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Biodiversity in Kenikeni Forest Reserve of Northern Ghana

Damian Tom-Dery*, Paul Hinneh and William Jasper Asante

Department of Forestry and Forest Resources Management, Faculty of Renewable Natural Resources, University for Development Studies, Tamale, Ghana.

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The objectives of this study were; (1) to determine the composition of woody species; (2) to estimate the diversity of woody species, and (3) to determine the structure of woody species in the reserve. Thirty nested circular plots were purposively established in various vegetation types. A total of 68 woody species were identified belonging to 25 plant families. The Shannon diversity index was computed to be 3.5 indicating high diversity. There were more trees/shrubs in lower diameter class than the others hence the reverse J- Shape bar chart. The study concluded that the high woody species diversity enables the reserve to perform its function of providing ecological protection for headwaters and serving as a reservoir for game as well as contributing to the preservation of biodiversity. It also concluded that the characteristics of vegetation in the reserve were generally similar to that of other guinea savanna areas.

Key words: Biodiversity, Kenekeni forest reserve, Savanna, woody species.

INTRODUCTION

Biological diversity is vital for human survival and economic well being (Sagar et al., 2003; Zhu et al., 2007). However, exceptional rate of deforestation and degradation of tropical forests (Schroeder et al., 1010) have accelerated the loss of biological diversity along with the water sources and non-timber forest products (Lamb et al., 2005). Currently, there is a drastic drop of biodiversity, a reduction of the density of the woody species, and a degradation of the structure of some species population (Sambou, 2004). The loss of biological diversity is perhaps the most critical concern for human survival as it influences all ecological services and livelihoods. This culminated in the advance of a human-vegetation nexus as the main subject of discussion since the Rio declaration (Tárrega et al., 2006).

Botanical assessments such as floristic composition and structure studies are important in the milieu of appreciating the range of plant diversity in different ecosystems (WCMC, 1992; Addo-Fordjour et al., 2009). They are useful for the assessment of sustainability of ecosystems since forests play a vital role in the conservation of plant species, and ecosystem management (Tilman, 1988; Ssegawa and Nkuutu, 2006). Ecological data obtained in this regard are not only important for the purpose of sound management practices but, also helpful in identifying important elements of plant diversity, protecting threatened and economic species and monitoring the state of vegetations (Tilman, 1988; Ssegawa and Nkuutu, 2006; Addo-Fordjour et al., 2009).

The savanna zone of Ghana is the most dominant vegetation type covering about 60.77% of the country's total landmass (Anonymous, 2002) and serves as a source of livelihood for about 30% of the population through the provision of economic resources such as *Vitellaria paradoxon* (Shea), *Parkia biglobosa* (Dawadawa), forage and fuelwood (Yaro, 2008). Despite the economic, social and environmental role of the

*Corresponding author. E-mail: tom_dery@yahoo.co.uk. Tel: +233203669027.

