Journal of Research in Forestry, Wildlife & Environment Vol. 9(3) September, 2017
http://www.ajol.info/index.php/jrfwe
jfewr ©2017 - jfewr Publications
E-mail:jfewr@yahoo.com
ISBN: 2141 – 1778
Danjuma and Yakubu, 2017

FLORISTIC COMPOSITION AND TAXONOMIC DISTRIBUTION OF PLANTS IN THE DRYLAND OF NORTHWESTERN NIGERIA

Danjuma M.N.[1*] and Yakubu I.[2]
[1]Department of Geography, Bayero University, Kano, Nigeria
[2]Department of Environmental Management, Bayero University, Kano, Nigeria
*Correspondence: *mndanjuma.geog@buk.edu.ng*

ABSTRACT

This study assessed floristic composition of plant species in the dryland of northwestern Nigeria with a view to understanding the inter-annual growth/decline in vegetation activity for sustainable management of species in the region. Quadrat sampling was conducted in nineteen study locations to inventory, identify and record plant species at 100m x 100m plots. Samples of species that were not directly identified in the field were collected on pressers and transported to herbarium of the Department of Biological Sciences of Bayero University Kano for identification. Results of this study revealed that a total of 50 plant species were encountered in the study area. These species fall into 22 families, 35 trees, 13 shrubs and 2 herbs. The families Caesalpiniaceae and Mimosaceae at 7% dominate the area with seven species while Sapotaceae, Mimosoideae, Meliceae, Malvaceae, Lamiceae, Euphorbiaceae, Burseraceae, Bombaceae, Balanitaceae, Ascelpiadaceae, Apocynaceae and Annonaceae are occasional with either one or two members. Analysis of abundance and rarity of species reveals that 10% and 90% of the encountered species were abundant and rare respectively in the study area. These finding poses serious ecological concerns in the study area, thus we recommended that rare species should be deliberately conserved by confronting the factors that increases rarity in the area. This may be achieved through targeted interventions aimed at reducing habitat loss and degradation.

Key words: floristic composition, taxonomic distribution, plants, northwestern Nigeria

INTRODUCTION

Nigeria is home to a wide range of habitats, ecosystems and substantial number of species diversity within them (Stuart and Adams, 1990). The number of species within any given location in the country depends partly upon certain factors including amount of rainfall received, habitat variation as well as anthropogenic activities. There are about 7,895 plants distributed in the four major biomes of the country (Federal Government of Nigeria, FGN, 2001). Some are abundant while others are rare (Gbile, Ola-Adams, and Soladoye, 1984; David, 2008). Several studies have noted that the diversity of species is greatly depleting in all parts, but more alarming in northern Nigeria (David, 2008). This calls for urgent action and prompt assessments including routine measurement of floristic composition because it can form and facilitate the basis for forest conservation planning (Villasenor, Maeda, Rosell and Ortiz, 2007) and decision making (Gordon and Newton, 2006).

Because floristic composition is one of the major anatomical characters of the plant community (Dansereau, 1960), it is usually measured or estimated on a plant community basis (van der Maarel, 2005). Therefore floristic composition is seen as a fundamental aspect of plant community research. There have been numerous studies on floristic in various parts of the world. Common areas studied are: inventory (Whittaker and Niering, 1965; Risser and Rice, 1971; Gentry, 1988; Padalia *et al*., 2004), disturbance intensity on regeneration, (Murphy and Lugo, 1986; Kennard *et al*., 2002), phenological assessment (Frankie *et al*., 1974), comparison of tree species diversity (Pitman *et al*., 2002), monitoring (Sukumar *et al*., 1992), species area and species individual relationship (Condit *et al*., 1996), modelling patterns of species diversity and/or species distributions (Phillips *et al*., 2003) as well as taxonomic diversity (mostly interpreted as the variation among and within species into taxonomic units such as Phyla, Orders, Families, Genera and Species) (Moksia *et al*., 2012). Others

focused on potential sites of species richness and diversity (Prasad, Reddy and Dutt, 2008); Danjibo, (2015), hotspots of high endemism in the tropical areas (Viswanathan, 1986; Borokini, 2003) as well as regeneration status of species (Sathish, Viswanath, Kushalappa, Jagadish and Ganeshaiah, 2013).

