

Tree species composition, richness and diversity in the northern forest-savanna ecotone of Ghana

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ABSTRACT

Objective: Stand structure, composition, abundance and diversity of tree species of the northern forest-savanna ecotone were characterized to determine their spatial variability for land management.

Methodology and result: An inventory of the in-situ tree community of the northern forest-savanna ecotone of Ghana was undertaken using the stratified random sampling technique. In all, 1453 individuals, representing 88 species, 78 genera and 30 families were identified in the study. *Antiaris toxicaria*, *Adansonia digitata*, *Acacia albida*, *Azelia africana* and *Vitellaria paradoxum* were found most dominant in the vegetation. A gradation of tree distribution was evident as the 'near-savanna' portion of the ecotone was more species-rich than the 'near-forest' portion. Significant differences were observed of the species richness, densities and diversity of trees across sites ($P < 0.05$) and savanna trees were preponderant over forest species.

Conclusion and application: This work has provided evidence of variability in tree species composition, richness, density and diversity across the northern forest-savanna ecotone of Ghana. The information could be crucial for monitoring and managing agro-ecosystems sustainability. A future study would be required to isolate proximate factors of tree species distribution in the ecotone.

Key Words: composition, density, diversity, forest-savanna ecotone, Ghana, richness, tree species,

INTRODUCTION

In most tropical agro-ecosystems where land cover fluxes are rapid than natural restoration, tree species composition, distribution and diversity are particularly susceptible to change from continuous stress factors such as bushfires, logging and cultivation (Uhi, 1987; Lykke, 1998). The tree component of vegetation must therefore be constantly monitored and managed in order to direct successional processes towards maintaining species and habitat diversity (Pickett and White, 1985; Turner, 1987). This is much so in forest-savanna ecotones for their vital role in differentiation and speciation of tropical

ecosystems (Smith *et al.*, 1997). Ghana's northern forest-savanna ecotone is an integral part of the Guinean forest-savanna (Fairhead and Leach, 1996), a major agricultural frontier of the country (Afikorah-Danquah, 1997; Amanor and Pabi, 2007) and holds a number of deciduous and evergreen forest species embedded in savannas (Swaine and Hall, 1988). Following decades of rapid land cover conversions of the original forest-savanna mosaics, the present vegetation is much fragmented with considerable loss of tree cover (Pabi and Attua, 2005; Amanor and Pabi, 2007). Though several

studies have investigated land cover dynamics in the ecotone (e.g. Pabi and Attua 2005; Amanor and Pabi, 2007; UNEP, 2008; Van der Geest, 2011) there is little management knowledge of tree species composition, richness and diversity of the ecotone. Most studies so far addressing this management gap have nonetheless focused on the neighboring forest (e.g. Asase and Oteng-Yebeoah, 2007; Addo-Fordjour *et al.*, 2009) and savanna ecotypes (e.g. Asase *et al.*, 2009; Asase and Tetteh, 2010; Tom-Dery *et al.*, 2012). This paper will address aspects of this research gap with the aim of contributing to data needed for protection of threatened and economic species and for managing and monitoring the agro-ecosystems' sustainability. On basis of these, we studied the composition and structure of the tree community in the ecotone by collecting data to answer the following questions: (i) what is the species composition and structure of the tree

community; (ii) What are the spatial patterns of tree distribution in terms of structure and composition; and (iii) what is the relative abundance of forest and savanna tree species in vegetation? The results were discussed using local knowledge and existing relevant literature.

The study area location and physical characteristics: The study area lies approximately central to the Brong-Ahafo region of Ghana, between latitudes 7°22' - 8°0'N and longitudes 1°32' - 2°25'W and transcends the moist semi-deciduous forest to the south and the Guinea savanna woodland to the north (figure 1). The area is characterized by variable topography with undulating land of 5-10% slope in the south and a predominantly flat land of between 0-2% slopes in the north. Valley basins tend to be wide and generally far apart, thus leaving extensive areas for mechanized commercial farming (Zschechel *et al.*, 1997).