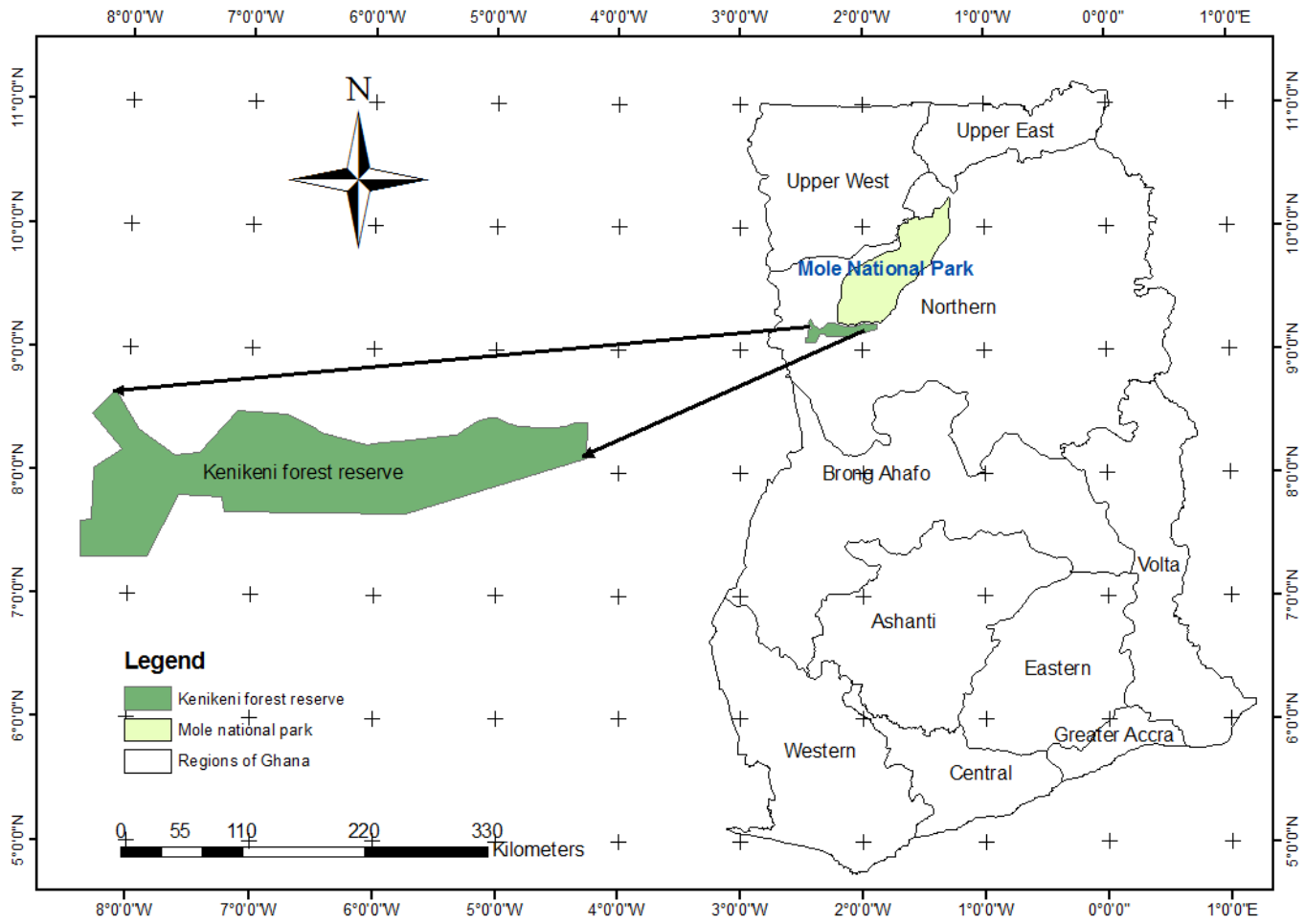

Figure 1. Map of Ghana indicating the Kenikeni Forest Reserve.

savanna vegetation, there are not enough data on ecological studies unlike the forest ecosystem where major data has been collected as a result of it being perceived as having a greater commercial value. Previous research on the guinea savanna vegetation type of Ghana included Oteng-Yeboah (1996), Asase and Oteng-Yeboah (2007), Asase et al. (2009) and Tom-Dery et al. (2012), all of which concluded that the floristic composition (species richness) and abundance of woody species in different areas of the guinea savanna zone are variable. The Kenikeni Forest Reserve (KFR) located in the savanna biome was established in 1955 to provide ecological protection for the headwaters of several streams and rivers that feed the Black Volta River and also serve as a reservoir for game and control of erosion (GWS, 2006). The woodland lacks basic data on the structure and composition (diversity) of woody species and also data on the supply of savanna resources to determine their sustainability. The objectives of this study were; (1) to determine the composition of woody species; (2) to estimate the diversity of woody species, and (3) to determine the structure of woody species in the reserve.

MATERIALS AND METHODS

Study area

The study was carried out at the KFR that has a total land area of 515.92 km^2 (GWS, 2006). The reserve is located in the West Gonja District of the Northern Region, Ghana which is located within longitude 1° 5' and 2° 58' West and Latitude 8° 32' and 10° 2' North (WGDA, 2008). Temperatures are generally high with the maximum occurring between March/April and lowest between December/January with mean monthly temperature of 27°C and average annual precipitation of 1144 mm (WGDA, 2008). The topography is generally undulating with altitude of between 150 and 200 m above sea level. The following communities (Grupe, Kanato, Kabampe and Sonyo) are fringing the reserve and traditionally hold the reserve in high esteem as an abode for their idol called "Kipo". Figure 1 is a map of Ghana indicating the study area. Bush fire is an annual ritual in KFR as in other savanna areas. Wild grazing animals from the neighboring Mole National park and domestic cattle of Fulani herd's men are a common occurrence in KFR.

A total of 30 nested circular sampling plots were laid. The first circular plot of radius 12.62 m was laid at random and the subsequent plots laid 50 m away from each other. Trees with diameter at breast height (DBH) of 10 cm and above were recorded within the 12.62 m radius plot. Smaller circular plots of 100 m^2 were located in the larger plots for the survey of young trees above a

height of 1.30 m and below a DBH of 10.0 cm. Smaller circular plots of 25 m^2 were further located within the 100 m^2 plots for regenerating plants below 30 cm diameter. All individuals in these regeneration plots and subplots were counted by species.

All species of woody plants found rooted within each plot were identified and their individual plants counted. The identification of tree and shrub species was based on their physiognomic characteristics and later confirmed using relevant literature (Hutchinson and Dalziel, 1957-1971; Arbonnier, 2004), and by comparison with already identified specimens at the University for Development Studies Herbarium. All botanical nomenclature in this article follows IPNI (2008).

Data analysis

The individual-based rarefaction methodology described by Gotelli and Colwell (2001) was used to estimate the expected number of species for the construction of species accumulation curve with 95% confidence level. The free statistical software EstimateS version 8.2.0 (Gotelli, 2012) was used for the species accumulation curve. The program was set to randomized samples with replacement and shuffle; the individual plants among plots within species 50 times.

Species diversity index for the site was computed using the Shannon Wiener diversity index (H') to determine the extent of woody component diversity (Magurran, 1988).

$$H' = \sum_{i=1}^{S} - (Pi * \ln Pi)$$

Where H = the Shannon diversity index, Pi = fraction of the entire population made up of species i, S = numbers of species encountered, and $\sum$ = sum from species 1 to species S.

