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Frequency Class Distribution of Vegetation in the Dryland of Northwestern Nigeria

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Abstract

This study categorises plants into five frequency classes based on their abundance. Data for the study was sourced from quadrat sampling. The sampling was conducted using 100m x 100 m quadrat on transect line that runs from Abonabo, Chiromari, Meleri, Asayaya, Dankira and Mairobi (Jigawa State); Garki, Garni, Daneji, Jani, Maje, and Bugaje (Katsina State); Bugawa, Dutsi and Bazai (Zamfara); Gundumi, Modawa, Daraye and Chana (Sokoto State). Sampling involved: quadrat laying, inventorying, identification and recording of species. Samples of species that were not directly identified on the field were collected on pressers and transported to herbarium of Department of Biological Sciences of Bayero University Kano for identification. Data was analysed in Microsoft EXCEL. Result of class distribution analysis reveals a reversed J shape similar to Raunkiaer's normal frequency diagram. Also found are: frequency class A constitutes thirty three species (66%), class B constitute 8 (16%), C constitutes 5 species (10), and class D has three species (6%) while class E has one species (2%). The study recommends that targeted programmes that will ensure planting of selective multipurpose species should be mounted in the area. Indigenous techniques of resources management such as farmer managed natural regeneration can be used to achieve this objective.

Keywords

Frequency Class Distribution, Dryland, North-Western Nigeria

1. Introduction

Though vegetation attributes are measured for various purposes, literatures have shown that frequency is a primary attribute. Because of its importance to ecologists, frequency has been used to determine forest and rangeland conditions for management (U.S. Department of the Interior, 1996). Frequency reflects the spread, distribution or dispersion of a species in a given area. The term is usually expressed in terms of percentage occurrence.

Frequency class distribution shows classes or intervals of species' entries with a count of their number in each class. Studies on frequency class distribution appear first in early 20th century from the work of Raunkiaer in 1934. Today, the literature is replete with research on frequency class distribution particularly because their understanding is very crucial for conservation. Frequency class distribution may help in knowing the factors that controls the presence or absence and concentration of species. With the knowledge that the dryland environments are so dynamic, this study assesses the frequency of species with a view to providing information for conservation indigenous plants in the area. This study gives baseline information on the frequency class distribution of fifty plant species to enable stakeholders to take appropriate decisions and measures in sustainable management of the fragile ecosystem.