Despite plethora of writings on floristic composition and species taxonomic distribution that appeared in various contexts in Nigeria (Borokini, 2003; Onyekwelu, Mosandl and Stimm, 2007; Kayode and Ogunleye, 2008; Khobe, 2011; Edet, Ijeomah and Ogogo, 2011; Bello, Isah and Ahmad, 2013; Sani, Aliero, Aliero, and Ahmed, 2014); Zakari, (2015); Adeyemi, Ibe and Okedimma, 2015), only a few have focused on the dryland ecosystem outside the forest. With increasing threats to the dryland ecosystems particularly due to human disturbances (Maestre *et al.*, 2012) and changing climate (Körner, 2000; Intergovernmental Panel on Climate Change, 2002), the debate is whether the abundance patterns observed in forests can be generalised to drylands (Ulrich *et al.*, 2016). Hence providing up to date information of plants' status and taxonomic distribution in the dryland of northwestern Nigeria (which not been archived fully) remains the key goal of this study. This work also assesses abundance and rarity based on the understanding that these parameters are appropriate surrogates for healthy ecosystem management in the study area.

MATERIALS AND METHODS

Study Area

Northwestern 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, northwestern region occupies a total of 226, 662 km^2. The dryland of Nigeria constitute the Sudan and the Sahelian savanna with typical low rainfall and sparse vegetation. Mortimore and Adams (1999) noted that in Nigeria, the drylands are located north of latitude 12^{o}N. The study area lies within latitudes 12^{o}N and 14^{o}N and longitude 3^{o}E and 10.35^{o}E. It covers six states namely: Jigawa, Kano, Katsina, Zamfara, Sokoto and Kebbi. This study however covers Jigawa, Katsina, Zamfara and Sokoto.

Climate of northwestern 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).

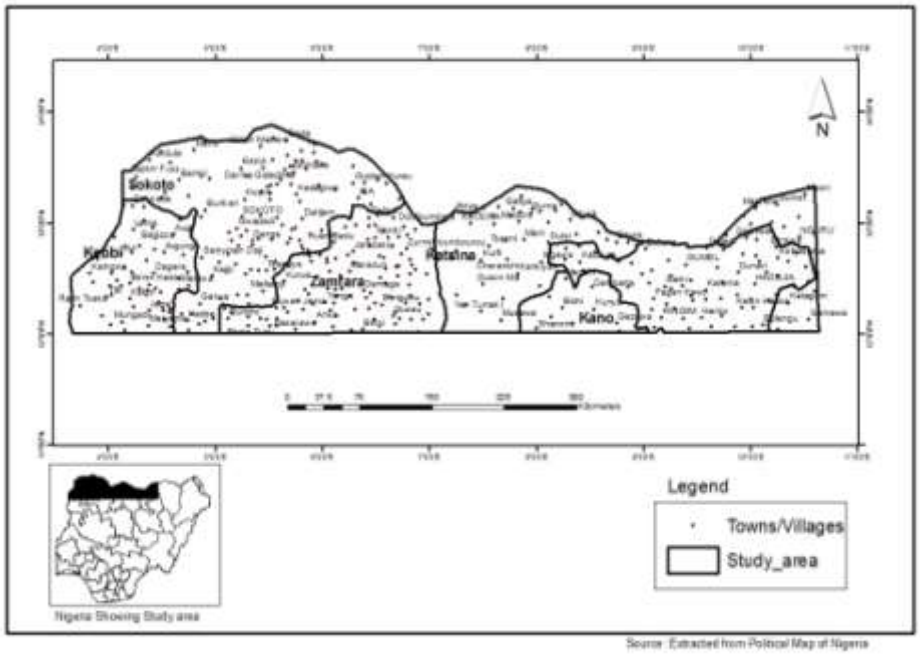

Figure 1: Dryland of Northwestern Nigeria

Average annual rainfall in dry land 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 northwestern Nigeria is of the West African type which follows the pattern of rainfall distribution. The northwestern 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*.

RESEARCH METHODS

Sampling of Study Locations

Sampling of studied 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 area diagonally, from the bottom right corner (latitude 12^0N and latitude 14^0N) to the top left corner (longitude 4.5^0E and longitude 10.8^0E) 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).

