	18
2.	Fabaceae	*A. albida* *T. indica* *A. nilotica* *P. biglobosa* *P. reticulatum*	4	5	14
3.	Combretaceae	*A. leocarpus*	1	1	2
4.	Sapotaceae	*V. paradoxa*	1	1	3
5.	Anacardiaceae	*P. birrea*	1	1	5
6.	Malvaceae	*A. digitata*	1	1	2
7.	Myrtaceae	*E. camaldulensis*	1	1	6
	Total		**11**	**12**	**50**

Source: Field Survey, 2018

Acacia nilotica had the lowest frequency occurrences in the study area due to its low suppression effects of arid- zone trees on plant stand and growth of crops rate in the climatic region and its structural anatomical development of the tree does not strikes well in the geographical zone of the study area.

Table 2: Floristic composition and importance of tree species in University

Family name	Species names	Authority	Common name	Uses
Meliaceae	*Khayasenegalensis*	(Desr) A. Juss	Mahogany	For construction of furniture's and interior trim.
Meliaceae	*Azadiractaindica*	Adr. Juss	Neem	Leaves are used to treat skin diseases and neem oil is used to detoxify blood.
Fabaceae	*Parkiabiglobosa*	(Jacq) R.Br. ex G. Don	Locust beam	The seeds and leaves are used to feed livestock and poultry.
Sapotaceae	*Vitellariaparadoxa*	C.F Gaertn	Sheabutter	Used for cosmetics as emollient.
Anacardiaceae	*Poupartiabirrea*	(A.Rich.) Hochst	Danya	Fruits are eaten as food.
Myrtaceae	*E. camaldulensis*	Dennis Haugen	Zeti	For charcoal production and beekeeping
Fabaceae	*Pilostigmareticulatum*	(DC) Hochst.	Kargo	The leaves and pods are use for animal fodder.
Malvaceae	*Adansona digitata*	Carl Linnaeus	Baobab	Used as forage for ruminant.
Combretaceae	*Anogeisusleocarpus*	(DC.) Guill. and Perr.	Bambara	Leaves are crushed to make yellow dyes
Fabaceae	*Acacia albida*	(Del.) Achev.1934	Apple ring	Ashes of the wood are used in making soap
Fabaceae	*Tamarindusindica*	Carl Linnaeus	Tamarind	For ornamental shade and edible pods
Fabaceae	*Acacia nilotica*	(Liann)willd ex. Dellile	Gabaruwa	The fruits are use to produced tannin and garlic acid.

Source: Field Survey, 2018

Table 3: Frequency, density and diversity indices of species in the University

Species name	Frequency	Relative frequency	Density	Relative density	Pi	Shannon wieners index
Khayasenegalensis	75	10.35	2.0	16	0.16	- 0.293
Azadirachtaindica	75	10.35	2.5	20	0.2	- 0.321
Acacia albida	75	10.35	0.75	6	0.06	- 0.168
Tamarindusindica	50	6.90	0.5	4	0.04	- 0.128
Acacia nilotica	25	3.45	0.25	2	0.02	- 0.078
Parkiabiglobosa	75	10.35	1.0	8	0.08	- 0.202
Pilostigmareticulatum	100	13.79	1.0	8	0.08	- 0.017
Anogeisusleocarpus	25	3.45	2.0	4	0.04	- 0.128
Vitellariaparadoxa	50	6.90	0.75	6	0.06	- 0.168
Poupartiabirrea	50	6.90	1.25	10	0.1	-0.230
Adansonia digitata	25	3.45	2.0	4	0.04	- 0.128
Eucalyptus camaldulensis	100	13.79	1.5	12	0.12	-0.254
Total	**725**	**100**	**15.5**	**100**	**1.64**	**2.115**