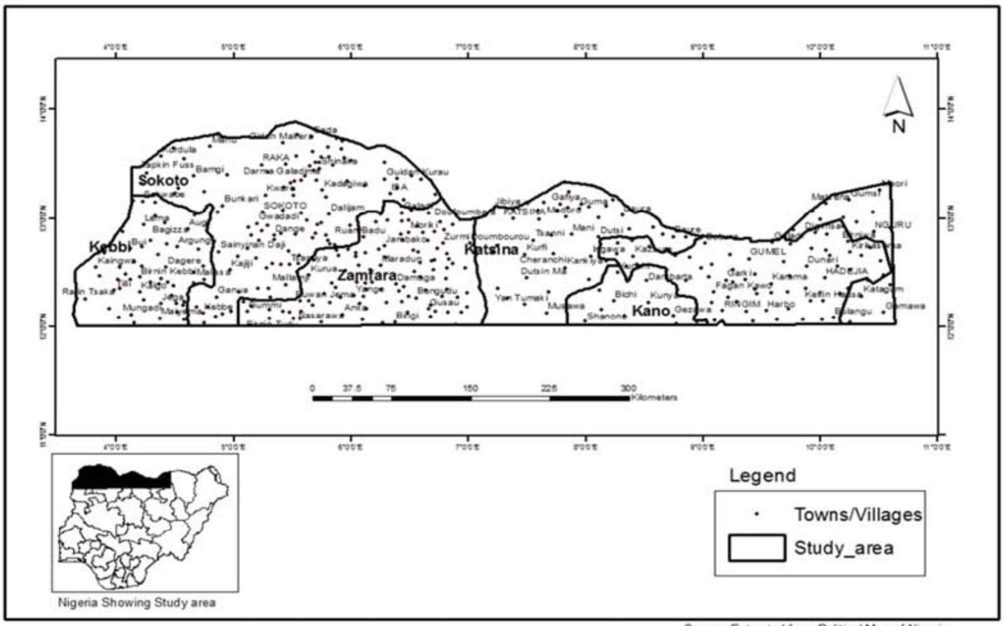
2. Study Area

North-western Nigeria is composed of three distinct geographic entities: Sokoto-Rima Basin, the Kano Region and the North Central Highlands (Udo, 1970). Of the Nigeria's total area of 923,768 km^2, North-western region occupies a total of 226, 662 km^2. The dryland of Nigeria constitutes the Sudan and the Sahelian savanna with typical low rainfall and sparse vegetation. Mortimore and Adams (1999) noted that in Nigeria, the dry lands are located north of latitude 12^{0}N. The study area lies within latitudes 12^{0}N and 14^{0}N and longitude 3^{0}E and 10.35^{0}E. It covers six states namely: Jigawa, Kano, Katsina, Zamfara, Sokoto and Kebbi. This study however covers Jigawa, Katsina, Zamfara and Sokoto.

Climate of North-western Nigeria is the tropical wet and dry type. It is coded as 'Aw' by Koppen in which distinctive wet and dry seasons are caused by the fluctuations of the ITCZ (Inter-tropical convergence zone) or the ITD south to north to bring rainy season and north to south to bring dry season. The ITCZ separates humid maritime (mT) air mass originating from the Atlantic Ocean and dry desert air mass (cT). The ITCZ follows the apparent movement of the sun, (northwards in April – July and southwards in September – October).

Average annual rainfall in dryland of Nigeria varies from 500mm in the northeastern part to 1000mm in the southern sub-area, but it is unreliable in many parts. Unpredictability and unreliability characterize the pattern of rainfall in the area (Mortimore, 2001). In addition to high inter-annual variability, the rainfall regimes of dryland of Nigeria are highly concentrated in few months, often intermitted with violence of storms. Thus the region is, by nature, prone to recurrent and sometimes intense and persistent periods of drought (Mortimore and Adams, 1999).

The vegetation type of North-western Nigeria is of the West African type which follows the pattern of rainfall distribution. The North-western Nigeria falls within Sudan Savanna zone of Nigeria, distinguished by large expanse of grasslands with widely spaced trees of varying heights and diversity. The Sudan savanna belt is found dominating the Sokoto Plains across to the Chad Basin, covering over a quarter of the country's land area. It is found in places with rainfall of about 600 - 1000 mm and 4 - 6 months of dry season. The vegetation is made up of grasses 1-2 m high and often stunted trees. Some of the most frequent trees in this environment are *Hyphaene thebaica*, *Parkia biglobosa, Adansonia digitata, Fadherbia albida, Tamarindus indica*, and *Borassus aethiopum, Prosopis africana, Balanite aegyptiaca, Acacia nilotica* and exotic species such as *Azadirachta indica, Eucalyptus camaldulensis and Cassia siammea*.



Source: Extracted from Political Map of Nigeria

Figure 1. *Dryland of North-western Nigeria.*

3. Research Methods

3.1. Sampling of Study Locations

Sampling of study villages was done using belt line transect method so as to capture the villages on either side of the line (Fewster, Laake, and Buckland, 2005). The line transect was plotted on a classified map of the study diagonally from the bottom right corner (latitude 12^{0}N and 14^{0}N) to the top left corner (longitude 4.5^{0}E and 10.8^{0}E) northwards.

The study area extends from Chana in the West to Abonabo in the East and cut across nineteen locations. These are: Abonabo, Chiromari, Meleri, Asayaya, Dankira and Mairobi (Jigawa State), Garki, Garni, Daneji, Jani, Maje, and Bugaje (Katsina State), Bugawa, Dutsi and Bazai (Zamfara), Gundumi, Modawa, Daraye and Chana (Sokoto State) (Figure 2).

