Journal of Tropical Biodiversity and Biotechnology
Volume 08, Issue 01 (2023): jtbb76354
DOI: 10.22146/jtbb.76354

Research Article

Forest Structure and Tree Species Diversity of the Abasumba Globally Significant Biodiversity Area, Ghana

Felix Tetteh Kabutey[1]*, Daniel Wodah[2]
1)Department of Environmental Science, Faculty of Science Education, University of Education, P.O. Box 25 Winneba, Ghana
2)Department of Science Education, University for Development Studies, Tamale Ghana
* Corresponding author, email: ftkabutey@uew.edu.gh

Keywords:
Tropical dry forest
floristics composition
tree species diversity
biodiversity index
Tree dispersion patterns
Submitted:
19 July 2022
Accepted:
14 December 2022
Published:
27 March 2023
Editor:
Furzani Binti Pa'ee

ABSTRACT
We studied the forest structure and tree species diversity with diameter-at-breast-height (dbh) ≥ 10 cm in the Abasumba Globally Significant Biodiversity Area Ghana. Sixteen 25 m * 25 m plots were demarcated and trees with dbh ≥ 10 cm were inventoried following International Plant Nomenclature Index. The characteristic three–storey structure of tropical forests was shown, 68.7% of trees were in the lower 4.5–18 m and middle 18–30 m storeys. A majority 91.4% of 342 trees was in the dbh of 10–30 cm and a least 8.6% of 32 trees in 31–60 cm had dbh > 60 cm. Total of 46 species, 38 genera and 17 families, with mean Alpha, Shannon and Simpson's Diversity indices of 13.9, 1.44 and 0.07 and importance value index of 300.0 for 374 trees ha^{-1} was recorded. Plant families Sterculiaceae, Meliaceae, Leguminosae, Ulmaceae and Bombacaceae was the majority encountered while *Triplochiton* scleroxylon, *Cola millenii*, *Trichilia monadelpha*, *Hymenostegia afzelii*, *Celtis* mildbraedii, *Ceiba pentandra* and *Ficus sur* was the most occurring species in 54.0% of the plots accounting for 52.0% of the IVI for all trees. *Blighia sapida*, *Bridelia grandis*, *Dialium guineense*, *Draceana arborea*, *Ficus sur*, *Holarrhena floribunda*, *Holoptelea grandis*, *Margaritaria discoidea*, *Rauvolfia vomitoria*, *Trilepisium madagascariense*, *Vitex ferruginea*, *Ximenia americana* and *Xylia evansii* had one individual in the 10,000 m^2 area indicated that they are rare and should be given conservation priority in the forest reserve.

INTRODUCTION
Dry tropical forests are the utmost vulnerable of most dry forest ecosystems and they are contended to warrant significance for protection because they are fragments of formerly extended ecosystems which are now nonexistent (Ocón et al. 2021). They hold varied and exceptional biological communities which their logging backs the loss of the planets biodiversity (Cabin et al. 2000; DryFlor et al. 2016). A large part of these tropical forest ecosystems are found in Africa and other dry islands, accounting for ca. 40–70% forested areas in the world (Riggio et al. 2020). Presently, few intact dry forests exist which offer the ecological services required to aid millions of sustenance farmers in the world's deprived communities, with most of them been disturbed or fragmented through human activities as they can easily be cleared with fire for new grazing grounds or converted into agriculture land use (Jacobson et al. 2019; Vogt et al. 2019; Siyum 2020). Population growth, urbanization and food

production are the lead in the need for land giving rise to a greater logging within dry forests than in moist forests (FAO 2020).

The predominant view is that Ghana's forest ecosystem and its biodiversity are susceptible to anthropogenic disturbances viz. encroaching agriculture, and mining is one of the highest deforestation rates in the West African sub-region (Owusu et al. 2018; Bentsi-Enchill et al. 2022). Currently, annual logging at 0.70%, 0.50%, 0.40%, and 0.60% for the periods of 1990–2000, 2000–2005, 2005–2010 and 2010–2015 were reported within Ghana (Keenan et al. 2015; Acheampong et al. 2019). Logging within forest reserves has increased substantially, with regards to exhaustion of lands, Hawthorne & Musah (1993) previously conveyed that close to half 50.0% of conserved forestry were depleted or in bad state and with other current studies confirming similar trends (Acheampong et al. 2019; Brobbey et al. 2020).