RESULTS AND DISCUSSION

Woody species composition

A total of 68 woody species were recorded (Table 1). Fifty four (54) species were identified to be trees, 12 shrubs, 2 lianas representing 79.4, 17.6 and 2.9% respectively. The most abundant woody species in the reserves were *Vitellaria paradoxa* (7.7%), *Detarium microcarpum* (6.7%), *Isoberina doka* (6.5%), *Afzelia africana* (6.5%), *Pterocarpus erinaceus* (5.7%) and *Burkea africana* (5.7%). Table 1 illustrates all the woody species recorded in Kenikeni forest reserve.

The species accumulation curve (Figure 2), is the cumulative number of species recorded as a measure of the sampling effort. The individual-based species accumulation curve shows that the majority of woody plants in the reserve were sampled during the study as seen in the curve as it reaches the asymptote. About 71% (Table 1) of woody species genera consisted of only one species. Genera with two or more species included Combretum (4), Acacia (3), Terminalia (3), Trichilia (2), Annona (2), Strychnos (2), Pteleopsis (2), Vitex (2) and Gardenia (2). The species identified in the reserve were similar to those reported elsewhere in guinea savanna areas of Ghana (Schitt and Adu-Nsiah, 1993; Houssain and Hall, 1996; Oteng-Yeboah, 1996; Asase and Oteng-Yeboah, 2007; Asase et al., 2009; Tom-Dery et al., 2012). Species like *Rourea coccinea, Dalbergia afzeliana*, and *Hoslundia opposita*, recorded by Asase et al. (2009) in Sinsabligbini Forest Reserve but not in other savanna areas, were found in this study. The following species; *Afraegle paniculata, Dichrostchys cinerea, Erythrina senegalensis, Feretia apodanthera, Khaya senegalensis, Malacantha alnifolia, Manilkara multinervium, Prosopis africana, Tetracera alnifolia and Xerroderis stuhlamanii* recorded in this study were not found in the nearby Damongo scarp (Tom-Dery et al., 2012).

In a similar study at the nearby Damongo scarp, Tom-Dery et al. (2012) reported 61 woody species belonging to 25 families (using ten plots of size 225 m^2) while a study of woody plant composition in a tropical savanna in northern Ghana, Asase et al. (2009) noted 62 woody species belonging to 19 families using 15 plots of radius 10 m. Schitt and Adu-Nsiah (1993) recorded a very high number (148) of tree species in the Mole National Park, Damongo (MNP), while Houssain and Hall (1996) reported a lower number (90) of tree species in the same MNP. Though most of the species recorded in this study were recorded in the above studies, a few different species (22%) were also recorded. This indicates that floristic composition of savanna is variable, even over relatively homogenous areas (Hopkins, 1979; Lawson, 1985).A total of 25 woody species families was recorded with the most species rich families (Table 2) being Leguminosae (45.2), Combretaceae (18.6), Rubiaceae (9.2) and Meliaceae (4.5). The reported high species diversity of tree families Leguminosae (formerly Fabaceae) and Combretaceae in the guinea savanna have been noted elsewhere (Hopkins, 1979; Asase and Oteng-Yeboah, 2007; Asase et al., 2009; Tom-Dery et al., 2012). In a study of three traditional groves in northern Ghana, Oteng-Yeboah (1996) also reported the predominance of the family Leguminosae (Caesalpinaceae, Papilionaceae, and Mimosaceae) and Combretaceae in the different groves which is similar to the results of this study. However, Meliaceae, though reported as dominant in this study, was not a dominant family in the other studies except in Tom-Dery et al. (2012). Hence, the same families may run through the various guinea savanna zones of northern Ghana but some may be dominant whereas others are not. Interestingly, some families (Sapotaceae and Anacardiaceae) with few species recorded very high abundances (Table 2); which follows that not all the families with many species are abundant (Asase et al., 2009) in the reserve.

Woody species diversity

The study revealed Shannon-Wiener Index of diversity

Table 1. Woody species, their families and abundances in the KFR.

