INTERNATIONAL JOURNAL OF PLANT, ANIMAL AND ENVIRONMENTAL SCIENCES
IJPAES

Volume-3, Issue-3, July-Sept-2013
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ISSN 2231-4490
Coden : IJPAES www.ijpaes.com

Received: 1st Mar-2013 *Revised: 7th Mar-2013* *Accepted: 9th June-2013*

Research article

TREE SPECIES DIVERSITY ANALYSIS OF KOGO FOREST RESERVE IN NORTH-WESTERN NIGERIA

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ABSTRACT: This research was carried out to determine the tree species composition, relative density and dominance, richness and evenness (diversity) of Kogo Forest Reserve in North-Western Nigeria. Eight sample plots (100m x 100m) were laid at random within the forest reserve, and tree species found were enumerated by point centered quarter (PCQ) method. A total of 249 tree stands were encountered in the reserve, belonging to twenty nine different tree species, distributed within 25 genera and into sixteen 16 families. Family *Caesalpiniaceae* had the highest number of six species in five genera, followed by *Mimosaceae* with four species belonging to four different genera. Families *Anacardiaceae* and *Combretaceae* had three species each while family *moraceae* had two species within a genus and all the other eleven 11 families had one species each. Species *Annogeisus leiocarpus* had the highest relative density and dominance of 24.49% and 23.23% respectively, followed by *Isoberlinia doka* with 18.07% and 13.14%, and the least was *Annona senegalensis* having 0.40% and 0.05% respectively. Shannon's diversity index was 2.626, Species evenness *(E_H)* 0.78, Species richness *(d)* 1.84 and Shannon's maximum diversity *(H_{max})* was 3.37. Kogo had a moderate diversity and hence closure of the forest for exploitation to allow the forest to fully regenerate and enhance the fertility of the soil is therefore recommended.
Key words: Kogo, Diversity, Relative density, Forest reserves and *Annogeisus leiocarpus*

INTRODUCTION

Tree species are perennial woody plants. [9] defined tree as a woody plant that has many secondary branches supported by single main stem or trunk with clear apical dominance. It has a minimum height specification at maturity varying from 3m to 6m, and a minimum of 10 cm trunk diameter (30 cm girth) [6]. Compared with most other plants, trees are long-lived, some reaching several thousand years old and growing to up to 115 m (377 ft) high [5]. Tree species is a plant form that occurs in many different sets of species, genera, orders and families. They show a variety of growth forms, shapes, vegetative and reproductive characteristics, leading to their great range of diversity.

Species diversity is one of the analytical tools applied in determining the degree of variability of species within a community or a region. It is a count of the different species present in an area. Species richness is essentially a measure of the number of species in a defined sampling unit. And it is the basic component of diversity of any community, while species evenness refers to relative abundance or proportion of individuals among the species. The distribution and abundance of different tree species over a landscape is what constitutes diversity in respect of tree species. Trees are the major structural component of forest ecosystems, and these forests are disappearing at an alarming rates owing to deforestation for extraction of timber and other forest produce (Raghubanshi and Tripathi 2009) or total conversion to other uses.

Nigeria is among the ten countries with the highest annual net negative change rates from 2000–2005 degrading at the rate of 3.3% (FAO, 2006). And as the most populous country in Africa, Nigerian populace exerts extreme pressures on biodiversity of the remaining forests. Trees, many other plants and wildlife are over exploited and poached, and the natural environment faces increased degradation from expanding unsustainable agriculture, water pollution, air pollution, and a variety of other anthropogenic factors [24].

This must not be unconnected with lack of strong conservation ethics, law enforcement, corruption and extreme poverty, leading to severe encroachment and illegal exploitation of forest tree resources, which resulted to depletion in biodiversity of the existing forests, reduced productivity and tree species extinction. And as forest degradation is usually accompanied by species extinction, reduction in biodiversity and decrease in primary productivity. This highlighted the need to quantify or determine habitat characteristics of our forest reserves for proper conservation and sustainable management of the forest resources.

The major objective of this research was to determine the tree species composition, diversity (richness and evenness) as well as the relative density and dominance of tree species within Kogo Forest Reserve, in north-western Nigeria. Determination of these characteristic features of Kogo Forest Reserve will no doubt reveal an insight on ways to prescribe and execute appropriate managerial measures based on an identified specific objective.