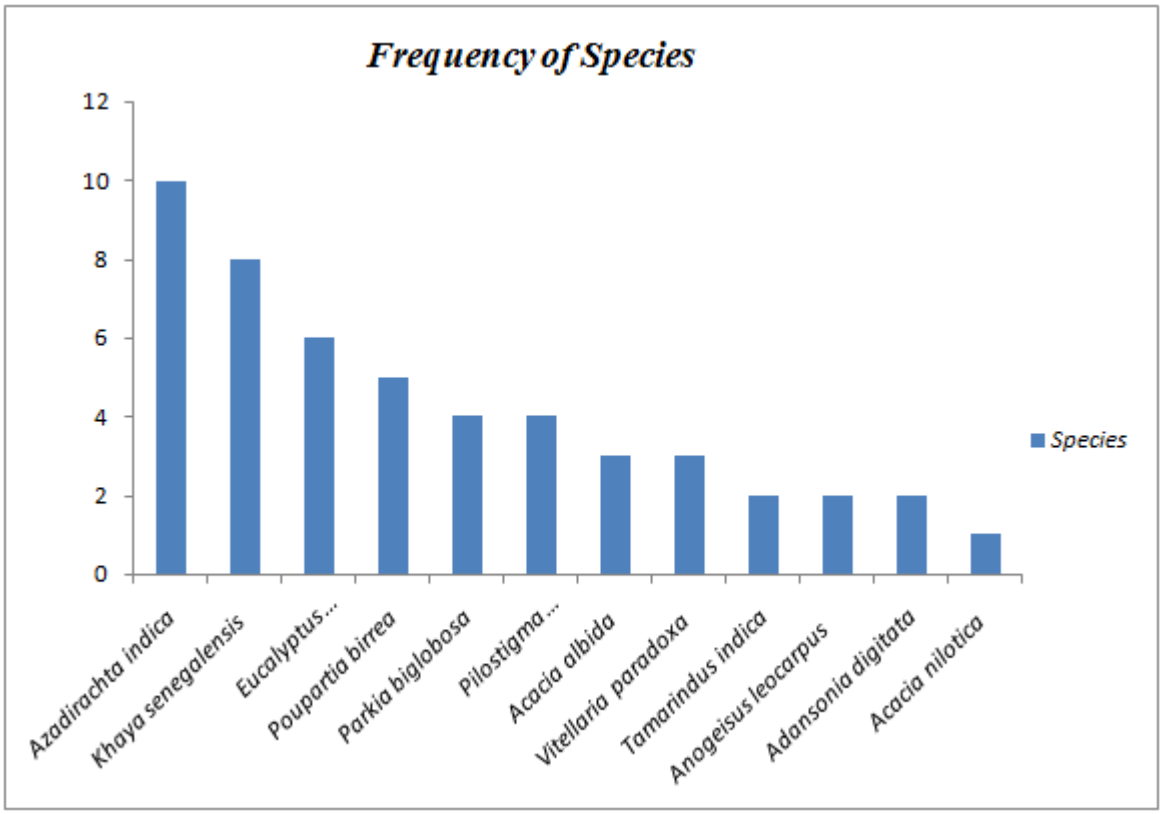

Fig. 2: Showing the frequency status species in forest reserve

Diversity indices and species evenness obtained in the forest reserve

Table 2, showed the total frequency of seven hundred and twenty five (725), which makes up the forest reserve in the study area and it's contain average diversity in terms of species genetic materials and processes of the ecosystems in the environment. The relative frequency was (100), this played a central role in the functioning of biosphere in the reserve and P^1 was calculated to have a total of (1.64). From Table 3, it was estimate that Shannon-Wiener (H-index) had (2.115) which showed that the trees in the reserve were found to be fairly diverse in the ecosystem in terms of species distribution and abundances. This is in agreement with the value obtained for temperate forest which ranges from 1.16-3.40 (Pande *et al.*, 1996) and Dabagi Forest Reserve where value was 1.45 (Shamaki *et al.*, 2015). Conversely, Salami and Lawal, (2018), had lower species diversity of the reserve to be 1.35 (H^i) in orchard of Federal University Dutse, Jigawa. This value of the diversity index for this study closes within the general limit of diversity index of 1.5-3.5 (Kent and Coker, 1992). Simpsons index (D) obtained was (0.640), which showed that the reserve indicated a healthy forest reserve. This was not in agreement with low Simpson's Index (D) of 0.029 in Oban Forest Reserve which indicates that the diversity of the reserve is high and it is an indicative of a healthy reserve (Young and Swiachi, 2006). The Species evenness (E) had (0.54) in the study area, which indicated an average diverse ecosystem. Conversely, Salami (2017) showed that high evenness indices data obtained 0.96 and 0.94 for Omo Biosphere Reserve and Gambari Forest Reserve respectively is an indication of high species distribution. Margalif (d) was calculated to be 2.812 which indicate average abundance and richness of genetic resources in the study area (Table 4).