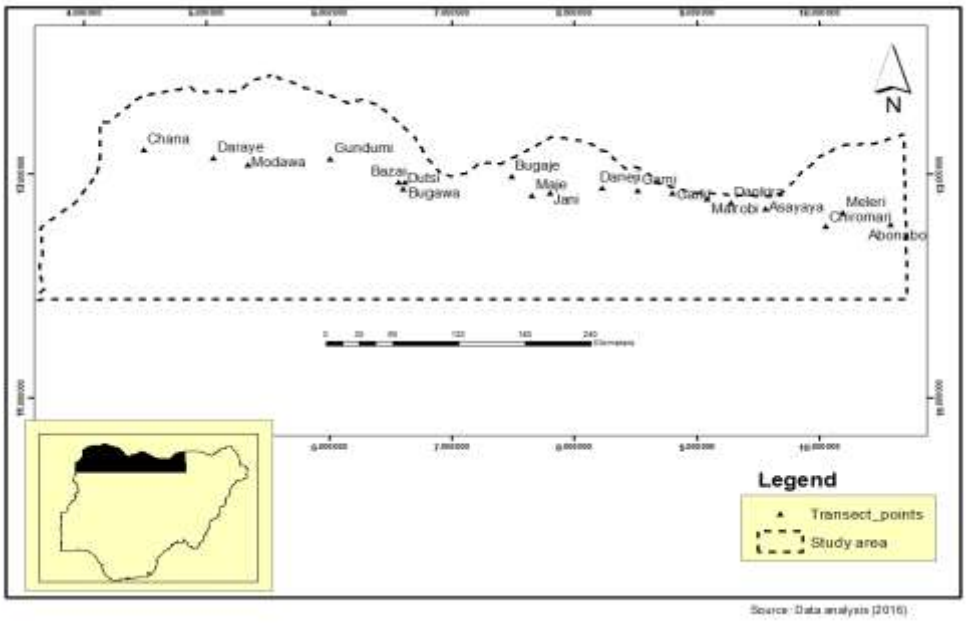

Figure 2: Study Locations in the Dryland of Northwestern Nigeria

Procedures for Data Collection and Analysis

Data for the study was sourced from quadrat sampling. This was conducted using 100m x 100m tools 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 100 x 100 m^2 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 floristic species. Samples of unknown plants 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 recorded.

Data Analysis

Data of collected from quadrat sampling was arranged in spreadsheet software (EXCEL) and analysed using formulae below as found in (Curtis and McIntosh, 1951).

$$RF = FS/TFSx100$$

Where:

RF = Relative Frequency
FS = Frequency of a species
TFS = Total frequencies of all species

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).

RESULTS AND DISCUSSION

Floristic Composition

Table 1 shows a total of fifty plant species that were encountered in nineteen locations in the dryland of northwestern Nigeria. It depicts that the study area consist of 35 trees (71% of the encountered species), 13 shrubs (25% of the encountered species) and 2 herbs (4% of the encountered species) which fall into 22 families and 41 genera. The families are: *Mimosaceae, Caesalpiniaceae, Combretaceae, Meliceae, Rhamnaceae, Mimosoideae, Balanitaceae, Anarcadiceae, Ascelpiadaceae, Euphorbiaceae, Bombaceae, Annonaceae, Fabaceae, Apocynaceae, Palmae, Rubiaceae, Ebenaceae, Moraceae, Burseraceae, Malvaceae, Lamiceae* and *Sapotaceae.* All species are indigenous with the exception of *Azadirachta indica* which is a native of the Indian subcontinent (Le Houérou, 2009). This species was imported into Nigeria in the 1950s for afforestation (Arnborg, 1988).

This study is in line with Bello, Isah and Ahmed (2013) that the family *Caesalpiniaceae* had the highest number of six species in five genera, followed by *Mimosaceae* with four species belonging to four different genera in Kogo reserve, Katsina. 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. It also supports Dangulla (2013) who reported that a total of 671 stands of woody species which belong to 40 species, 35 genera and 21 were encountered in Yabo Area, Sokoto State. The most dominant families are *Anacardiaceae, Balanitiaceae, Caesalpiniaceae, Combretaceae, Fabaceae, Leguminosae* and *Melieceae*.

Findings of this study concerning the dominance of *Caesalpiniaceae* and *Mimosaceae* families corroborate previous studies which reported that parklands are mostly based on the dominance of one or a few families and multipurpose tree species (Boffa 1999; Nikiema, 2005).This study similarly agrees with Danjibo (2015) and Zhigila *et al.* (2015) who reported that *Caesalpiniaceae* and *Mimosaceae* were the most dominant families in their respective areas of study.