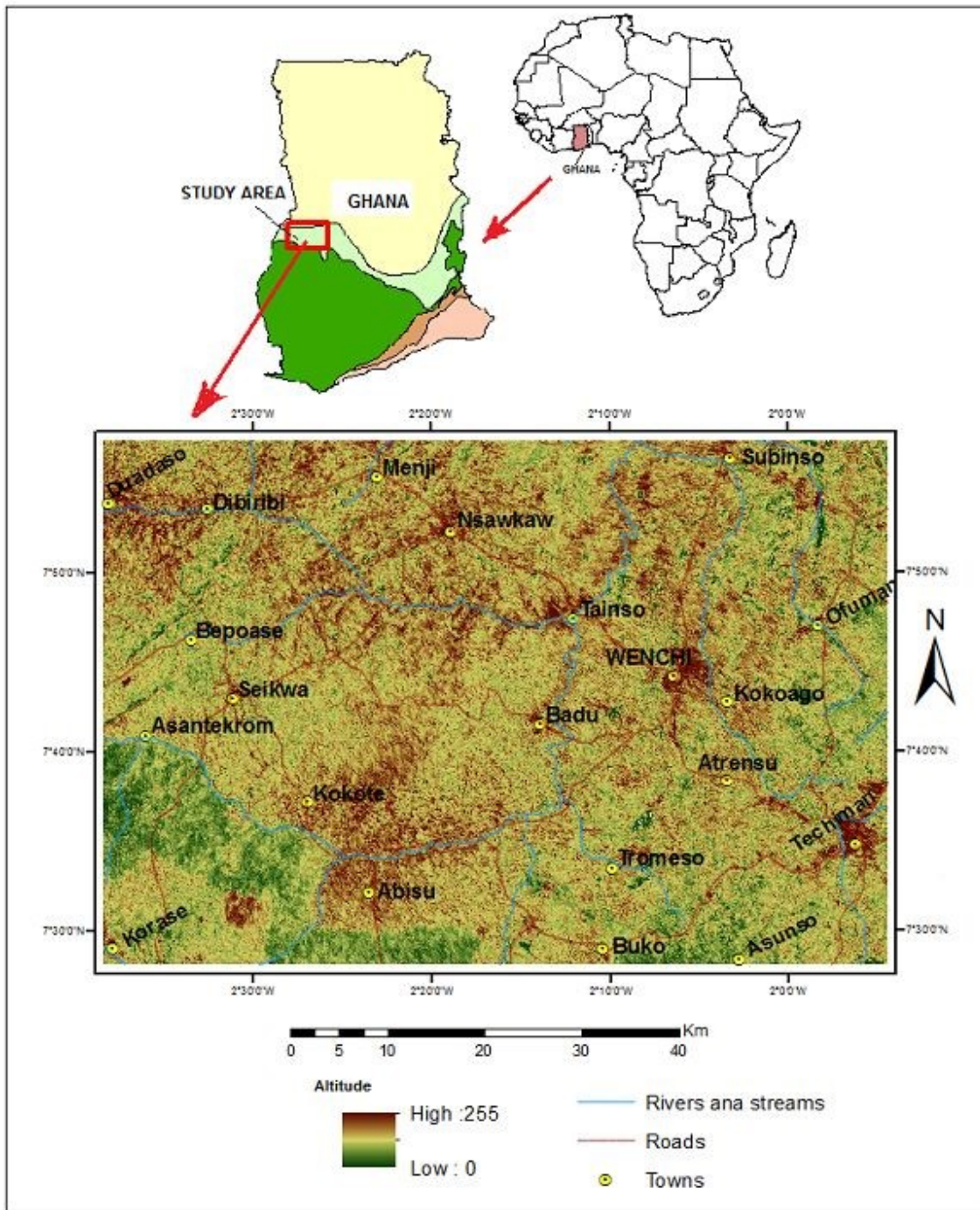


Figure 1: Location map of study area in the context of agro-ecological zones

The climate is characterized by high temperatures averaging 23.9°C (75°F) and a double maxima rainfall regime. Rainfall ranges from an average of 100 cm in the northern parts to 140 cm in the south and the vegetation is savanna woodland interspersed with high forest mosaics and gallery

forests along banks of streams and rivers (Amanor and Pabi, 2007). Agriculture is the major economic activity of the area, accounting for a high proportion of the income of the economically active population. Food crop farming is the dominant economic activity, using diverse cropping systems (Amanor and Pabi,

2007). Major food crops grown are maize, yam, plantain, cocoyam, pepper, and tomato. These are produced principally for subsistence and occasionally for the local and urban markets. Food cropping is combined with collection and trading in non-timber forest products. Cocoa, oil palm, and citrus are the predominant cash crops (Afikorah-Danquah, 1997). Population distribution and land

management varies across the ecotone with implications for changes in tree species composition, abundance and diversity. In the south, population is much higher and community land is administered by lineages who allocate land to members (Amanor and Pabi, 2007) while the sparsely populated north tends to practice communal land tenure (Van der Geest, 2011).