Species	Family	Life form	Abundance
Acacia dudgeon Craib.	Leguminosae	Small tree	1
Acacia goumaensis A.Chev.	Leguminosae	Tree	4
Acacia hockii De Wild.	Leguminosae	Small tree	2
Afraegle paniculata (Schum & Thonn.) Engl.	Rutaceae	Tree	3
Afzelia africana Sm.	Leguminosae	Tree	26
Allophyllus africanum P. Beauv.	Sapindaceae	Small tree	2
Annona glauca Schumach. & Thonn.	Annonaceae	Shrub	2
Annona senegalensis Pers.	Annonaceae	Shrub	6
Anogessius leiocarpus Guill. & Perr.	Combretaceae	Tree	8
Balanites aegyptiaca (L.) Dellile	Zygophylaceae	Small tree	2
Bombax costatum Pellegr. & Vuillet	Bombacaceae	Tree	2
Bridelia ferruginea Benth.	Euphorbiaceae	Small tree	1
Burkea africana Hook.	Leguminosae	Small tree	23
Combretum adenogonium Steud.ex A.Rich	Combretaceae	Small tree	14
Combretum collinum Fresen	Combretaceae	Small tree	1
Combretum molle R. Br. ex. G. Don.	Combretaceae	Small tree	17
*Combretum nigricans*Leprieur ex Guill. & Perr.	Combretaceae	Small tree	3
Crossopteryx febrifuga (Afzel.ex G. Don.) Benth.	Rubiaceae	Tree	9
Dalbergia afzeliana G. Don.	Leguminosae	Liana	2
Daniellia oliveri (Rolfe) Hutch. & Dalz.	Leguminosae	Tree	11
Detarium microcarpum Guill. & Perr.	Leguminosae	Tree	27
Dichrostchys cinerea (L) Wright & Arn.	Leguminosae	Shrub	15
Diospyros elliotii F. White	Ebenanaceae	Tree	1
Entada africana Guill & Perr.	Leguminosae	Small tree	2
Erythrina senegalensis A. Rich.	Leguminosae	Tree	1
Erythrophloem africanum Harms.	Leguminosae	Small tree	2
Feretia apodanthera Del.	Rubiaceae	Shrub	3
Ficus glumosa Del.	Moraceae	Tree	2
Gardenia aqualla Stapf. & Hutch.	Rubiaceae	Shrub	2
Gardenia ternifolia Schumach.	Rubiaceae	Shrub	1
Grewia mollis Juss.	Tiliaceae	Small tree	1
Hexalobus monopetalus Engl. & Diels.	Annonaceae	Small tree	1
Hoslundia opposita Vahl.	Lamiaceae	Shrub	2
Hymenocardia acida Tul.	Euphorbiaceae	Tree	2
Isoberlinia doka Craib. & Stapf.	Leguminosae	Tree	26
Khaya senegalensis A. Juss.	Meliaceae	Tree	4
Kegelia africana (Lam.) Benth.	Bignoniaceae	Small tree	1
Lannea acida A. Rich.	Anacardiaceae	Tree	18
Malacantha alnifolia Pierre	Sapotaceae	Tree	5
Manilkara multinervium Dubard	Sapotaceae	Tree	1
Maytenus senegalensis (Lam.) Exell.	Celastraceae	Shrub	3
Mitragyna inermis (Wild.) Kuntze	Rubiaceae	Tree	2
Nauclea latifolia Sm.	Rubiaceae	Shrub	3
Parkia biglobosa (Jacq.)R.Br.ex G.Don	Leguminosae	Tree	4
Parinari curatellifolia Planch.ex.Benth.	Chrysobalanaceae	Tree	2
Pericopsis laxiflora (Benth.ex. Baker) Meeuwen	Leguminosae	Tree	5
Piliostigma thonningii (Schumach.) Milne-Redh.	Leguminosae	Small tree	3
Prosopis africana Taub.	Leguminosae	Tree	1
Pseudocedrela kotschyi Harms	Meliaceae	Tree	3
Pteleopsis suberosa Engl. & Diels	Combretaceae	Shrub	1
Pterocarpus erinaceus Lam.	Leguminosae	Tree	23

Table 1. Contd.

Rourea coccinea (Schumach. & Thonn.) Hook.F	Connaraceae	Shrub	1
*Securidaca longipenduculata*Fresen.	Polygalaceae	Small tree	4
Sterculia setigera Delile	Sterculiaceae	Small tree	2
Stereospermum kunthianum Cham	Bignoniaceae	Tree	1
Strychnos innocua Delile	Loganiaceae	Small tree	6
Strychnos spinosa Lam.	Loganiaceae	Small tree	2
Tamarindus indica L.	Legumimosae	Tree	2
Terminalia avicennioides Guill. & Perr.	Combretaceae	Small tree	15
Terminalia macroptera Guill. & Perr.	Combretaceae	Tree	1
Terminalia mollis S. Vidal.	Combretaceae	Tree	15
Tetracera alnifolia DC.	Dilleniaceae	Liana	1
Trichilia emetica Vahl.	Meliaceae	Tree	5
Trichilia roka (Forssk) Chiov	Meliaceae	Tree	6
Vitellaria paradoxa C. F. Gaertn.	Sapotaceae	Tree	31
Vitex chrysocarpa Planch	Lamiaceae	Small tree	1
Vitex doniana Sweet.	Verbanaceae	Shrub	2
Xerroderis stuhlamanii (Taub.) Mendonca	Leguminosae	Tree	2