According to Hall & Swaine (1981) in Ghana, the southern marginal dry forest is amongst the greatest threatened ecologies. It is classified amongst the driest forest ecosystems which occur as small-scattered patches about (ca. 20 km^2) characterized with low floral diversity and tree canopies, few commercial timber species with an annual rainfall of 750-1275 mm (Asase & Adeniyi 2021). In Ghana, there are two types of southern marginal dry forests, but the one located in the Cape Coast-Winneba area within the coastal savanna ecosystem is the most susceptible (Asase & Adeniyi 2021).

Abasumba Globally Significant Biodiversity Area (GSBA) is one of the outstanding remains of the Awutu Forest classified as southern marginal forest zone (Hall & Swaine 1981). It is an important GSBA for the conservation of plant biodiversity as it represents rare stands of forest which serve as home to forest-based species with special biological interest (Hawthorne & Abu-Juam 1995). However, there are no existing data on the diversity of *flora* or *fauna* in the Abasumba, GSBA after several years of demarcation as a forest reserve. Understanding the forest structure, plant species diversity and forms of tree distribution can offer the foundation for effective protection and superintendence of the biodiversity of the forest reserve (Asase & Adeniyi 2021; Thammanu et al. 2021). Knowledge about forest structure and plant biodiversity is important for conservation purposes, also the plants offer resources and serve as homes of other *fauna* (Huang et al. 2003; Lelli et al. 2019). Apart from the national forest inventory of economic timber species in the dry forests by the Forestry Commission of Ghana (Ghartey 1989), there is no other former research on the tree species diversity of the Abasumba, GSBA. The goal of the research was to (i) identify as well as enumerate all tree species at dbh ≥ 10 cm distribution across tree stands; (ii) analyze floristic constitution and tree species biodiversity; and (iii) determine tree species dispersion patterns, basal area distributions and importance value index (IVI) of the Abasumba, GSBA. The results of this research are expected to facilitate decisions regarding choice of species in afforestation programs for the restoration of the southern marginal dry forests in Ghana.

MATERIALS AND METHODS

Study Location

Abasumba GSBA is a portion of Southern Dry Forest Zone, in the Awutu –Effutu–Senya political district and it was first reserved as a protected area in 1927 (Baker & Willis 2014). It is situated between Cape Coast and Winneba Forest districts in Central Region, Ghana and lies approximately at Latitudes 5°37'37" and 5°38'38" N and Longitudes 0°31'32"and 0° 32'33" W (Figure 1). The altitude ranges between 160 and 200 m with