METHODS

Site selection and field measurements: Site selection was facilitated by using an available land-cover map of the area (Pabi and Attua, 2005) and study plots were demarcated depending on the readiness of community leaders to volunteer parcels of land for the investigation. Sampling took place between August 2010 and May 2011. To effectively cover the study area, improve estimation accuracy, and analyse data spatially, the study area was divided into three geographical zones on basis of proximity to the two major ecotypes adjoining the area – the semi-deciduous forest to the south and the Guinea savannah to the north. These were designated as - ‘near-forest ecotone’ (NFE), ‘near-savannah ecotone’ (NSE) and ‘mid-ecotone’ (ME) sites. In each site, the plotless sampling technique was applied along three transects laid at least 1km apart. This approach is fast, economic and less labour-intensive (Hopkins, 1974). All living trees were identified to species based on Taylor (1952), Hutchinson and Dalziel (1957-1972) and Hawthorne (1990) and all nomenclature followed the International Plant Nomenclature index (IPNI, 2008). The diameter at breast height (dbh) of each tree ≥10 cm was measured with tape (data was obtained of sizes < 10cm dbh but not included in this analysis). Between tree distances were measured and averaged for each site. All trees with multiple trunks were considered as an individual as long as there was a visible connection between trunks and only the thickest trunk was measured.

Data Analysis: Differences in species diversity between sites (β diversity) were compared by Shannon-Weaver’s index (H) which takes into account evenness as well as number of species at a site, estimated as (Magurran, 2004):

$$H = - \sum_{i=1}^n P_i \ln(P_i) \dots\dots\dots (1)$$

where P_i is the proportion of the total number of trees belonging to species i and $\ln(P_i)$ is the natural logarithm of that proportion, and \sum is summation over all species (n). The index has low sensitivity to plot size differences (Magurran, 2004).

Tree density per hectare (D) for each site was obtained as:

$$D = \frac{10000}{d^2} \dots\dots\dots (2)$$

Where d is the mean distance between trees (Hopkins, 1974).

Information on tree density and diversity of the three sites provided basis for statistical analysis using SPSS software, version 17.0. Differences in tree counts, density and diversity at sites were tested by applying the Kruskal–Wallis test, after log-transformation of data. To test for the differences in similarity of sites, a pairwise Wilcoxon rank sum test was conducted. The assumption of normality was assessed using the Shapiro–Wilk test (Crawley, 2007) and where tests indicated significant differences between sites, means were compared with the post hoc Tukey’s HSD tests. The free statistical software, Estimate S version 8.2 for Windows was used for the estimation of species diversity (Colwell, 2009)

RESULTS

Species composition and richness: Tree species composition and richness (abundance) at the level of family and species at study sites are indicated in Table 1 below. In all, 1453 trees representing 88 species, 78 genera and 30 families were identified.