Table 4: Diversity indices, species evenness and obtained in the study area

Diversity indices (variables)	Values
Shannon-wiener (H-index)	2.115
Simpsons index (D)	0.640
Evenness	0.540
Margalif (d)	2.812

Source: Field Survey, 2018

Tree growth variables obtained

The growth values obtained at the study area were showed in Table 5. Total basal area obtained was (438.14 m^2ha^{-1}) which implied that the study area had a high values of trees density and values which can be useful when properly managed and harvested for human purposes such as the construction of furniture's, electric poles, foal fuel, charcoal production, etc. The total volumes of trees from the study area were 0.600 m^3ha^{-1} and the mean volume obtained was (0.150 m^3ha^{-1}). The average diameter at breast height is 8.763 m^2ha^{-1}. The inventory count of different species in the study area was fifty (50) in number. The population of the sampled area is in abundance within the four sampled plots, seen there is less anthropogenic activities in the reserve which may term to increase the level of productivity in future if properly well managed to check point planting of young seedling species and harvesting.

Table 5: Tree Growth variables obtained at the Study area

Areas	Values
Total basal area (m^2ha^{-1})	438.14
Total volume (m^3ha^{-1})	0.600
Mean volume (m^3ha^{-1})	0.150
Average Diameter at BH (m^2ha^{-1})	8.763
Number of species in the study area	50

Source: Field Survey, 2018

Table 6: Age distribution class in the forest reserve

Diameter class (cm)	Number/ha^{-1}	Percentage
10- 19.9	–	–
20- 29.9	2	4
30- 39.9	4	8
40-49.9	1	2
50-59.9	7	14
60- 69.9	2	4
70 -79.9	3	6
80- 89.9	6	12
90- 99.9	5	10
>100	20	40

Source: Field Survey, 2018

Diameter distribution pattern of forest reserve in Faculty of Agriculture

There were higher number of stems per hectare in the bigger diameter classes of 100 cm and above with population sizes of forty (40%) of trees in Faculty of Agriculture Federal University Dutse, Jigawa state (Table 6). This showed that the reserve is well managed with large spaced. Conversely, Oduwaiye *et al.* (2002) revealed that all the plots accessed had the largest class of diameter below 10 cm at the Okomu Permanent Sample Plot. Salami and Akinyele, (2017) discovered highest number of trees for diameter class 10-19.9 cm (27.93%) at Gambari Forest. Also, Oduwaiye and Ajibode (2005) reported the highest number of trees for diameter class of 11-30 cm followed by those of between 0-10 cm at Onigambari Forest Reserve. Diameter at breast height of 20-29.9 and 60-69.9 cm had the same number of two (2) while the lowest occurred in the ranges of 40 – 49.9 cm with one (1) individual stand in the study area (Table 6).

Conclusion

The inventory measurement designed in the Forest Reserve at the Faculty of Agriculture, Federal University Duste, Jigawa State was study to assess the woody plant diversity in other to denotes the number and variety of different species in the ecosystem within the study area. Good knowledge on how to give a proper accountability of a reserve and preserving the diversity is essential for both present and future generation. Human benefit greatly from products that biodiversity provide. Unfortunately, human induced changes that have greatly altered the population of the biodiversity. The purposes of the inventory measurement of the study are to assess the woody plant diversity, distribution and composition in the study area, in order to determine species richness, abundances and to evaluate diameter distribution basal area, volume and density of the study area through systematic sampled method, by which line transect were laid in the study area and equal size of 30 × 30 m were alternately laid in the direction along each transect at 100 m interval in other to have four (4) sampled plots for transect which make up a total area of 360 m^2. Human disturbances have influenced the structural complexity of the forest reserve with the removal of large and tall trees, and shifting cultivation that reduces the soil fertility of reserve area which result in low tree density and volume, the absences of an emergent layers as well as gap creation. However despite the degradation, high floristic composition and woody plant species diversity were observed in the forest reserve study area. Furthermore, the presences of some pioneer species and other naturally regenerated seedlings and saplings, indicated that the process of ecosystem recovery had commenced in the study area. The observed potential for natural recovery opens an avenue for reconciling management, conservation, environmental, social and economic demands on this degraded forest. Management interventions such as enrichment planting regulated selective logging and protection of naturally regeneration can further assist in the restoration of this ecosystem. This will ensure sustainability and the ability of the forest to continue to provide and benefits for local communities while biodiversity conservation is achieved.

Recommendations

University should provide proper equipment in the department in order to carry out inventory measurement to facilitate easy access of the trees in their different location. Also, reserve environment should be weeded from time to time so as the trees will not compete with unwanted plant for nutrients; once a tree is been harvested in the reserve area, new ones should be planted to replace the harvested ones in order to balance the planting and harvesting rate. Enrichment planting should be employed in order to improve density of the reserve. Different species of seedlings should be provided by the university so that there will be a more diverse forest reserve management. Lastly, reserve must be protected through the use of fence; also awareness and public enlightenment to the people around the reserve.

Conflict of Interest

Authors declare that there is no conflict of interest reported on this work.

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