MATERIALS AND METHODS

Study Area

The research was carried out at Kogo Forest Reserve No: 10, as identified in Gazette No: 53 of 1931 under the Forestry Ordinance, 1927 of the northern protectorate, and amended in 1937 as Katsina Native Administration Forest Reserve No: 10. It was re-constituted as The Katsina Local Authority Forest Reserve No: 10 (Kogo Forests), as contained in the North-Central State of Nigeria Gazette No 27, Vol. 5. It lies between longitudes 10^0 84'- 11^0 23'E and latitudes 06^0 08'- 07^0 51'N. It covers approximately 212.65sq miles (550.76sq km), and falls within Faskari and Sabuwa Local Government Areas of southern Katsina State, in north-western Nigeria at the extreme savanna of northern guinea (Fig.1).

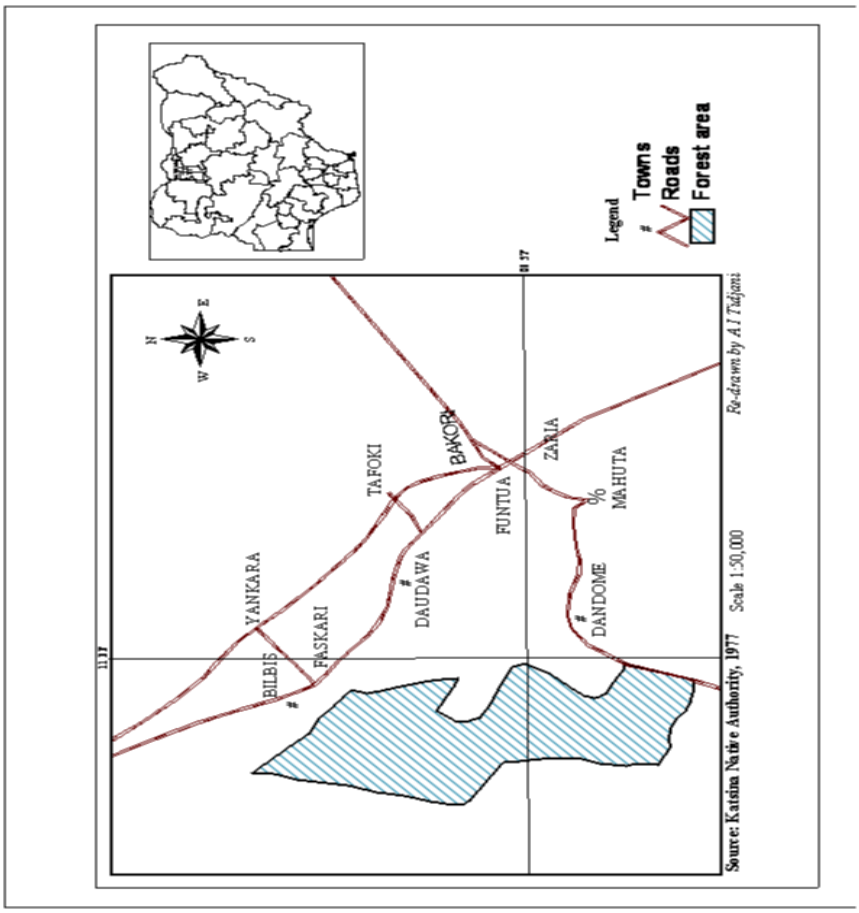

Fig 1: Map showing Kogo Forest Reserve.

The area is characterized by defined wet (rainy) season spanning from May up to October and peak rainfall in August (100-150cm) and the dry season occupies the rest of the year. The mean annual temperature is 27^0C, while humidity less than 60%. [11]. It is a woodland savanna consisting of trees in association with perennial shrubs and annual grasses. The forest found in the area may be termed "Savannah bush of doka association" and the reserve consists of rolling uplands and valleys with numerous tributaries feeding to 3 major rivers. Soil types from sandy loam to the darkest loam are present as contained in the proposal document of Katsina Native Administration Reserve No. 10 (Kogo Forests) of 1933.