Table1: Tree species (dbh ≥ 10 cm) enumerated at the three sampling sites

Family	Species	Study sites			RA (%)
		NFE	ME	NSE	
Anarcadiaceae	<i>Lannea acida</i> A. Rich.		√	√	1.51
	<i>Lannea welwitschii</i> (Hiern) Engl.	√	√		0.21
	<i>Spondias mombin</i> L.	√			0.34
Annonaceae	<i>Annona senegalensis</i> Pers.		√	√	2.13
Apocynaceae	<i>Holarrhena floribunda</i> (G.Don.) Dur.& Schinz	√	√		0.83
	<i>Rauvolfia vomitoria</i> Afz.	√			1.10
Araliaceae	<i>Cussonia barteri</i> Seem.	√	√		1.17
Arecaceae	<i>Borassus aethiopum</i> Mart.		√	√	2.62
	<i>Elaeis guineensis</i> Jacq.	√	√	√	2.20
Bignoniaceae	<i>Kigelia africana</i> (Lam.) Benth.		√	√	0.62
	<i>Margaritaria discoides</i> (Baill) Webster		√	√	0.34
	<i>Markhamia lutea</i> (Benth.) K.Schum.			√	0.48
	<i>Newbouldia laevis</i> P. Beauv.	√			0.55
	<i>Spathodea campanulata</i> P. Beauv.	√			0.55
Bombacaceae	<i>Adansonia digitata</i> L.		√	√	3.30
	<i>Bombax buonopozense</i> Beauv.	√	√	√	0.83
	<i>Ceiba pentandra</i> (L.) Gaertn.	√	√		1.45
Celastraceae	<i>Maytenus senegalensis</i> (Lam.) Exell.			√	0.41
Chrysobalanaceae	<i>Parinari curatellifolia</i> Planch. ex Benth.		√	√	0.96
Combretaceae	<i>Anogeissus leiocarpus</i> (DC.) Guill. & Perr.		√	√	2.48
	<i>Combretum racemosum</i> P. Beauv.	√	√		1.31
	<i>Terminalia avicennioides</i> Guill. & Perott.	√	√		0.89
	<i>Terminalia glaucescens</i> Planch. Ex Benth.		√	√	0.69
	<i>Terminalia superba</i> Engl. et Diels.	√			0.21
Compositae	<i>Vernonia colorata</i> (Willd.) Drake			√	0.21
Ebenaceae	<i>Diospyros heudelotii</i> Hiern.			√	0.14
	<i>Diospyros mespiliformis</i> Hochst. ex A.DC.			√	0.48
Euphorbiaceae	<i>Alchornea cordifolia</i> Muell. Arg.	√	√		2.96
	<i>Bridelia ferruginea</i> Benth.		√	√	1.51
	<i>Drypetes floribunda</i> (Müll.Arg.) Hutch.	√			0.28
	<i>Phyllanthus discoideus</i> (Bail) Wild	√			0.22
	<i>Securinega virosa</i>			√	0.69
Fabaceae	<i>Albizia adianthifolia</i> Schum.	√	√		0.96
	<i>Albizia zygia</i> MacBride	√	√		2.68
	<i>Lonchocarpus sericeus</i> Kunth.		√	√	0.89
	<i>Parkia biglobosa</i> (Jacq.) Benth.		√	√	2.34
	<i>Parkia clappertoniana</i> Keay		√	√	1.86
	<i>Pterocarpus erinaceus</i> Poir.			√	0.96
Gentianaceae	<i>Anthocleista vogelii</i> Planch.	√	√		1.86
Hypericaceae	<i>Harungana madagascariensis</i> Lam. ex Poir.			√	0.89
Leguminosae	<i>Acacia albida</i> Del.		√	√	3.30
	<i>Azelia africana</i> Sm. ex Pers.	√	√	√	3.23
	<i>Burkea africana</i> Hook.		√	√	1.45