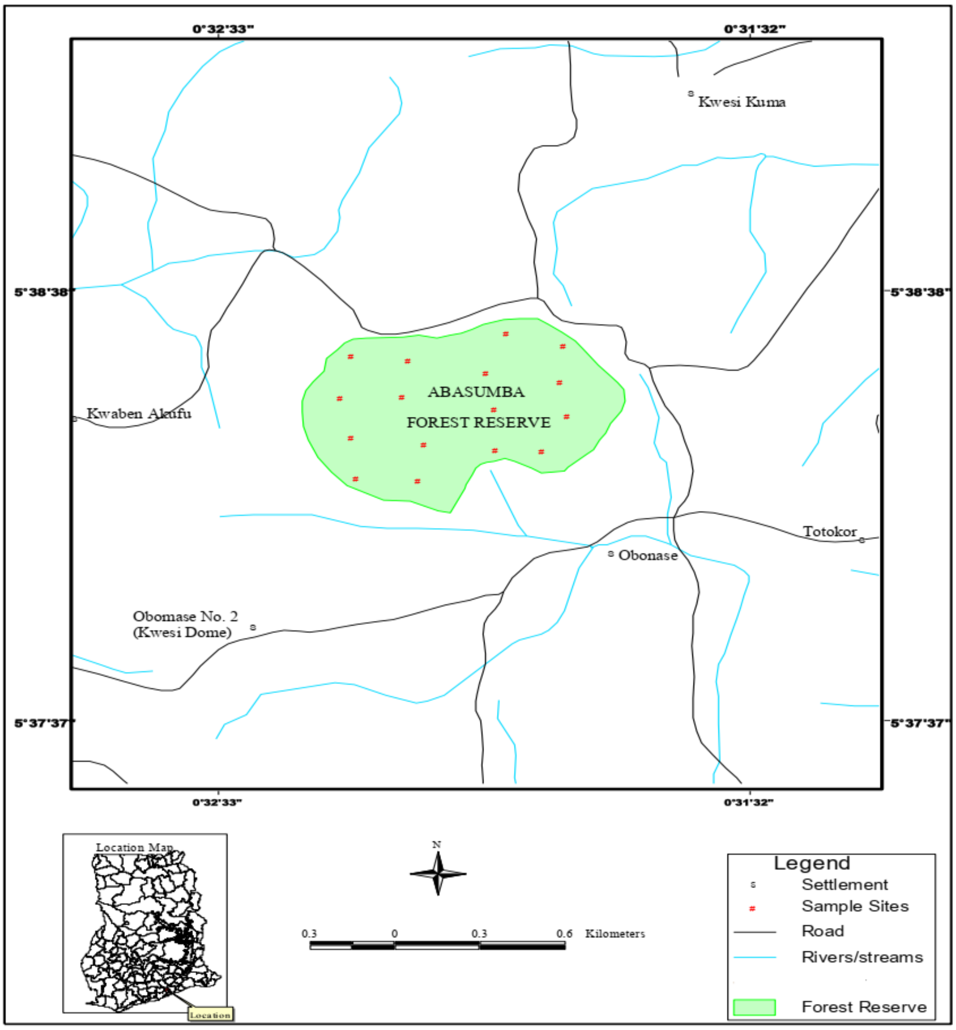

Figure 1. Topographical Map of Abasumba GSBA showing sampling sites.

isolated hills, reaching about 300 m above sea level, with a land area of 1.5 km^2 and a perimeter of about 3.48 km. The relief is generally hilly, undulating landform interrupted by gorges and valleys; the parent rock is quartzite/shales and granite. Rainfall pattern is even with two peaks; a major in May to June, and a minor in October, however, rainy seasons are preceded by two dry seasons occurring in November to February and August to September, respectively.

Data Collection

After the initial investigation, the forest reserve was divided into four compartments based on the cardinal points, South–West (Compartment 1), North–West (Compartment 2), North–East (compartment 3) and South–East (Compartment 4). Four sampling sites of (25 m * 25 m) 0.0625 hectares were randomly delineated within each compartment with the aid of Garmin's GPS 12 Personal Navigator. The choice of (25 m * 25 m) 0.0625 ha plots was based on successful usage in the sampling of vegetation types in Ghana so that this study would be comparable. The number of quadrats required to assess the biodiversity were determined using the species area curve (Sahu et al. 2007). To study the state of the forest and tree species variety of Abasumba, GSBA all trees within the sites were catalogued viz. species name, elevation, and diameter at breast height dbh ≥ 10 cm (1.3 meters). Tree species having many trunks were taken as one, as long as there was a visible linkage amongst the trunks and with the thickest trunk measured. All living trees were identified using tree spotters based on Flora of West Tropical Africa 1927 (Hutchinson & Dalziel 1927), Field guide of the forest trees of Ghana (Hawthorne 1990), Woody plants of Western African forests (Hawthorne & Jongkind 2006) and Photo guide for the Forest Trees of Ghana (Hawthorne 2006), all naming were based on the International Plant Nomenclature index (IPNI 2008).