Table 1: Floristic Composition in the Dryland of northwestern Nigeria

Botanical Names	Local Names (Hausa)	Life forms	Families
Acacia macrostachya	Gardaye	Tree	Mimosaceae
Acacia nilotica	Bagaruwa	Tree	Mimosaceae
Acacia seyal	Farar kaya	Tree	Mimosaceae
Adansonia digitata	Kuka	Tree	Bombaceae
Albizia chevalieri	Katsari	Tree	Mimosaceae
Alyscicarpus vaginalis	Tinya	Tree	Fabaceae
Anogiessus leiocarpus	Marke	Tree	Combretaceae
Azadirachta indica	Bedi	Tree	Meliceae
Balanite aegyptiaca	Aduwa	Tree	Balanitaceae
Bauhinia rufescens(a)	Sisi	Tree	Caesalpiniaceae
Borassus aethiophum	Giginya	Tree	Palmae
Butyrospermum parkii	Kadanya	Tree	Sapotaceae
Cassia sieberiana	Malga	Tree	Caesalpiniaceae
Combretum lamprocarpum	Kartakara	Tree	Combretaceae
Commiphora africana	Dashi	Tree	Burseraceae
Dichrostachys cinerea	Dundu	Tree	Mimosaceae
Diosphyros mespiliformis(a)	Kanya	Tree	Ebenaceae
Diospyros mespiliformis(b)	Kaiwa	Tree	Ebenaceae
Fadherbia albida	Gawo	Tree	Mimosoideae
Ficus iteophylla	Shiriya	Tree	Moraceae
Ficus spp.	Lubiya	Tree	Moraceae
Ficus thonningii	Gamji	Tree	Moraceae
Hyphaene thebaica (big)	Goriba	Tree	Palmae
Lannea acida	Faru	Tree	Anacardiceae
Lonchocarpus cyanescens	Talage	Tree	Fabaceae
Maerua crassifolia	Jiga	Tree	Caesalpiniaceae
Mitragyna inermis	Giyayya	Tree	Rubiaceae
Parkia biglobosa	Dorowa	Tree	Mimosaceae
Piliostigma reticulatum	Kalgo	Tree	Caesalpiniaceae
Prosopis africana	Kirya	Tree	Mimosaceae
Sclerocarya birrea	Danya	Tree	Anacardiceae
Securinega virosa	Filasko	Tree	Euphorbiaceae
Tamarindus indica	Tsamiya	Tree	Caesalpiniaceae
Vitex doniana	Dinya	Tree	Lamiceae
Ziziphus spina-christi	Kurna	Tree	Rhamnaceae
Annona senegalensis	Gwandar daji	Shrub	Annonaceae
Bauhinia rufescens (b)	Tsatstsagi	Shrub	Fabaceae
Calatropis procera	Tumfafiya	Shrub	Ascelepiadaceae
Cassia singuena	Runhu	Shrub	Caesalpiniaceae
Combretum micranthum	Geza	Shrub	Combretaceae
Feretia apodanthera	Kuru-kuru	Shrub	Rubiaceae
Ficus sycomorus	Baure	Shrub	Moraceae
Guiera senegalensis	Sabara	Shrub	Combretaceae
Indigofera tictora	Baaba	Shrub	Fabaceae
Sesbania dalzielli	Alambo	Shrub	Fabaceae
Terminalia avicennoioides	Bauji	Shrub	Combretaceae
Waltheria indica	Hankuha	Shrub	Malvaceae
Ziziphus mauritania	Magarya	Shrub	Rhamnaceae
Perguleria tomentosa	Fatakka	Herb	Apocynaceae
Rogeria adenophylla	Loda	Herb	Caesalpiniaceae

Hausa names of species were obtained from von Maydell (1990) and Blench and Dendo (2007).
Diosphyros mespiliformis represent Kaiwa and Kanya (Hausa) according to Blench and Dendo (2007).
Bauhinia rufescens represent Sisi and Tsatstsagi (Hausa) according to Blench and Dendo (2007).

Caesalpiniaceae and *Mimosaceae* dominate the dryland of northwestern Nigeria perhaps because their members can regenerate from the remaining rootstock when rainfall begins. This corroborates Nikiema (2005) who reported that the *Caesalpiniaceae* are dominant in the dryland in Namibia because of their high regenerative ability.

Species Abundance

Species abundance refers to how common or rare a species is relative to other species in a defined location or community (Preston, 1948). Relative abundance is the percent composition of an organism of a particular kind relative to the total number of organisms in the area. Abundance is a fundamental component of species diversity (Fangliang, LaFrankie, and Song, 2002) and a key indicator of both community composition and dynamics of plants (Bossel and Krieger, 1994). This study considers abundant species as any plant with relative abundance above 10% and/or appears in more than ten locations in the study area.

Table 2 shows that abundant species are plants with high number of individuals in the study area. Five species were considered as abundant plants. *Azadirachta indica* and *Ziziphus mauritania* fall into this category because the species appear in more than ten study locations. The occurrence of few species in the abundance category depicts serious ecological concerns in the study area.