	<i>Cassia sieberiana</i> DC.			√	0.55
	<i>Daniellia oliveri</i> (Rolfe) Hutch. & Dalz.			√	1.24
	<i>Detarium microcarpum</i> Guill. & Perr.			√	1.24
	<i>Dialium dinklagei</i> Harms.	√	√		1.24
	<i>Erythrophleum guineense</i> G. Don			√	1.10
	<i>Isobertinia doka</i> Craib. & Stapf.			√	0.96
	<i>Millettia thonningii</i> (Schum. et Thonn.) Bak.	√			0.34
	<i>Piliostigma thonningii</i> (Schumach.) Milne-Redh.			√	0.96
	<i>Swartzia madagascariensis</i> Desv.			√	0.14
	<i>Tamarindus indica</i> L.			√	0.89
Lepidobotryaceae	<i>Musanga cecropioides</i> R. Br.	√			1.10
Meliaceae	<i>Azadirachta indica</i> A. Juss.	√	√	√	2.88
	<i>Carapa procera</i> DC.			√	0.74
	<i>Khaya grandifolia</i> (Desr.) A. Juss.	√	√		0.69
	<i>Khaya senegalensis</i> (Desr.) A. Juss.			√	1.45
	<i>Pseudocedrela kotschyi</i> Harms.			√	0.23
	<i>Trichilia monadelpha</i> (Thonn.) J. De Wilde	√			0.83
Moraceae	<i>Antiaris toxicaria</i> Engl.	√	√		3.72
	<i>Bosquiea angolensis</i> Ficalho	√	√		0.76
	<i>Ficus exasperata</i> Vahl.	√	√		1.65
	<i>Ficus sur</i> Forssk.			√	0.55
	<i>Milicia excelsa</i> (Welw.) Benth.	√			0.34
Ochnaceae	<i>Lophira alata</i> Banks ex. C.F. Gaertn.			√	0.55
	<i>Lophira lanceolata</i> Tiegh.			√	1.31
Palmae	<i>Raphia hookeri</i> Mann & Wendl.	√	√		1.58
Papilionaceae	<i>Baphia nitida</i> Lodd.	√	√		0.89
Rubiaceae	<i>Crossopteryx febrifuga</i> (Afzel. ex G. Don.) Benth.			√	1.31
	<i>Gardenia ternifolia</i> Schum. & Thonn.			√	0.89
	<i>Mitragyna inermis</i> (Willd.) O. Ktze			√	0.28
	<i>Morinda lucida</i> Benth.	√	√		1.45
	<i>Nauclea latifolia</i> Sm.	√			0.62
Sapindaceae	<i>Allophylus africanus</i> P.Beauv.	√	√		2.68
	<i>Lecaniodiscus cupanioides</i> Planch ex.Benth			√	0.62
Sapotaceae	<i>Pachystela</i> sp.			√	0.48
	<i>Malacantha alnifolia</i> (Bak.) Pierre			√	0.76
	<i>Vitellaria paradoxum</i> C.F. Gaertn.			√	3.17
Sterculiaceae	<i>Cola cordifolia</i> (Cav.) R.Br.	√	√		0.83
	<i>Cola gigantea</i> A. Chev.	√	√		1.38
	<i>Hildegardia barteri</i> (Mast.) Kosterm	√	√		0.83
	<i>Nesogordonia papaverifera</i> R. Capuron	√			0.34
	<i>Sterculia tragacantha</i> Lindl.	√			0.55
	<i>Triplochiton scleroxylon</i> K. Schum.	√			0.34
Tiliaceae	<i>Grewia mollis</i> Juss.			√	0.89
Ulmaceae	<i>Trema orientalis</i> (L.) Blume			√	0.28
Verbanaceae	<i>Vitex doniana</i> Sweet			√	0.28

Figure 2 indicates the species accumulation curve of sites, which is the cumulative number of species recorded as a measure of sampling effort. It again shows that most

species present at study sites were included in samples because the curves each approach an asymptote.

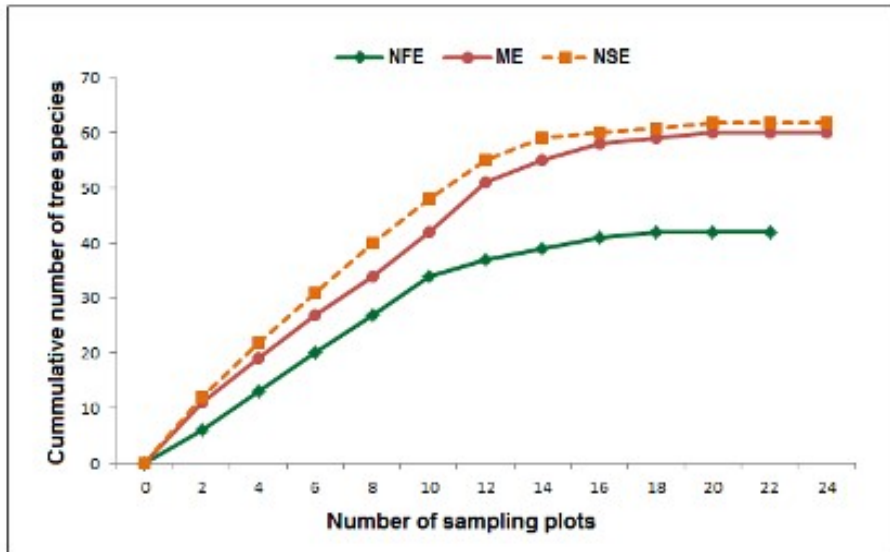


Figure 2: Species accumulation curves for tree species at study sites as a function of sampling effort

Figure 3 indicates families with at least 5% composition in the tree community. Members of the Leguminosae (subfamily Papilionoideae, Mimosoideae and Caesalpinioideae) were the most dominant, comprising

13 species and constituted nearly 17 percent of the trees population. The next dominant family was the Fabaceae, which comprised 6 species and accounted for 9.7 percent of the trees encountered.