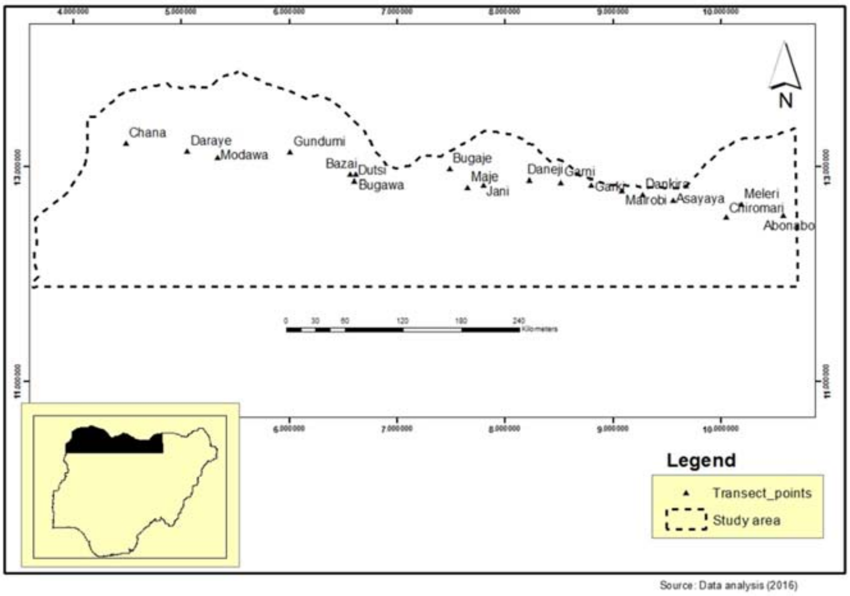


Figure 2. *Study Locations in the Drylandof North-western Nigeria.*

3.2. Procedures for Data Collection and Analysis

Data for the study was sourced from quadrat sampling. This was conducted using 100 x 100 m^2 quadrat on transect line that runs from Abonabo, Chiromari, Meleri, Asayaya, Dankira and Mairobi (Jigawa State); Garki, Garni, Daneji, Jani, Maje, and Bugaje (Katsina State); Bugawa, Dutsi and Bazai (Zamfara); Gundumi, Modawa, Daraye and Chana (Sokoto State). The choice of 100m x 100m is in line with (Kindt and Coe, 2005) that quadrat should be large enough for differences related to vegetation to become apparent. Sampling which was conducted between January and March 2016 involved: quadrat laying, inventorying, identification and recording of species. Samples of species that were not directly identified on the field were collected on pressers and transported to herbarium of Department of Biological Sciences of Bayero University Kano for identification. Local names of plants were also collected. Data of collected from quadrat sampling is arranged in spreadsheet software (EXCEL) and analysed using formulae below as found in (Curtis and McIntosh, 1951).

$$\text{Frequency} = \frac{\text{Number of quadrat in which the species occurs}}{\text{Total number of quadrats studied}}$$

The EXCEL program is particularly appropriate for data that are naturally arranged in a grid, such as the species recorded from a number of samples (Henderson, 2003).

4. Results and Discussion

4.1. Frequency of Vegetation

Frequency is an important parameter of vegetation which reflects the spread, distribution or dispersion of a species in a given area. The term is usually expressed in terms of percentage occurrence. Researchers have shown that there is greater probability of species occurrence when it is distributed uniformly in an area. However, a species may be clustered in a part of the area where it will occur in few quadrats.

Table 1 shows the frequency of plants in the drylandof North-western Nigeria which ranges from 0.05 to 0.84. Species with the highest frequencies are: *Piliostigma reticulatum* (0.84), *Fadherbia albida* (0.68), *Azadirachta indica* (0.68), *Ziziphus mauritania* (0.68), *Adansonia digitata* (0.57), *Gueira senegalensis* (0.57) and *Balanite aegyptiaca* (0.52). Notable multipurpose species that have low frequencies are: *Acacia seyal* (0.15), *Tamarindus indica* (0.15), *Anogiessus leiocarpus* (0.10), *Diosphyros mespiliformis* (0.10), *Vitex doniana* (0.10), *Prosopis africana* (0.05), *Butyrespermum parkii* (0.05) *Prosopis africana* (0.05), *Cassia singuena* (0.05) and *Ficus thonningii* (0.05) (Table 1).

High frequency of some plants may be due to farmers' selective management of species in the study area. For example, *Fadherbia albida* has high frequency in the study area probably because of its reversed phenology which gives it a remarkable habit of shedding its leaves during the rainy season and re-growing them during the dry season. Due to that character, the species does not compete with food crops for light, water or nutrients and therefore resprout vigorously. This agrees with Roupsard *et al*. (1999) and Cameron (2011) that *Fadherbia albida* does not compete with other plants within its immediate surrounding for essential nutrients. The species is protected in sub-Saharan Africa for its multipurpose uses as fodder and as fertility enhancer on farmlands. Findings of this study relates to Arnborg (1988) and Larwanou, Abdoulaye, and Reij (2006) that the tree is greatly appreciated and protected since ancient times in West Africa through farmer managed natural regeneration.

According to Rice (1984) plants are known to exhibit allelopathy by releasing water soluble phyto-toxins from leaves, stem, roots, fruits and seeds and such metabolites play an inhibitory role in delay or complete inhibition of seed germination. Allelopathy results to stunted growth and injury to root systems of other plants. This agrees with Woitke and Dietz (2002) and Aleem, Alamu and Olabode (2014) who reported that some exotic, invasive species have the potential to affect the structure of native plant communities due to allelopathy.