Table 2: Abundant Plant Species in the Dryland of northwestern Nigeria

Botanical Names	Total Number of Species	Number of Quadrats which the Species Appear	Relative Abundance %
Piliostigma reticulatum	245	16	20.00
Fadherbia albida	165	13	13.50
Guiera senegalensis	136	11	11.12
Azadirachta indica	114	14	9.38
Ziziphus Mauritania	99	13	8.10
Total Species	**759**		

Species Rarity

Rare species are groups of organisms that are very uncommon, scarce or infrequently encountered. Rarity rests on a specific species being represented by small organisms in an area (Prendergast, Quinn, Lawton, Eversham, and Gibbons, 1993). Rarity is most simply based on species' distribution and abundance (Gaston, 1994). According to Reveat (1981) rarity is merely the current status of an extant organism which is restricted either in numbers or area to a level that is demonstrably less than the majority of other organisms of comparable taxonomic entities. Species that are restricted in numbers or spatial occurrence are considered to be rare *relative* to the distribution and abundance of other species making up the pool of interest (Smith and Knapp, 2003).

The actual rarity cut point selected is a subjective decision (Magurran, 2004). Hence, this study considered species with 10% relative abundance and restricted by spatial occurrence rare in line with (Flather, Knowles and Kendall, 1998) and (Smith and Knapp, 2003) respectively. Therefore any species which appear in less than ten locations in the study area is rare.

Table 3 shows that rare species are represented by forty five species with relatively few individuals across the study area. A total of thirty species representing 67% of encountered plants are multipurpose woody species. There are variations in the number of individuals of the rare species because in addition to natural perturbations, the levels of resistance to anthropogenic stress vary from one plant to another. This study however, finds a converse situation where some rare species are not considered threatened in the area. *Acacia nilotica* (51 individuals) and *Balanite aegyptiaca* (47 individuals) are vulnerable but not threatened with extinction in the dryland of northwestern Nigeria (Danjuma, 2016). This finding supports Gaston (1994) who reported that a species may qualify as rare but may not be considered at risk of extinction. *Adansonia digitata* and *Balanite aegyptiaca* are considered rare species despite appearing in eleven and ten locations respectively because their relative abundance is not up to 10% which is supported in the literature including Flather, Knowles and Kendall (1998).

Table 3: Rare Plant Species in the Dryland of northwestern Nigeria

Botanical Names	**Total Number of Species**	**N**	**%**
Acacia nilotica	51	8	4.17
Balanite aegyptiaca	47	10	3.84
Calatropis procera	28	4	2.29
Securinega virosa	26	4	2.12
Diosphyros mespiliformis (a)	26	4	2.12
Cassia sieberiana	25	3	2.04
Adansonia digitata	24	11	1.96
Lannea acida	23	8	1.88
Acacia seyal	23	3	1.88
Annona senegalensis	22	6	1.80
Perguleria tomentosa	19	1	1.55
Combretum micranthum	15	2	1.22
Hyphaene thebaica (big)	14	6	1.14
Sclerocarya birrea	12	7	0.98
Parkia biglobosa	11	7	0.90
Mitragyna inermis	10	1	0.81
Dichrostachys cinerea	9	2	0.73
Ziziphus spina-christi	9	2	0.73
Tamarindus indica	8	3	0.65
Terminalia avicennoioides	8	1	0.65
Indigofera tictora	7	7	0.57
Commiphora africana	6	2	0.49
Acacia macrostachya	6	1	0.49
Alyscicarpus vaginalis	6	1	0.49
Waltheria indica	6	1	0.49
Rogeria adenophylla	4	1	0.33
Anogiessus leiocarpus	3	2	0.24
Diospyros mespiliformis (b)	3	2	0.24
Sesbania dalzielli	3	1	0.24
Ficus thonningii	3	1	0.24
Bauhinia rufescens (b)	2	3	0.16
Ficus iteophylla	2	2	0.16
Vitex doniana	2	2	0.16
Albizia chevalieri	2	1	0.16
Combretum lamprocarpum	2	1	0.16
Cassia singuena	1	1	0.08
Bauhinia rufescens (a)	1	1	0.08
Butyrospermum paradoxa	1	1	0.08
Feretia apodanthera	1	1	0.08
Ficus spp.	1	1	0.08
Ficus sycomorus	1	1	0.08
Lonchocarpus cyanescens	1	1	0.08
Prosopis africana	1	1	0.08
Total Species	**463**		

N= Number of quadrats in which the species appear

CONCLUSION

Floristic composition is a measure for understanding change in species richness at regional scales (Ulrich *et al.*, 2016). One vital aspect of floristic composition assessment that this study utilised is the emphasis on regional basis.