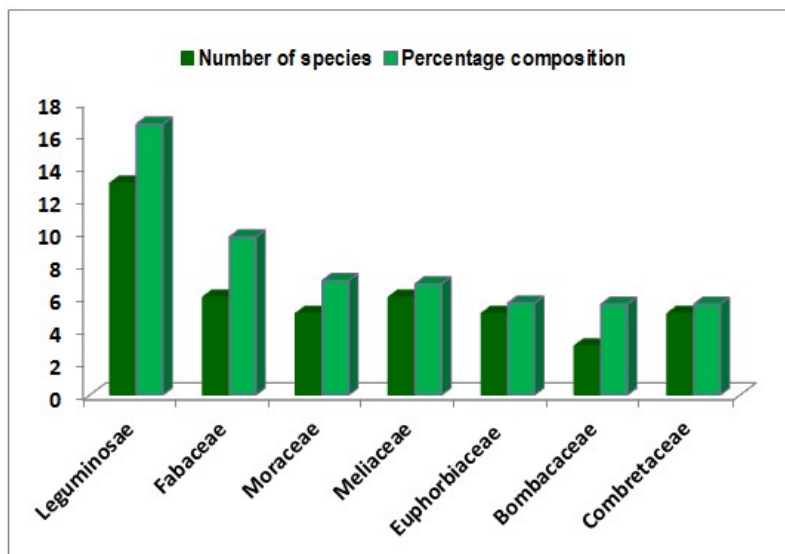


Figure 3: Families with at least 5% composition in tree vegetation

The two legume families collectively comprised more than one-fourth (26.34 percent) of the entire trees sampled. Other families substantially represented in the vegetation are the Moraceae, Meliaceae, Euphorbiaceae, Bombacaceae and the Combretaceae. Collectively, they comprised 30.62 percent of ecotone trees. Table 3A

shows the first 20 tree species that occurred in large numbers and their relative abundances. Collectively, they constituted 49.66% of the total tree population. Of this species savanna trees were more abundant comprising 60.39% compared to forest and intermediate species with only 39.61% composition

Table 3 A: The first 20 most abundant tree species identified in samples

Species	% Relative abundance	Native habitat
<i>Antiaris toxicaria</i>	3.72	forest
<i>Acacia albida</i>	3.30	savanna
<i>Adansonia digitata</i>	3.30	savanna
<i>Azalia africana</i>	3.23	savanna
<i>Vitellaria paradoxum</i>	3.17	savanna
<i>Alchornea cordifolia</i>	2.96	intermediate
<i>Azadirachta indica</i>	2.88	savanna
<i>Albizia zygia</i>	2.68	forest
<i>Allophylus africanus</i>	2.68	savanna
<i>Borassus aethiopicum</i>	2.62	savanna
<i>Anogeissus leiocarpus</i>	2.48	savanna
<i>Parkia biglobosa</i>	2.34	savanna
<i>Elaeis guineensis</i>	2.20	intermediate
<i>Annona senegalensis</i>	2.13	savanna
<i>Parkia clappertoniana</i>	1.86	savanna
<i>Anthocleista vogelii</i>	1.86	forest
<i>Ficus exasperata</i>	1.65	forest
<i>Raphia hookeri</i>	1.58	forest
<i>Bridelia ferruginea</i>	1.51	savanna
<i>Lannea acida</i>	1.51	savanna

The five most abundant species of the vegetation were *Antiaris toxicaria* (bark cloth tree), *Adansonia digitata* (baobab), *Acacia albida* (ana tree), *Azalia africana* and *Vitellaria paradoxum* (shea-butter tree). With the exception of *Antiaris toxicaria*, which is of forest origin, all others are characteristic of savanna ecosystems (Lawson, 1986; Hawthorne, 1990). On the other hand, species such as *Burkea africana*, *Daniellia oliveri*, *Terminalia glaucescens* and *Vitex doniana* previously identified by Hopkins (1974) as common ecotone species, however were rarely found. Indeed, such previously

dominants like *Hymenocardia acida*, *Parinari polyandra* and *Pterocarpus erinaceus* were not listed at all in this study.