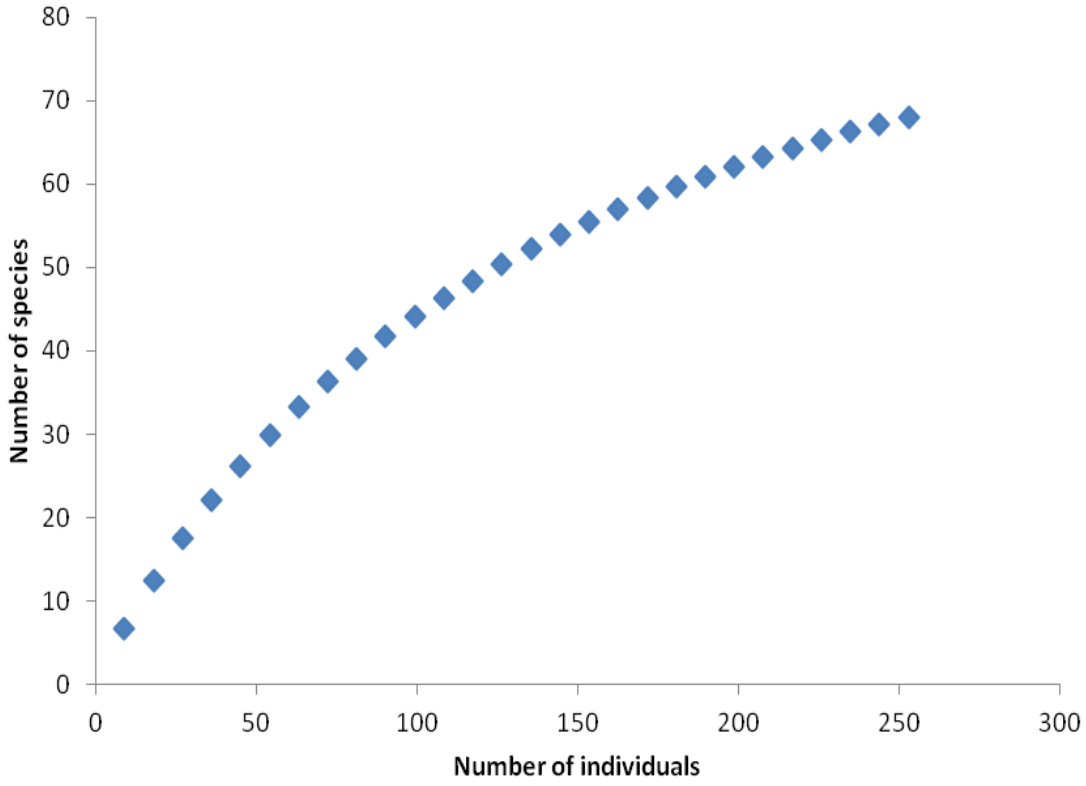

Figure 2. Woody species accumulation curve indicating the sampling effort in the KFR.

(H') of 3.50 for the Kenikeni forest reserve. This index tells about species richness (number of species) and evenness (species distribution) (Magurran, 1988), the larger the value of H' the greater the species diversity and vice versa. This index is usually found to fall between 1.5 and 3.5 and is rarely above 5.0 (Magurran, 2004). An ecosystem with H' value greater than 2 can be classified as medium to high diversity in terms of species (Barbour et al., 1999). Thus, KFR has reasonably high species diversity. Species noted to have contributed to high

Table 2. Families of woody species identified with their respective species richness and relative abundances in the KFR.

Tree family	Species richness	Relative species richness	Abundance	Relative abundance
Anacardiaceae	1	1.5	18	4.5
Annonaceae	3	4.4	9	2.2
Bignoneaceae	2	2.9	2	0.5
Bombacaceae	1	1.5	2	0.5
Celastraceae	1	1.5	3	0.7
Chrysobalanaceae	1	1.5	2	0.5
Combretaceae	9	13.2	75	18.6
Connaraceae	1	1.5	1	0.2
Delleniaceae	1	1.5	1	0.2
Ebenaceae	1	1.5	1	0.2
Euphorbiaceae	2	2.9	3	0.7
Lamiaceae	2	2.9	3	0.7
Leguminosae	20	29.4	182	45.2
Loganiaceae	2	2.9	8	2
Miliaceae	4	5.9	18	4.5
Moraceae	1	1.5	2	0.5
Polygalaceae	1	1.5	4	1
Rubiaceae	6	8.8	20	5
Rutaceae	1	1.5	3	0.7
Sapotaceae	3	4.4	37	9.2
Sapindaceae	1	1.5	2	0.5
Sterculiaceae	1	1.5	2	0.5
Tiliaceae	1	1.5	1	0.2
Verbanaceae	1	1.5	2	0.5
Zygophylaceae	1	1.5	2	0.5

species diversity included: *V. paradoxa* (0.195), *D. microcarpum* (0.179), *A. Africana* (0.174), *I. doka* (0.174) and *B. africana* (0.161).

Gandiwa (2011) recorded H'=2.90 in unburnt site and H'=2.36 in semi-arid southern African savanna in Bulawayo, Zimbabwe. Giliba et al. (2011) reported a high diversity of 4.27 in Miombo woodlands in Tanzania. Savadogo (2007) in Tiogo State forest in Burkina Faso, West Africa Sudan savanna vegetation, reported diversity in various vegetation types that is; Gallery forest 1.3, Dense woodland 4.34, Open woodland 3.89 and Fallow 2.9 giving an average diversity of 3.08 below the diversity index of this research. Nikiema (2005) also recorded H'=2.39 in the protected forest vegetation of the National Park of pô named "*Kabore Tambi"* in Burkina Faso. In Ghana, H' values of 2.90 was reported in the semi-deciduous forest type by Addo-Fordjour et al. (2009).

The KFR is of high conservation value as it provides basic ecosystem services as well as possessing fundamental resources to meet basic needs of local communities. The reserve importantly harbors areas critical to local communities' traditional cultural identity (FSC, 2002). Three woody species (*A. africana, K. senegalensis* and *V. paradoxa*) recorded in KFR are stated as vulnerable in the IUCN red list of threatened species (IUCN, 2012).