Despite the clearly recognised benefits provided by drylands vegetation, they continue to be lost at unprecedented rates. One major finding of this study is that the dryland of northwestern Nigeria possesses substantial numbers of species, most of which are woody from few taxonomic families and rare. The few abundant species even though well spread, are also highly threatened. This may further compound the widespread diversity loss earlier reported in various studies in this area. This study highlights that understanding the causes of rarity is key to reducing extinction threats associated with many rare species encountered in the area. Furnished with knowledge that species might be naturally rare and/or overexploited, there is urgent need to launch a concerted national initiative to ensure in depth documentation of floristic diversity especially of indigenous multipurpose plants which are being lost due to over-exploitation. This work provides knowledge base for action plan that will reduce obstacles to vegetation conservation in Nigeria.

.

RECOMMENDATIONS

1. This study recommends that rare species should be conserved by confronting the factors that result in increased rarity in the area. This can be achieved through targeted interventions aimed at reducing habitat loss and degradation, controlling the introduction or invasion of exotic species, pollution, as well as direct human exploitation.
2. There is need for capacity building of farmers who relatively retained species' diversity on crop fields. These can be achieved through incentive measures and policy reform that ensures fairness in resource allocation.

REFERENCES

Adeyemi, A.A., Ibe, A.E. and Okedimma, F.C. (2015).Tree Structural and Species diversities in Okwangwo Forest, Cross River State, Nigeria. *Journal of Research in Forestry, Wildlife and Environment*, 7(2).

Arnborg, T. (1998). *Where Savanna Turns into Desert: Experiences From the Sudan Savanna Zone in Sokoto State, Nigeria*. International Rural Development Centre, Uppsala

Bello, A.G., Isah, A.D. and Ahmad, B. (2013). Tree species diversity analysis of Kogo Forest Reserve in north-western, Nigeria. *International Journal of Plant, Animal and Environmental Sciences*, 3(3): 189-196.

Blench, R. and Dendo, M. (2007). Hausa Names for Plants and Trees. 2nd Edition, 8 Guest Road, Cambridge, United Kingdom.

Boffa, J.M. (1999). Agroforestry parklands in sub-Saharan Africa. FAO Conservation Guide 34.

Borokini, T.I. (2013). A Systematic Compilation of IUCN Red-listed Threatened Plant Species in Nigeria. *International Journal of Environmental Sciences*, Vol. 3(3):104-133

Bossel, H. and Krieger, H. (1994). Simulation of multi-species tropical forest dynamics using a vertically and horizontally structured model. *Forest Ecology and Management*, 69:123-144.

Condit, R., Hubbell, S.P. and Lafrankie, J.V. et al. (1996). Species-area and species-individual relationship for tropical trees: A comparison of three 50-ha plots. *Ecology*, 84: 549-562

Curits, J.T. and McIntosh, R.P. (1951). An Upland Forest Continuum in the Prairie-Forest Border Region on Wisconsin. *Ecology*, 32:476-496. http://dx.doi.org/10.2307/1931725

Dangulla, M. (2013). *The* Diversity and Spatial Variability of Woody Species in Yabo Area, Sokoto State. A Thesis Submitted to the School of Postgraduate Studies, Ahmadu Bello University, Zaria, Nigeria.

Danjibo, M. (2015). Assessment of Land Use/Land Cover Change and Floristic Composition of Kuwanka Banza Forest Reserve Kebbi State,

Nigeria. An Unpublished Master of Science (forest biology and silviculture) Dissertation Submitted to the Department of Forestry and Environment, Usmanu Danfodiyo University, Sokoto, Nigeria.

Danjuma, M.N. (2016). Conservation Status of Vegetation in the Dryland of Northwestern Nigeria. *Proceedings of 30th Annual Conference of Nigeria Meteorological Society (NMetS).* Held in Federal University of Agriculture, Abeokuta between 21 to 24th November 2016.

Dansereau, P. (1960). The Origin and Growth of Plant Communities. **In**: Zarrow, M.X. (ed.), *Growth in Living System: Proceedings of International Symposium on Growth*, Purdue University, Indiana, Basic Books, New York.

David, M. (2008).*118/119 Biodiversity and Tropical Forest Assessment for Nigeria*. USDA Forest Service/International Forestry for USAID/Bureau for Africa. Washington, DC.

Edet, D.I., Ijeomah, H.M. and Ogogo, A.U. (2011). Preliminary assessment of tree species diversity in Afi Mountain Wildlife Sanctuary, Southern Nigeria. *Agriculture and Biology Journal of North America*, 3(12): 486-492.