Table 1. *Frequency of Vegetation.*

Botanical Names	N	F	% Occurrence
Piliostigma reticulatum	16	0.84	84
Fadherbia albida	13	0.68	68
Azadirachta indica	13	0.68	68
Ziziphus Mauritania	13	0.68	68
Adansonia digitata	11	0.57	57
Guiera senegalensis	11	0.57	57
Balanite aegyptiaca	10	0.52	52
Acacia nilotica	8	0.42	42
Lannea acida	8	0.42	42
Sclerocarya birrea	7	0.36	36
Parkia biglobosa	7	0.36	36
Annona senegalensis	6	0.31	31
Hyphaene thebaica	5	0.26	26
Securinega virosa	4	0.21	21
Cassia sieberiana	4	0.21	21
Diosphyros mespiliformis (a)	4	0.21	21
Calatropis procera	4	0.21	21
Acacia seyal	3	0.15	15
Tamarindus indica	3	0.15	15
Dichrostachys cinerea	2	0.10	10
Ziziphus spina-christi	2	0.10	10
Commiphora Africana	2	0.10	10
Anogiessus leiocarpus	2	0.10	10
Diospyros mespiliformis (b)	2	0.10	10
Vitex doniana	2	0.10	10
Ficus iteophylla	2	0.10	10
Combretum micranthum	2	0.10	10
Indigofera tictora	1	0.10	10
Bauhinia rufescens	2	0.10	10
Feretia apodanthera	1	0.10	10
Mitragyna inermis	1	0.05	05
Alyscicarpus vaginalis	1	0.05	05
Acacia macrostachya	1	0.05	05
Borassus aethiophum	1	0.05	05
Ficus thonningii	1	0.05	05
Bauhinia rufescens	1	0.05	05
Combretum lamprocarpum	1	0.05	05
Albizia chevalieri	1	0.05	05
Bauhinia rufescens	1	0.05	05
Lonchocarpus cyanescens	1	0.05	05
Prosopis Africana	1	0.05	05
Ficus spp.	1	0.05	05
Butyrospermum parkii	1	0.05	05
Terminalia avicennoioides	1	0.05	05
Waltheria indica	1	0.05	05
Sesbania dalzielli	1	0.05	05
Cassia singuena	1	0.05	05
Ficus sycomorus	1	0.05	05
Perguleria tomentosa	1	0.05	05
Rogeria adenophylla	1	0.05	05
Σ	50	09.91	

Azadirachta indica is allelophatic in nature and that may ensure its high frequency in the study area.

Adansonia digitata is frequent species in the study area perhaps because it is raised naturally on farmlands for its multipurpose uses. Finding on the species dominance corroborates previous work by Keay (1989) that the tree is evenly distributed in arid and semi-arid zones of Nigeria. *Tamarindus indica* has low frequency in the study area. Danjibo (2015) reported that the species has a frequency of 1.51% in Kuwanka Forest Reserve. Its low frequency in the study area may be due to over harvested of its fruits, bark and roots for use in rural diets, for medicine, fuel and raw materials for processed goods in Africa as has been found in El Siddig *et al.* (2006) and Havinga *et al.* (2010). *Prosopis africana* is less frequent in farming and pastoral communities of West Africa. Danjibo (2015) reported that at frequency 1.20% the species is less frequent in Kuwanka Forest Reserve in Kebbi State. Low frequency of *Prosopis africana* in the study locations may not be unconnected to over-exploitation. Similar findings are found across Africa. Weber, Larwanou, Abasse and Kalinganire (2008) reported that *Prosopis africana* is disappearing in landscapes of Niger Republic. Over-exploitation of its special wood that is diffuse porous, moderately dense and highly favored and used for construction poles, mortars, pestles, handles for farm implements, firewood and charcoal as well as tablets ensures its disappearance in sub-Saharan Africa (Nygård and Elving, 2000).

Acacia seyal, Tamarindus indica, Anogiessus leiocarpus, Borassus aethiophum, and *Prosopis africana,* has low frequencies probably due to over-exploitation for medicinal products and fuelwood. The exploitation is so massive on collectively owned farmlands in most study locations in North-western Nigeria; a finding corresponds to Lykke (1998) and O'Higgins (2007) who reported that common pool resources particularly vegetation are over-exploited by humans than those under private access. This supports the assertion of the World Health Organisation (WHO) who estimated that eighty per cent (80%) of people in the developing world are reliant on traditional medicines and eighty-five per cent (85%) of these medicines use plant extracts (Sheldon *et al.,* 1996).