Structure of woody species in Kenikeni forest reserve

The regeneration study revealed a total of 45 woody species in all sampling plots, representing 19 families. The diameter class 1 to 10.0 cm (75.7%) was highest with 158 individuals, followed by the diameter class 11 to 20.0 cm (21.5%) with 86 individuals, and lastly, big woody species with DBH greater than 20 cm recorded (2.8%) had 11 individual woody species. This indicates that the majority of individual woody species were regenerating plants (75.7%) as illustrated in Figure 4. There were also more trees than shrub in the reserve. The bar chart drawn (Figure 3) shows a typical reverse J-Shape.

The occurrence of lower diameter woody species is an indication that the woody species in the reserve are good enough to regenerate naturally and face no danger of extinction (Anonymous, 2005) while Niekema (2005) associated this to the occurrence of bush fire and the subsequent competition for nutrients by species.

Generally the prevalence of young woody species is an

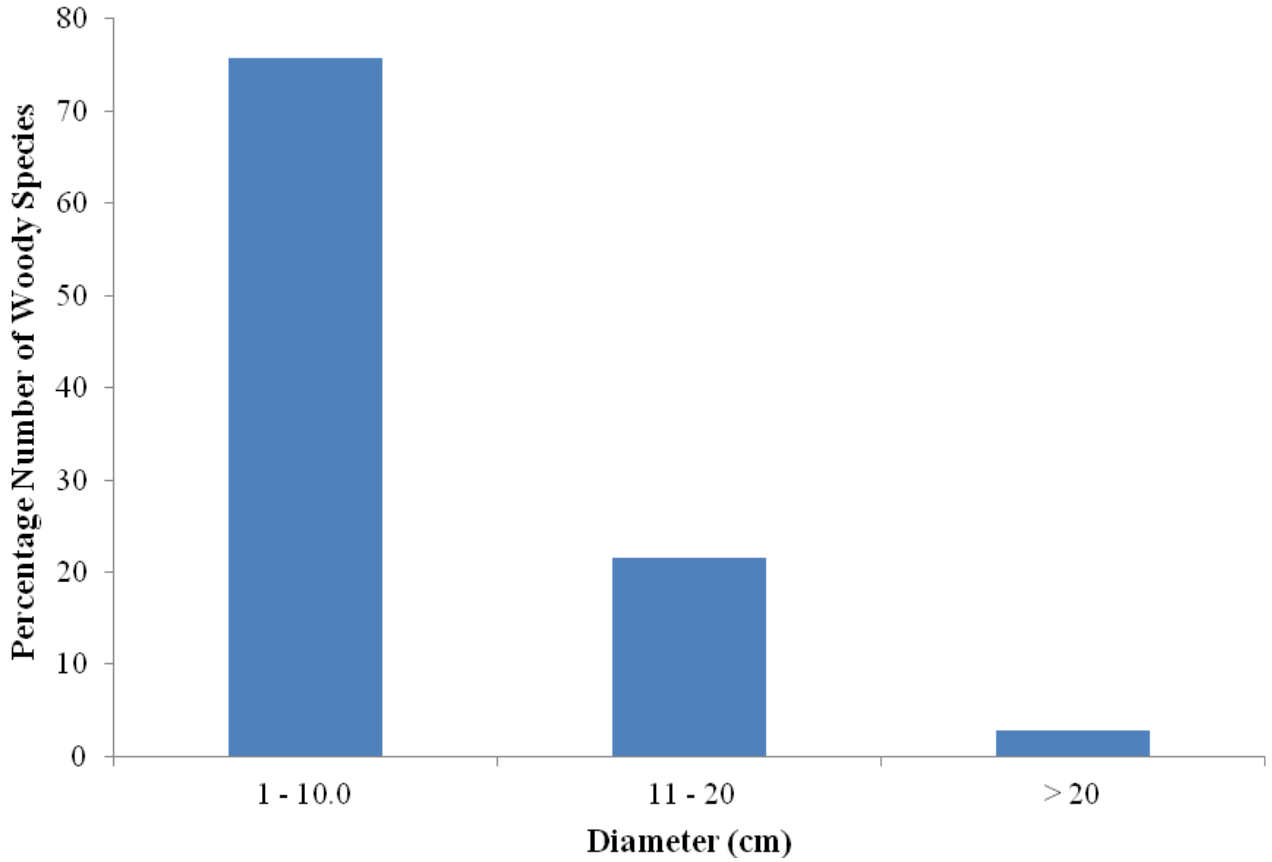

Figure 3. Distribution of woody species in the various diameter classes in the KFR.

Figure 4. Photographs of two sample plots showing the trees and shrubs on the KFR.

indication of a secondary forest defined as forests regenerating largely through natural processes after significant human and/or natural disturbance of the original forest vegetation (Chokkalingam and DeJong, 2001).

The savanna vegetation is generally under threat from bushfires (Abatania and Albert, 1993; Gordon and Ametekpor, 1999; GWS, 2006) and grazing animals (Winter, 1991; Smith and Franks, 2000) which promotes the spread of weeds. It was observed that important economic trees such as *V. paradoxa* (Shea) was among the dominant species in the reserve, which conforms to the suggestion of Yaro (2008) that savanna vegetation of Ghana provides ecological conditions for economic trees such as Shea and Dawadawa. Apart from *Acacia* spp., which was an exotic savanna species, all the other species observed were native savanna species.