Fangliang, H., LaFrankie, J.V. and Song, B. (2002).Scale dependence of tree abundance and richness in a tropical rain forest, Malaysia. *Landscape Ecology*, 17: 559–568

Federal Government of Nigeria (2001). *First National Biodiversity Report*. Nigeria

Flather, C.H., Knowles, M.S. and Kendall, L.A. (1998). Threatened and endangered species geography: Characteristics of hot spots in the conterminous United States. *BioScience*, 48:365-76.

Frankie, G.W., Baker, H.G. and Opler, P.A. (1974). Comparative phenological studies of trees in tropical wet and dry forests in the lowlands of Costa Rica. *The Journal of Ecology*, 62: 881-919.

Gaston, K.J. (1994). *Rarity*. London: Chapman and Hall.

Gbile, Z.O., Ola-Adams, B.A. and Soladoye, M.O. (1984). List of rare species of the Nigerian Flora. Research Paper Forest Series No 47. Forestry Research Institute of Nigeria, Ibadan, Nigeria.

Gentry, A.H. (1988). Changes in plant community diversity and floristic composition on environmental and geographical gradients. *Ann Mo Bot Card*, 75: 1-34.

Gordon, J.E. and Newton, A.C. (2006). Efficient floristic inventory for the assessment of tropical tree diversity: A comparative test of four alternative approaches. *For Ecol Manage*., 6: 564–573.

Henderson, P.A. (2003). Practical Methods in Ecology. Oxford, UK: Blackwell Publishing

Intergovernmental Panel on Climate Change, IPCC (2002). Climate Change and Biodiversity. *IPCC Technical Paper V*, IPCC.

Kayode, J. and Ogunleye, T.O. (2008). Checklist and Status of Plant Species Used as Spices in Kaduna State of Nigeria. *African Journal of General Agriculture*, 4(1): 13-18.

Kerr, J.T. and Burkey, T.V. (2002) Endemism, diversity, and the threat of tropical moist forest extinctions. *Biodivers Conserv*., 11: 695–704.

Kennard, D.K., Gould, K. and Putz, F.E. et al. (2002). Effect of disturbance intensity on regeneration mechanisms in a tropical dry forest. *Forest Ecology and Management*, 162: 197-208

Khobe, D. (2007). Species Composition and Range Condition of Jibiro Grazing Reserve, Adamawa State, Nigeria. *Global Journal of Science Frontier Research*, Volume XI Issue IX Version I, 21-24

Kindt, R. and Coe, R. (2005).Tree Diversity Analysis. A manual and software for common statistical methods for ecological and

biodiversity studies. World Agroforestry Centre (ICRAF), Nairobi

Körner, C.H. (2000). Biosphere responses to CO2-enrichment. *Ecol. Appl*., 10:1590–1619.

LeHouérou, H.N. (2009). *Bioclimatology and Biogeography of Africa.* Berlin Heidelberg: Springer-Verlag

Maestre, F.T., Salguero-Gómez, R. and Quero, J.L. (2012). It's getting hotter in here: determining and projecting the impacts of global change on drylands. *Phil.Trans. R. Soc. B* 367: 3062–3075.

Magurran, A.E. (2004). Measuring biological diversity. Malden, MA: Blackwell Science

Moksia, F., Louis, Z., Pierre, M.M. and Bernard-A.N. (2012). Woody species composition, structure and diversity of vegetation of Kalfou Forest Reserve, Cameroon. *Journal of Ecology and the Natural Environment*, 4(13):333-343.

Mortimore, M. and Adams, W.M. (1999). Working the Sahel: Environment and Society in Nigeria. London: Routledge.

Mortimore, M. (2001). A Profile of Rainfall Change and Variability in the Kano – Maradi Region, 1960 – 2000. *Drylands Research Working Paper 25*, Dryland Research, Crewkerne, UK.

Murphy, P.G. and Lugo, A.E. (1986). Ecology of tropical dry forest. *Annual Review of Ecology*, 17:67-88. http://dx.doi.org/10.1146/annurev.es.17.110186.000435.

Nikiema, A. (2005). Agroforestry Parkland Species Diversity: Uses and Management in Semi-Arid West Africa (Burkina Faso). PhD Thesis, Department of Plant Sciences, Wageningen University, Wageningen

Onyekwelu, J.C., Mosandl, R., Stimm, B. (2007). Tree species diversity and soil status of two natural forest ecosystems in lowland humid tropical rainforest region of Nigeria. Conference on International Agricultural Research for Development. University of Kassel-Witzenhausen and University of Göttingen, October 9-11, 2007.

Padalia, H., Chauhan, N. and Porwal, M.C. et al. (2004). Phyto-sociological observations on tree species diversity of Andaman Islands, India. *Current Science*, 87: 799-806.