Methodology

After a detailed reconnaissance of the entire reserve, the part of vegetation concerned in this research was tree species that are not less than 10cm trunk diameter only. Eight sample plots of 100m x 100m each were selected at random by Point Centered Quarter (PCQ) method, and was applied for the inventory of the forest site. Trees were identified using [8] and [7]. The following measurements were carried out on each tree stand within all sampled plots:

(a) GBH (1.3m above ground level) using Girth tape (M)
(b) Total height of trees using Haga altimetre (M)
(c) Distances from centre point (M) and

Data Analysis

The tree data collected was analyzed to determine the following parameters:

(i) Species relative density (RD) for each tree species was determined by:

$$RD\ (\%) = \left(\frac{n_i}{N}\right) \times 100$$

n_i= number of individual species; N = Total number of species in the entire community.

(ii) Basal area (Ba) for each stand=$\left(\frac{1}{2}d\right)^2 x\ \pi$.

where d= tree diameter, and π =3.142 (constant).

(iii) Species relative dominance (RDo) was computed using:

$$RDo = \frac{\left(\sum Ba_i\, x100\right)}{\sum Ba_n}$$

Ba_i = basal area of individual trees belonging to species i , Ba_n = stand basal area of all species, as adopted by Onyekwelu (2007).

(iv) Species diversity index was calculated using Shannon-Wiener diversity index (Kent and Coker, 1992)

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

H' = Shannon-Wiener diversity index; S = total number of species in the community; P_i = proportion of S made up of the ith species; ln = natural logarithm.

(v) Shannon's maximum diversity index was calculated using the formula;

H max = ln (s)

(vi) Species richness or variety index (d) was determined by the formula

$$d = \frac{S}{\sqrt{N}}$$ (Margalef, 1958).

Where, S = number of species, N = number of individuals of all species.

(vii) Species evenness in the community was obtained using Shannon's equitability (E_H):

$$E_H = \frac{H'}{H_{max}} = \frac{-\sum_{i=1}^{s} p_i \ln(p_i)}{\ln(s)}$$

RESULTS AND DISCUSSION

A total of 249 tree stands were encountered within the eight randomly sampled plots. Twenty nine different tree species distributed within 25 genera and into 16 families were found within the reserve. Family *Caesalpiniaceae* had the highest number of six species in five genera, followed by *Mimosaceae* with four species belonging to four different genera. Families *Anacardiaceae* and *Combretaceae* had three species each, while family *Moraceae* had two species belonging to same genus and all the other 11 families had one species each as presented in table 1. The species and families of tree species encountered in Kogo Forest Reserve gave a vegetation close to what Mu'azu (2010) found in the neibouring Kuyambana Forest Reserve, Maru in Zamfara State which was described as Sudan savanna with a transition to Guinea savanna. The dominance of *Caesalpiniaceae, Mimosaceae* and *Combretaceae* families in Kogo is almost in line with his findings. The twenty nine different tree species of kogo is higher than that of Zamfara Forest Reserve which stood at 21 and 24 as documented by [16], and also twice higher than that of Isah and where they recorded only 11 tree species at Dabagi Forest Reserve in the Sudan savanna of North-Western Nigeria. All these variations may largely be as a result of differences in climatic as well as edaphic factors that characterize each ecological zone. Comparatively, the findings of [10] in Ehor Forest Reserve in Edo State (Forest Zone) of Southern Nigeria, where 2,062 tree stands were identified (in just 3 compartments of the forest reserve) belonging to 99 different species distributed into 87 genera and 36 families. These differences confirms variability in terms of weather and climate between the two ecological zones of the forest sites as the major factor dictating the distribution and abundance of varieties of different floral species as described by [3]. Among the 29 different tree species found within the reserve, table 2 showed the relative density (RD) and relative dominance (RDo) each of the 29 different tree species found within the reserve. The results indicated that *Anogeissus leiocarpus* had the highest relative density and dominance of 24.50% and 23.23% followed by *Isoberlinia doka* with 18.07% and 13.14% respectively. *Terminalia macroptera* followed with a density of 10.04%, while *Parkia biglobosa* had the third highest dominance of 9.41%. *Annona senegalensis, Acacia sieberiana, Balanites aegyptiaca, Monotes kerstingii, Vitex doniana, Daniellia oliveri* and *Ficus platyphylla* recorded the least relative density of 0.40% each and same *Annona senegalensis* recorded the least relative dominance of 0.05%. But at neibouring Kuyambana, *Isoberlinia doka* had the highest followed by *Prosopis africana* and *Anogeissus leiocarpus,* which may be as a result of the slight ecological variation or over-exploitation of the woody genetic resources as reported [19] at the neibouring Kuyambana Researve. Consequently, *Anogeisus leiocapus* taking the lead in terms of relative dominance and density at Kogo may be as a result of heavy or excessive logging suffered by *Isoberlinia doka* due to its high demand and economic value as confirmed by the forestry personnel attached to the forest reserve during data collection at the forest site. *Annona senegalensis, Acacia sieberiana, Balanites aegyptiaca, Monotes kerstingii, Vitex doniana, Daniellia oliveri* and *Ficus platyphylla* recorded one stand each with the least relative density and same *Annona senegalensis* recorded the least relative dominance followed by *Acacia sieberiana, Daniella oliveri* and *Piliostigma reticulatum*. This signifies that *Annona senegalensis, Acacia sieberiana and Daniella oliveri* were at the top of the list of vulnerable tree species under threat of extinction from the reserve, which may be as result of over-exploitation, competition, climatic or edaphic factors.