Foundation species (Aaron et al., 2005), which by virtue of their structural or functional attributes creates locally stable conditions for other species, and by modulating and stabilizing fundamental ecosystem processes were found in the reserve. Notably, *B. africana, D. microcarpum* and *V. paradoxa* are important locally and regionally common woody species. *B. Africana* is one of the most abundant tree species in both the MNP (Houssain and Hall, 1996) and KFR. Its flowers are a good source of honey (Ecocrop, 2007) while the leaves are the only food resource of two kinds of edible caterpillars (Van Wyk and Gericke, 2000). *D. microcarpum* is a useful medicinal plant and has several domestic uses (Kouyaté and van Damme, 2006) for the fringing communities. They are sought after by elephants which feed on the leaves, roots and fruits which are also eaten by monkeys (Houssain and Hall, 1996). *V. paradoxa* on the other hand is a typical savanna tree with regular patterns of fissuring bark. The edible fruit makes it attractive to a wide range of animals. A large variety of birds, ungulates and primates, including humans, eat them, dispersing the seed in the process (ICRAF, 2009). The roles played by the above listed woody species confirm the significant ecological, social and economic functions of KFR.

CONCLUSIONS AND RECOMMENDATION

The Kenikeni forest reserve is as diverse as the other reserves in the district in terms of woody species diversity, with a greater number of trees than shrubs. The characteristics of the vegetation in the reserve were generally similar to those of other guinea savanna areas confirming that the woody species richness and abundance in different areas of the guinea savanna zone are variable. The high woody species diversity enables the reserve to perform its function of providing ecological protection for the headwaters and also serve as a reservoir for game as well as contribute to the preservation of biodiversity. The reserve has areas of high conservation values which suggest the fringing communities playing a role in the maintenance of ecosystem function as they consider such areas as sacred. Notwithstanding the species composition, diversity and the role of the reserve in modulating ecological processes, it faces anthropogenic threat of increasing population of the fringing communities.

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REFERENCES

Aaron ME, Bank MS, Clinton BD, Colburn EA, Elliott K, Ford CR, Foster DR, Kloeppel BD, Knoepp JD, Lovett GM, Mohan J, Orwig DA, Rodenhouse NL, Sobczak WV, Stinson KA, Stone JK, Swan CM, Thompson J, Von Holle B, Webster JR (2005). Loss of foundation species: Consequences for the structure and dynamics of forested ecosystems. Front Ecol. Environ. 3(9):479-486.

Abatania L, Albert H (1993). Potentials and constraints of legume production in the farming systems of Northern Ghana. In: Proceedings of the third workshop on improving farming systems in the Interior Savanna zone of Ghana, Nyankpala Agricultural Experimental Station, NAES, Tamale, Ghana. pp. 170-181.

Addo-Fordjour PS, Obeng AKA, Addo MG (2009). Floristic composition, structure and natural regeneration in a moist semi-deciduous forest following anthropogenic disturbances and plant invasion. Int. J. Biodvers. Conserv. 1(2):021-037.

Anonymous (2002). National biodiversity strategy for Ghana. Ministry of Environment and Science, Accra.

Anonymous (2005). Chachayalaishan Major Wildlife Habitat. Forest Bureau. Tapei-Taiwan. http//:www.mhhe.com/ecology (Assessed on 2/06/12).

Arbonnier M (2004). Trees, shrubs and lianas of West African dry zones. CIRAD, Margraf Publishers.

Asase A, AA Oteng-Yebeoah (2007). Assessment of plant biodiversity in the Wechiau community Hippopotamus.Sanctuary in Ghana. J. Bot. Res. Inst. Texas 1:549-556.

Asase A, Patrick KE, John YA (2009). Floristic composition, abundance and distribution pattern of woody plants in a tropical savanna in Northern Ghana. J. Bot. Res. Inst. Texas 3:309-316.

Barbour MG, Burk JH, Pitts WD (1999). Terrestrial plant ecology. 3rd edition. Benjamin/Cummings Publishing Company, Menlo Park, California.

Chokkalingam, U and Dejong, W (2001). Secondary forest: a working definition and typology. Int. For. Rev. 3(1):19-26.

Ecocrop. (2007). http//www.ecocrop.fao.org. (Assessed on 04/08/12).

FSC (2002). FSC International Standard, FSC Principles and Criteria for Forest Stewardship, 196 Forest Stewardship Council AC.

Gandiwa E (2011). Effects of repeated burning on woody vegetation structure and composition in a semiarid southern African savanna. Int. J. Env. Sci. pp. 458-471.

Giliba RA, Boon EK, Kayombo CJ, Musamba EB, Kashindye AM, Shayo PF (2011). Species Composition, Richness and Diversity in Miombo Woodland of Bereku Forest Reserve, Tanzania. J. Biodvers. 2(1):1-7.

Gordon C, Amatekpor JK (1999). The sustainable integrated development of the Volta Basin in Ghana. Volta Basin Research Project, Accra, Ghana. P. 159.