Butyrespermum parkii is over-exploitation for fuel wood and shea butter in northern Nigeria. Many studies including Nichol (1989), Hall *et al*. (1996), and Okullo, Hall and Obua (2004) have reported that the tree is overexploited for shea butter and charcoal in Kano Closed Settled Zone and other parts of Africa which resulted to the disappearance of the species' mother trees in most parts of the continent.

The pattern of frequency distribution exhibited in Table 5.6 indicates that species are deliberately regenerated and exploited for fuel wood, animal fodder or herbal products in the study area. Selective harvesting of plants for medicine and fuel wood is taking its toll on species frequencies on both farm and bush fields.

4.2. Frequency Class Distribution

Frequency class distribution began with Raunkiaer (1934) who made an elaborative study on the frequency of species in about 8000 quadrats. He divided species into five classes: A, B, C, D, E and proposed the Raunkiaer's law of frequency which shows a distribution of species according to frequency classes they belong to. According to the law, species poorly distributed or dispersed in an area are likely to be presented more than those with more dispersion. In other words, A>B>C> = <D<E, i.e. A is greater than B, which is greater than C, and C may be greater or equal or lesser than D, which in turn is lesser than E.

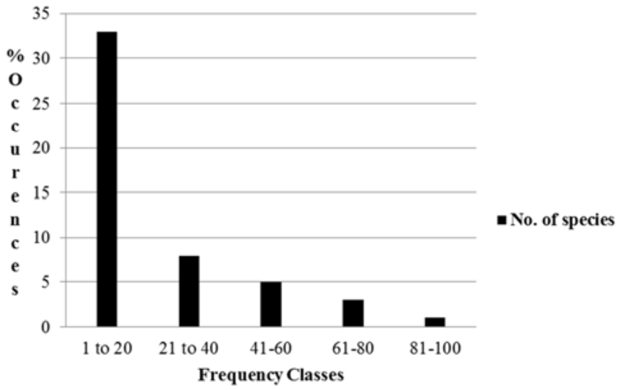


Figure 3. *Frequency Class Distribution of Plants.*

Frequency class distribution in this study is obtained by grouping the 50 encountered species into 5 classes based on their percentage occurrence. The classes are: A (1 – 20%), B (21 – 40%), C (41 – 60%), D (61 – 80%) and E (81 – 100%) in line with Kent and Coker (1992) and Demisse (2006). Result of class distribution analysis revealed a reversed J shape similar to the Raunkiaer's normal frequency diagram as obtained in Patrice *et al.* (2007). This study revealed that frequency class A constitutes thirty three species (66%), class B constitute 8 (16%), C constitutes 5 species (10), class D has three species (6%) while class E has one species (2%) (Figure 3). The presence of many multipurpose trees e.g *Tamarindus indica* (15%), *Anogiessus leiocarpus* (10%), *Vitex doniana* (10%), *Butyrospermum parkii* (5%) and *Prosopis africana* (5%) in classes B and C is an indication that the species are over-exploitation in the study area. These findings differ with Dangulla (2013) where no species was recorded in frequency classes D and E in Yabo area of Sokoto State. The presence of many multipurpose trees e.g *Tamarindus indica* (15%), *Anogiessus leiocarpus* (10%), *Vitex doniana* (10%), *Butyrospermum parkii* (5%) and *Prosopis africana* (5%) in classes B and C is an indication that the species are over-exploitation in the study area. These findings differ with Dangulla (2013) who reported no species in frequency classes D and E in Yabo area of Sokoto State.

The pattern in Figure 1 is not uncommon but may arise from human pressures principally on woody resources for energy and food. This corroborates Stephenne and Lambin (2004) who noted that human activities (e.g. changes in disturbance regimes, such as wood cutting) may directly or indirectly affect the regeneration of species and therefore the frequency decrease.

5. Conclusion

The dryland of Nigeria is subject to increasing pressures from human activities and climate which already affects vegetation. This study found that because species are sensitive to changes in climate and human activities in the area, their frequency remain low. This finding is thus imperative for monitoring some species whose frequency may vary dramatically from year to year. Our work differs from previous studies such as Dangulla (2013), because it synthesizes information from a broad range of species that are poorly distributed and/or highly dispersed.

Recommendations

1. Large scale restoration of indigenous plant species is recommended. This can be achieved through tree-based technology packages and information for a great frequency of tree species.
2. Control of massive local exploitation of forest resources (wood fuel in particular) is recommended by this study. In order to achieve this, highly restrictive protected area management policies of the past should be complemented by new ones.

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