Shannon-Weiner diversity index *(H')* value stood at 2.63. And as diversity indices varied with location depending on the species available within an ecological zone, Kogo Forest Reserve is blessed with a moderate diversity index, which lies within the general limits of 1.5-3.5 [13]. Compared with what was found by [4] at Dabagi Forest Reserve who recorded a *H*' value of 1.45 which is very low, but even higher than that of [14] in 3 sites of tropical dry deciduous forest of Western India, in which the shannon-Weiner Index (*H*') values of 0.67 to 0.79 were recorded. This implies that climate favours diversity and may be partly responsible for the diversity index obtained at Kogo. Moreover, in the lowland humid tropical rainforest region of Nigeria, [20] obtained *H'* values of 3.12, 3.31 and 2.82 at Oluwa, Queen's and Elephant forests.

This is also in line with the findings of [2] in comparison among the fresh water swamp forests of (Kulathupuzha, Anchal, Shendurney, Kathalkane, Pilarkan and Charmady) Karnataka, where *H'* of 2.53, 3.69, 2.46, 4.04, 3.25 and 4.90 respectively were obtained. This confirms that diversity or richness in terms of species and their distribution is largely dictated by climatic and ecological conditions.

Species evenness (E_H) as a measure of equitability of spread [15] was valued at 0.78, which is a bit higher than that of Dabagi (0.74) as recorded by [4], indicating that the available tree species were fairly and evenly distributed within the forest sites may be due to less competition for space among the tree species considering the characteristic nature of the ecological zones. This is in line with the findings of [21] who in four different experimental forests of University of Tehran recorded E_H of 0.64, 0.76, 0.71 and 0.65, of which despite the proximity, still variability among the different forested areas exist. Species richness (d) as the basic component of diversity of any community [1], Kogo reserve had a species richness of 1.84 which is comparatively low compared to 1.92, 1.85 and 2.16 for that of Oluwa, Queen's and Elephant forests of the low-land humid tropical rain forest region of Nigeria as reported by [20]. This may be due to more favourable environment of the tropical forest zone compared to extreme northern Guinea savanna ecological zone as well as level of encroachment. Shannon's maximum diversity (H_{max}) index of 3.37 in this study is greater than shannon index, indicated that all tree species within the forest site do not have equal area abundance may be as a result of more adoptability exhibited by some species or due to preference by the exploiters as shown in table 2.