Gotelli NJ (2012). EstimateS statistical estimation of species richness

and shared species from samples. http://viceroy.eeb.uconn.edu/EstimateS pages/EstimateS.flx.
Gotelli NJ, Colwell RK (2001). Quantifying biodiversity: procedures and pitfalls in the measurements of species richness. Ecol. Lett. 4:379-391.
GWS (2006). Northern Savannah Biodiversity Conservation Project, Biodiversity Survey-Keneikeni Forest Reserve. Ghana Wildlife Society, Accra.
Hopkins B (1979). Forest and savanna, 2nd ed. Heimemann Educational Books Ltd., London, UK.
Houssain M, Hall JB (1996). The trees of Mole National Park, Damongo, Ghana. Revised by C.C.H. Jongking. 2nd ed. GIJ Press, Accra, Ghana.
Hutchinson J, Dalziel JM (1957–1972). Flora of West Tropical Africa. Crown overseas agent, London, UK.
ICRAF (2009). AgroForestryTree Database. *Vitellaria paradoxa* C.F. Gaertn. www.worldagroforestrycentre. org. (Assessed on 04/08/12).
IPNI (2008). International plant nomenclature index. Published on the internet http://www.ipni.org [Accessed 4/02/12].
IUCN (2012). IUCN Red List of threatened species. Published on the internet http://www.redlist.org [Accessed 6 May, 2012].
Kouyaté AM, van Damme P (2006). *Detarium microcarpum* Guill. & Perr. In: Schmelzer, G.H. & Gurib-Fakim, A. (Editors). Prota 11(1): Medicinal plants/Plantes médicinales 1. [CD-Rom]. PROTA, Wageningen, Netherlands.
Lamb D, Erskine PD, Parrotta JA (2005). Restoration of Degraded Trop. For. Landscapes. Science 310:1628-1632.
Lawson GW (1985). Plant life in West Africa. Ghana Universities Press, Accra.
Magurran AE (1988). Ecological Diversity and its Measurement. Cambridge University Press, Cambridge.
Magurran AE (2004). Measuring Biological Diversity.Blackwell Publishing, Malden, Oxford and Victoria. P. 256.
Nikiema A (2005). Agroforestry Parkland Species Diversity: Uses and Management in Semi-Arid West Africa (Burkina Faso). PhD thesis Wageningen University, Wageningen.
Oteng-Yeboah, AA (1996). Biodiversity in three traditional groves in the Guinea Savanna, Ghana. In: L.J.G. Vander Maesen et al., eds. The biodiversity of Africa plants. Kluwer Academic Publishers, Dordrecht, London. pp. 188-197.
Sagar R, Raghubanshi AS, Singh JS (2003). Tree species composition, dispersion and diversity along a disturbance gradient in a dry tropical forest region of India. For Ecol. Manage. 186:61-71.
Sambou B (2004). Evaluation de l'Etat, de la dynamique et des tendances évolutives de la flore et de la végétation ligneuses dans les domaines soudanien et sub-guinéen du Sénégal. (Thèse de Doctorat d'Etat.) Institut des Sciences de l'Environnement, Faculté des Sciences et Techniques, Université Cheikh Anta Diop. 210 pp.
Savadogo P, Tigabu M, Sawadogo L, Odén PC (2007). Woody species composition, structure and diversity of vegetation patches of a Sudanian savanna in Burkina Faso. Swedish University of Agricultural Sciences Faculty of Forest Sciences. Department of Forest Genetics and Plant Physiology Tropical Silviculture and Seed Laboratory SE- 901 83 Umeå Sweden.
Schitt K, Adu-Nsiah M (1993). The vegetation of Mole National Park–FRMP. GWD/IUNC Project 9786, Accra. P. 48.
Schroeder J-M, Oke DO, Onyekwelu JC, Yirdaw E (2010). Secondary forests in West Africa: a challenge and opportunity for management. IUFRO World Series 25:335-354.
Smith G, Franks A (2000). Impacts of domestic grazing within remnant vegetation. In: S.L. Boulter et al., eds. Native vegetation management in Queensland. Brisbane, Department of Natural Resources.
Ssegawa P, Nkuutu DN (2006). Diversity of vascular plants on Ssese Islands in Lake Victoria, Central Uganda. Afr. J. Ecol. 44:22-29.
Tárrega R, Calvo L, Marcos E, Taboada A (2006). Forest structure and understory diversity in Quercus pyrenaica communities with different human uses and disturbances. For. Ecol. Manage. 227:50-58.
Tilman D (1988). Plant strategies and the dynamics and structure of plant communities. Princeton University Press, Princeton, New Jersey.
Tom-Dery D, Boakye P, Asante JW (2012). Woody Species Richness Abundance in a Tropical Savanna of Northern Ghana. J. Bot. Res. Inst. Texas 6(1):131-141.
Van Wyk B-E, Gericke N (2000). People's plants: a guide to useful plants of southern Africa. Briza Publications, Pretoria.
WCMC (1992). World Conservation Monitoring Centre. Global biodiversity; state of Earth's living resources. Chapman and Hall, London, UK.
WGDA (2008). West Gonja District Assembly profile.
Winter WH (1991). Australia's northern savannas. In: A.W. Patricia. Savanna ecology and management: Australian perspective and intercontinental comparisons. Blackwell publishing, Oxford. pp. 181-186.
Yaro JA (2008). An examination of theories on savannasation and the peasant-environment debate. West Afr. J. Appl. Ecol. 13:3-16.
Zhu JJ, Mao ZH, Hu L, Zhang JX (2007). Plant diversity of secondary forests in response to anthropogenic disturbance levels in montane regions of northeastern China. J. For. Res. 12:403-416.