Data analyses

The obtained forest information was evaluated for tree species diversity indices, basal area, relative density, relative frequency and relative dominance (Phillips 1959). Importance value index (IVI) for each tree was calculated as the sum of the relative frequency, relative density and relative dominance (Cottam & Curtis 1956). Local names were documented and evidence about the local uses of the trees identified was attained by accessing relevant literature (Hawthorne 2006).

Formulae used include:
Tree species variety of the Abasumba, GSBA was quantified using Shannon and Weiner indices, (Shannon & Weiner 1963),

$$H' = -\sum \left[\left(\frac{ni}{N}\right) log2 \left(\frac{ni}{N}\right)\right]$$

Simpson's (*D*) index of diversity (Simpson 1949),

$$D = \sum \left(\frac{ni(ni-1)}{N[N-1]}\right)$$

was calculated for each compartment and the complete Abasumba GSBA.
Where:
(*ni*) = Total number of individuals of species
(*i* and *N*) = Total number of all individual species within a vegetation.
Basal area (m^2) = Area occupied at breast height (1.3 m) = [p * $(dbh/2)^2$]
Where dbh = Diameter of a tree at Breast Height, approximately 1.3 m above ground level
Relative density = (Density of the species/Total density of all species) *100
Relative frequency = (Frequency of the species/Total frequency of all species) *100
Relative dominance = (Basal area of the species/Total basal area for all species) *100
Importance Value Index (IVI) = Sum of relative density + Relative frequency + Relative dominance.
Spatial distribution patterns of individual trees were determined using Biodiversity Professional (2022), Version 2.0 software. According to Kershaw (Green 1974), entities are haphazardly dispersed once their mean of variance ratio is 1 but gathered if the ratio is bigger than 1, but if the ratio is less than 1, then the entities are regularly dispersed.

RESULTS AND DISCUSSION

Results

Forest structure

The dbh measurement for trees indicated that majority of trees 62.0%, were small stemmed in dbh 10–30 cm. These sizes were recorded for 54.3% of the trees identified while, 29.4% exhibited dbh 31–60 cm but, 8.6% obtained dbh above 60 cm. *Ceiba pentandra* and *Triplochiton scleroxylon* trees represented the highest dbh of 136 and 134 cm respectively while the other species had dbh values below 120 cm Table 1.

Table 1. Tree species (dbh ≥ 10 cm) class interval and distribution in Abasumba GSBA.

DBH Class (Cm)	No. of Species	% of Species	No. of Individuals	% of Individuals
10 – 30	25	54.3	232	62.0
31 – 60	13	28.3	110	29.4
61 – 90	4	8.7	17	4.6
91 – 120	2	4.4	10	2.7
121 – 150	2	4.4	5	1.3
Total	**46**	**100.0**	**374**	**100.0**

Tree height distribution

The distribution of trees by height intervals revealed 34.2% of individual trees were in the heights of 15–20 m; 10–15 m forming 21.7% and 20–25 m forming 12.8% making up the second and third major groups respectively. Tree heights in the ranges of 30–35 m and 25–30 m constituted 10.4% and 9.9% respectively. The mean elevation of trees stood at 19.0 m in the elevation of 5–40 m as shown in Figure 2. There were few trees in the height range of 5–10 m and 35–40 m making up only 6.2% and 4.0% respectively, while trees with height ≥ 40 m constituted only 0.9% (Figure 2). The tallest individual trees in the Abasumba, GSBA were *Triplochiton scleroxylon* 48.3 m, *Celtis mildbraedii* 42.5 m, *Ceiba pentandra* 35.1 m and *Nesogordonia papaverifera* 32.6 m.