Table 1: Tree Families, Genera and Species of Kogo Forest Reserve

Family	Species	Frequency	V/N (Hausa)
Anacardiaceae	*Lannea acida*	10	Farun tudiya
	Lannea barteri	06	Faru
	Sclerocarya birrea	03	Danya
Annonaceae	*Annona senegalensis*	01	Gwandar Daji
Balanitaceae	*Balanities aegyptiaca*	01	Aduwa
Burseraceae	*Boswellia dalzielii*	11	Hano
Caesalpiniaceae	*Isoberlinia doka*	45	Doka
	Isoberlinia tomentosa	08	Farar Doka
	Piliostigma reticulatum	02	Kalgo
	Daniellia olivery	01	Maje
	Detarium microcarpum	08	Taura
	Tamarindus indica	08	Tsamiya
Combretaceae	*Anogeissus leiocarpus*	61	Marke
	Combretum leonense	10	Dantsen damo
	Terminalia macroptera	25	Kandare
Dipterocarpaceae	*Monotes kerstingii*	01	Hantso
Ebenaceae	*Diospyros mespiliformis*	03	Kanya
Meliaceae	*Gardenia aqualla*	03	Gaude
Mimosaceae	*Acacia sieberiana*	01	Farar kaya
	Entada africana	07	Tawatsa
	Parkia biglobosa	05	Dorowa
	Prosopis africana	03	Kirya
Moraceae	*Ficus glumosa*	02	Kawuri
	Ficus platyphyla	01	Gamji
Rubiaceae	*Breonadia salicina*	02	Kadanyar rafi
Sapotaceae	*Vitaleria paradoxa*	15	Kadanya
Sterculiaceae	*Sterculia setigera*	02	Kukkuki
Tiliaceae	*Grewia venusta*	03	Dargaza
Verbernaceae	*Vitex doniana*	01	Dinya
V/N: Vanacular Name		**249**	

Table 2: Species Relative Density and Dominance.

Species	Relative Density (%)	Relative Dominance (%)
Acacia sieberiana	0.401606	0.137739472
Annona senegalensis	0.401606	0.053804481
Anogeissus leiocarpus	24.49799	23.22887417
Balanites aegyptiaca	0.401606	0.484240331
Boswellia dalzielii	4.417671	7.004570021
Breonadia salicina	0.803213	2.775134259
Combretum leonense	4.016064	2.099215463
Daniellia oliveri	0.401606	0.215217925
Detarium microcarpum	3.212851	1.624996217
Diospyros mespiliformis	1.204819	1.057863357
Entada africana	2.811245	2.400991347
Ficus platyphylla	0.401606	1.627585557
Ficus glumosa	0.803213	1.163152001
Gardenia aqualla	1.204819	1.038863649
Grewia venusta	1.204819	0.459019481
Isoberlinia doka	18.07229	13.13834813
Isoberlinia tomentosa	3.212851	3.2003578
Lannea acida	4.016064	4.512077425
Lannea barteri	2.409639	4.255598188
Monotes kerstingii	0.401606	0.971843442
Parkia biglobosa	2.008032	9.412421437
Piliostigma reticulatum	0.803213	0.336278008
Prosopis africana	1.204819	0.965824066
Sclerocarya birrea	1.204819	1.557437965
Sterculia setigera	0.803213	0.673396711
Tamarindus indica	3.212851	4.153638696
Terminalia macroptera	10.04016	3.878630541
Vitellaria paradoxum	6.024096	6.566433402
Vitex doniana	0.401606	1.006446449
	100	100

Index	Value
Shannon-Weiner	2.62615
Species evenness (E_H)	0.779899
Species richness or variety (d)	1.837800327
Shannon's maximum diversity (H_{max})	3.36729583
Average stand basal area	950.246cm^2

CONCLUSION

It was concluded that the forest was quite rich in terms of tree species and that some species were facing the threat of extinction which may be as a result of over-exploitation, climatic and/or edaphic factors. This had already exposed much of the soil surface which may likely be the reason for low nutrient status of the soils. This therefore, highlighted the need to draw an integrated conservative approach that will restore the diminishing potentialities of the forest, and to appropriately implement it.

Recommendations

From the results of this research, the following recommendations are made:

1. Kogo reserve should be closed for exploitation for at least five to ten years, so as to allow the forest to fully regenerate and for the soil to regain it's fertility as concurred also by the forestry personnel attached to the forest.
2. Equally, alternative energy sources should be adequately provided at an affordable rate to all populace within and around the reserve.

3. Government should enact laws that will restructure the forestry sub-sector in order to achieve the desired benefits of the forests not destroying the resources.
4. Government should also employ more manpower to fully man the forest reserves with incentives to the forest guards.
5. Training and re-training of the forestry personnel in order to competently address the issue of illegal exploitation and other challenges of the forestry sector.
5. A properly documented management plan with clearly stated objectives to all our forest reserves should be drafted and adhere strictly to.
6. Non-Governmental Organizations (NGOs) should intervene in campaign against indiscriminate felling and in provision of alternative energy sources and the communities also to adopt the protection measures enlightened with.

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