Spatial distribution of tree species: Table 3B is a summary list of floristic and structural composition of trees identified at study sites. In both NSE and ME sites, 22 families each were listed while 18 families were in NFE. These comprised 43 genera in NFE, 45 in ME and 48 in NSE. Moraceae, Meliaceae and Euphorbiaceae were dominant in NFE and ME while the Leguminosae and Combretaceae dominated in NSE site.

Table 3B: Composition, diversity and structure of trees ≥ 10 cm dbh at study sites

Characteristics	NFE	ME	NSE	Total
No. of families	18	22	22	30
No. of genera	43	45	48	79
No. of species	43	52	48	88
Species native of forest	27	23	12	-
Species native of savanna	14	27	34	-
No. of intermediate species	2	2	1	-
Total individuals	343	536	574	1453
Mean tree density (ha^{-1})	127 \pm 15	131 \pm 23	164 \pm 12	-
Shannon diversity index	3.02 \pm 0.12	3.04 \pm 0.27	3.39 \pm 0.23	-

Fewer trees were listed in NFE (343 individuals or 23.61%) compared to NSE (574 individuals or 39.50%) and ME (536 individuals or 36.89%). Overall, trees typical of the savanna dominated the ecotone (53.75% or 781 individuals) compared to those of forest origin (32.29% or 478 individuals). While number of savanna species was increasing in the direction of the guinea savanna vegetation (NSE had 41.16% or 226 individuals; ME had 34.28% or 196 individuals and NFE had 14.67% or 51 individuals) forest species were reducing (2.44% or 14 individuals in NSE, 13.25% or 71 individuals in ME and a high of 72.01% or 247 individuals in NFE). Shannon's diversity ranged from 3.02 ± 0.12 to 3.39 ± 0.23 and was observed to be highest in the NSE, followed by the ME and the least in the NFE. Mean tree density ranged from 127 ± 15 to 164 ± 12 and was highest in the NSE, followed by the ME and the least in the NFE.

Statistical analyses: Structural characteristics of trees, based on number, species diversity and density per hectare were tested for differences between the three sites. There was a significant difference in number of

trees between sites (Kruskall–Wallis Test, $\chi^2 = 6.07$, $P < 0.001$). Significant differences were established between NFE and NSE (Wilcoxon rank-sum test, $P < 0.05$) and between NFE and ME (Wilcoxon rank-sum test, $P < 0.001$). However, between NSE and ME, no significant difference was established (Wilcoxon rank-sum test, $P = 0.65$). In addition, significant differences were found in tree density between study sites (Kruskall–Wallis Test χ^2 ; $P < 0.05$) with a significant difference existing between NFE and NSE (Tukey HSD, $P < 0.05$) and also between NSE and ME (Tukey HSD, $P < 0.05$). However, between NFE and ME, no significant difference was established (Tukey HSD, $P = 0.12$). Shannon species diversity varied significantly between the sites (Kruskall–Wallis Test $\chi^2 P < 0.001$). Post hoc Tukey's HSD test showed no significant difference between NFE and ME (Tukey HSD, $P = 0.61$). However, between NSE and NFE, a significant difference was established ($P < 0.001$) and between NSE and ME ($P < 0.000$).

DISCUSSION

Species composition and richness: The study identified the Leguminosae, Moraceae, Meliaceae and Fabaceae as the most represented families in the tree vegetation of the study area. Other also substantially represented were the Euphorbiaceae, Bombacaceae and Combretaceae. This observation is in close agreement with the findings of Asase and Oteng-Yeboah (2007) and Asase *et al.* (2009) that the Leguminosae and Combretaceae were dominant tree families in guinea savanna vegetation. Lawson (1986) also listed most of these families among those identified as common in the forest vegetation of West Africa. However, Euphorbiaceae and Bombacaceae, though found among the common families in this study, were not reported in earlier studies. The study also found that leguminous trees (belonging to the Leguminosae and Fabaceae) such as *Acacia albida*, *Azalia africana*, *Albizia zygia* and *Parkia* spp. were abundant in the ecotone. Elsewhere, Felker and Bandurski (1979) and Felker (1980) had attributed the abundance of leguminous trees to their role in maintaining nitrogen balance of agro-ecosystems for which reason they are protected and managed on farms. The most abundant species of the vegetation were *Antiaris toxicaria* (3.72%), *Adansonia digitata* (3.3%), *Acacia albida* (3.3%) and *Azalia africana* (3.23%). Most of these trees are of nutritional and economic significance and interviewees in local communities explained that they protected such trees from damage and even sometimes