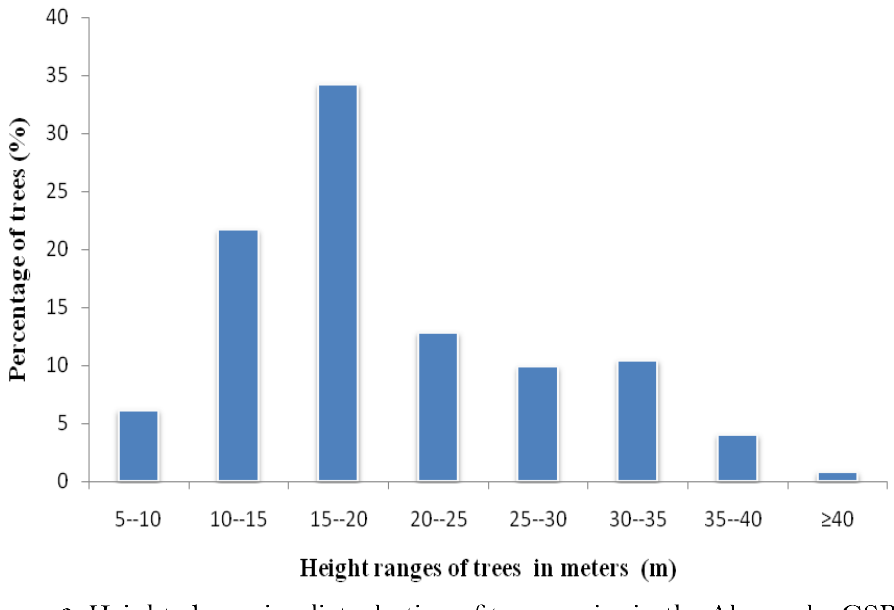

Figure 2. Height class wise distrubution of tree species in the Abasumba GSBA.

Species Diversity indices

Species diversity for the sampled compartments was determined Table 2. The highest Alpha species diversity 20.70 and Shannon diversity 1.56 indices were recorded in compartment 3, whiles compartment 1 had the highest Simpson index of 0.11. But, least value of Shannon 1.32 and Simpson 0.07 indices were in compartments 1 and 3, respectively. The Alpha diversity index were 8.70 to 20.70, Shannon diversity of 1.32 to 1.56 and Simpson's index of dominance measure were 0.04 to 0.11. The mean of Alpha, Shannon and Simpson's Diversity indices for the total Abasumba, GSBA was 13.9, 1.44 and 0.07 respectively.

Table 2. Species diversity indices of the sampled sites in Abasumba GSBA.

Diversity Indices	Compartment 1 (South–West)	Compartment 2 (North–West)	Compartment 3 (North–East)	Compartment 4 (South–East)	Mean
Alpha (α)	8.70	14.00	20.70	12.00	13.9
Shannon (H')	1.32	1.48	1.56	1.40	1.44
Simpson's (D)	0.11	0.06	0.04	0.05	0.07

Floristics composition

In total, 46 trees having dbh ≥ 10 cm within 38 genera and 17 families were recognized and enumerated in our recent research**.** The commonly encountered families were Sterculiaceae, Leguminosae and Moraceae, the remaining families were few between 1 to 2 species. Species belonging to Sterculiaceae which frequently occurred viz. *Cola millenii*, *Triplochiton scleroxylon*, *Nesogordonia papaverifera*, *Cola gigantea*, *Mansonia altissima*, *Hildegardia barteri.* Leguminosae, *Albizia adianthifolia*, *Albizia zygia*, *Baphia nitida*, *Dialium guineense*, *Erythrina senegalensis*, *Hymenostegia afzelii* and Moraceae, *Antiaris toxicaria*, *Ficus sur*, *Morus mesozygia* and *Trilepisium madagascariense* Table 3.