Phillips, O.L., Martinez, R.V., Vargas, P.N., Monteagudo, A.L. and Zans, M.E.C., et al. (2003). Efficient plot-based floristic assessment of tropical forests. *Journal of Tropical Ecology*, 19: 629–645.

Prasad, R.C., Reddy, C.S., and Dutt, C.B.S. (2008). Phytodiversity Zonation in North Andaman Islands, India using remote sensing, GIS and Phyto-sociological data. *Research Journal of Environmental Sciences*, 2: 1-12.

Prasad, R.C., Rajan, K.S., Dutt, C.B.S. and Roy, P.S. (2010) A conceptual framework to analyse the Land-use / land-cover changes and its impact on phytodiversity – A case study of North Andaman Islands, India. *Biodivers Conserv.*, 19: 3073- 3087.

Prendergast, J.R., Quinn, R.M., Lawton, J.H., Eversham, B.C. and Gibbons, D.W. (1993). Rare Species, the coincidence of diversity hotspots and conservation strategies. *Nature*, 365 (6444):335-33

Preston, F.W. (1948). The Commonness, and Rarity, of Species. *Ecology*, 29 (3): 254-283. Doi:10.2307/1930981

Reveat, J.L. (1981). The concept of rarity and population threats in plant communities. **In:** Morse, L.E. and Henefin, M.S. (ed.) *Rare plant conservation.* Bronx: New York Botanical Garden.

Risser, P. and Rice E.L. (1971). Diversity in tree species in Oklahoma upland forest. *Ecology*, 52: 876-880.

Sagar, R, Raghubanshi, A.S. and Singh, J.S. (2003). Tree species composition, dispersion and diversity along a disturbance gradient in a dry tropical forest region of India. *Forest Ecology and Management*, 186: 61-71.

Sani, H., Aliero, B.L., Aliero, A.A. and Ahmed, H.G. (2014).Floristic Composition and Life Forms Study of Woody Plants in Magama Local Government Area, Niger State, Nigeria. *Annual Research & Review in Biology*, 4(3): 527-537.

Sathish, B.N., Viswanath, S., Kushalappa, C.G., Jagadish, M.R. and Ganeshaiah, K.N. (2013). Comparative assessment of floristic structure, diversity and regeneration status of tropical rain forests of Western Ghats of Karnataka, India. *Journal of Applied and Natural Science*, 5 (1): 157-164.

Smith, M.D. and Knapp, A.K. (2003). Dominant species maintain ecosystem function with non-random species loss. *Ecology Letters*, 6:509-17.

Stuart, S.N. and Adams, R.J. (1990). *Biodiversity in Sub-Saharan Africa and its Islands: Conservation, Management, and Sustainable Use*. Gland, Switzerland: IUCN.

Sukumar, R., Dattaraja, H.S. and Suresh, H.S. et al. (1992). Long-term monitoring of vegetation in a tropical deciduous forest in Mudumalai, southern India. *Current Science*, 62: 608-613.

Udo, R.K. (1970).Geographical Regions of Nigeria, London: Heinemann

Ulrich, W., Soliveres, S., Thomas, A.D., Dougill, A.J., Fernando T., and Maestre, F.T. (2016). Environmental correlates of species rank − abundance distributions in global drylands. *Perspectives in Plant Ecology, Evolution and Systematics*, 20:56–64

van der Maarel, E. (2005). Vegetation Ecology. USA: Blackwell Publishing.

Viswanathan, T.V. (1986). Endangered tree species in northern Ethiopia. *Environ. Conserv.* 13: 71-72

Villasenor, J.L., Maeda, P., Rosell, A. and Ortiz, E. (2007). Plant families as predictors of plant biodiversity in Mexico. *Divers Distrib.*, 13: 871-876.

Von Maydell, H-J (1990). *Trees and Shrubs of the Sahel: their Characteristics and Uses*. Weikersheim, GmbH: Verlag Josef margrave.

Whittaker, R. and Niering, W.A. (1965). Vegetation of the Santa Catalina Mountains, Arizona: A gradient analysis of the south slope. *Ecology*, 46: 429-452.

Zakari, H.H. (2015). *Vegetation Composition and Conservation Status of Baturiya Wetland, Jigawa State, Nigeria.* A Thesis Submitted to the School of Postgraduate Studies, Ahmadu Bello University Zaria, Nigeria

Zhigila, D.A., Sawa, F.B.J., Abdul, S.D., Abba, H.M. and Tela, M. (2015). Diversity and Phytogeographic Investigation into Woody Plants of West Tangaza Forest Reserve, Sokoto State, Nigeria. *International Journal of Plant Research*, 5(4): 73-79