cultivated them for sustenance. This observation concurs with that of Yaro (2008) when he opined that economic trees like *Vitellaria paradoxum* and *Parkia biglobosa* are managed by local people in order to serve their livelihood needs. Species such as *Alchornea cordifolia* and *Azardiracta indica* were also found in substantial numbers probably because of their medicinal utility (Mante *et al.* 2012). Another conclusive observation was that savanna trees were preponderant in the vegetation than forest members. This probably could relate to the characteristic ability of most savanna trees to tolerate or resist fire damage and drought or regenerate quickly after a disturbance in fire-dominated vegetation (Orwa *et al.*, 2009; Kone *et al.*, 2012).

Spatial distribution of trees across ecotone: Spatial variations in plant density and diversity occur from complex interactions based on local ecological conditions, among other factors (Barnett and Kohn, 1991). In this study tree density varied spatially across the ecotone, ranging from 127 ± 15 to 164 ± 12 , though lower than estimations from other ecosystems. For example, Asase and Tetteh (2010) recorded a mean tree density per hectare (for trees ≥ 10 cm diameter at breast height) of 470 in a natural forest, 90 in cocoa agroforests and 125 in mixed food crops agroforests. Assessing trees ≥ 20 cm girth at breast height, Attua (2003) also reported mean tree density per hectare of 231.81 and 55.92 in undisturbed rainforest and matured fallows respectively.

Compared to the undisturbed or natural forests, tree density of the ecotone is low, though much higher than in cocoa and mixed food crops agroforests and matured fallows. In human-influenced ecosystems, differences in tree density could arise from differences in management intensity, culture and farm history (Schroth and Harvey 2007) and fire management practices (Higgins *et al.*, 2000). It is worthy of mention however, that sometimes a decline in tree density is inherent in management strategies for long-term cultivation to attain appropriate tree-crop combinations and for high crop production, and not necessarily implying degradation (Kalacska *et al.*, 2004). In many tropical biomes, fire is responsible for the denudation of tree cover and reduction of stand tree density (Hoffmann *et al.*, 2012). Forest trees and juveniles compared to savanna species are more

susceptible to top kill than their savanna counterparts due to their much thinner bark of the former (Hoffmann *et al.*, 2009). In addition, some savanna trees may have a suite of ecological traits that make them better adapted in fire-impacted environments and so increase in numbers (Hoffmann *et al.*, 2009; Gotsch *et al.*, 2010). There is no consensus, however, on the role of human affects density of economic tree species in particular and land management in general (Eriksen, 2007). While some studies affirm that anthropogenic disturbances, particularly burning, increases tree species richness (e.g. Kennard, 2002; Gould *et al.*, 2002) other views are contrary (King *et al.*, 1997; Kalacska *et al.*, 2004). Future work may have to quantitatively decipher what roles humans and other ecological factors play in the spatial distribution of trees in the ecotone.

CONCLUSION

The study concludes that tree population of the northern forest-savanna ecotone is presently dominated by the Leguminosae, Fabaceae, Moraceae, Meliaceae and Euphorbiaceae families. The existing flora, to a large degree, is dominated by savanna species, particularly those associated with guinea savanna vegetation. Nonetheless, distribution of trees is non-uniform across the ecotone and varies significantly between sites in relation to density, diversity and richness. Differences in fire frequency and expansion of cultivation could be the

key ecological factors of tree distribution in the ecotone though not established in this study. Future studies may have to forecast the trajectory of vegetation change while isolating environmental factors that are responsible for the observed differences in composition, diversity and distribution of tree species in the ecotone. The usefulness of data generated through this work is in its application for managing forest-savanna conversion to forest through fire-protection and re-forestation programmes in Ghana.

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