Basal area, Tree species dispersion patterns and Importance value index (IVI)

Generally, basal area was 2–35.3 m² ha⁻¹ and a total stem density of 374 stems ha⁻¹. Basal area value per species was 2.0 m² ha⁻¹ for *Dacryodes klaineana*, *Trichilia megalantha* and *Ficus sur* to 35.3 m² ha⁻¹ for *Albizia zygia*, whiles the relative density varied from 0.3 in *Draceana perrottetii* to 12.7 in *Cola millenii*, respectively. Total tree species varied from 1 to 46 individuals, 38 genera and 17 families. Species dispersion patterns showed 8 (17.4%) exhibited clustering, while 38 (82.6%) were randomly dispersed with no uniform dispersion. IVI is vital for comparing biological importance of trees within forests, as it shows the extent of dominance of species within forest stands (Asigbaase et al. 2019). Trees which have the highest importance value indices are the foremost dominant (Kacholi 2019). The dominant trees were *Triplochiton scleroxylon*-37.6, *Cola millenii*-28.9, *Trichilia monadelpha*-28.1, *Hymenostegia afzelii*-26.3, *Celtis* mildbraedi-23.9 and *Ceiba pentandra*-15.6, respectively. Conversely, the least dominant trees were *Ficus sur*-0.6, *Vitex ferruginea*-0.6, *Ximenia americana*-0.6 and *Draceana perrottetii*-0.6. Tree families Sterculiaceae, Meliaceae and Leguminosae were the most dominant and *Triplochiton scleroxylon* was the leading dominant tree Table 4.

Discussion

The current study is the foremost report about tree species diversity within the Abasumba, GSBA. This work affirmed the number of trees enumerated fall within the arrays stated earlier for other dry forests. Klitgaard et al. (1999) reported 49 trees per ha⁻¹ in a dry forest in Ecuador which compared well with 46 tree species identified in the Abasumba, GSBA. Conversely, Padalia et al. (2004) recorded 58 trees ha⁻¹ belonging to 176 genera and 81 families in a tropical evergreen Andaman Islands forest, India. Also, Suratman (2012) listed tree stem density of 315-510, tree species of 280-450, and a mean genus of 340-435 per ha⁻¹, in dipterocarp Kuala Keniam national park Malaysia which were all higher than those recorded in the Abasumba, GSBA. But the number of 46 species, 17 families and 38 genera reported per hectare here is lesser than those recorded for the dry forests in Central America of 53 species and 22 families (Gentry 1982). However, it is higher than 21 trees per ha⁻¹ recently enu-

Table 3. Summary of trees in the Abasumba GSBA according to families, local names and use.

Species Name	**Family**	**Local Name**	**Uses**
Albizia adianthifolia (Schumach.) W.Wight	Leguminosae–Mim.	Pampena	Medicinal
Albizia zygia (DC.) Macbr	Leguminosae–Mim.	Okoro	Timber, Fuel wood
Alstonia boonei De Wild	Apocynaceae	Nyame dua	Stoolwood, Timber
Antiaris toxicaria Lesch	Moraceae	Kyenkyen	Timber for Canoes
Baphia nitida Lodd.	Leguminosae–Pap.	Odwen	Walking stick
Blighia sapida K.D. Koenig	Sapindaceae	Ankye	Medicinal
Bridelia grandis Pierre ex. Huth.	Euphorbiaceae	Opamkotokrodu	medicinal
Ceiba pentandra L.	Bombacaceae	Onyina	Kapok, Timber
Celtis zenkeri Engl.	Ulmaceae	Esa–koko	Fuel wood
Celtis mildbraedii Engler	Ulmaceae	Esa	Fuel wood
Cola gigantean A. Chev.	Sterculiaceae	Watapuo/Owataku	Medicinal
Cola millenii K Shum.	Sterculiaceae	Mofra Cocoa	Medicinal
Dacryodes klaineana (Pierre) H.J.Lam	Burseraceae	Adwea	Paper making
Dialium guineense Willd.	Leguminosae–Caes.	Yoye (Asenaa)	Food
Dracaena perrottetii Baker	Dracaenaceae		Medicinal
Draceana arborea (Willd.) Link	Dracaenaceae		Medicinal
Erythrina senegalensis DC.	Leguminosae–Pap.		Medicinal
Ficus sur Forssk.	Moraceae	Odoma	Ornamental
Hildegardia barteri (Mast.) Kosterm.	Sterculiaceae	Akere–Kyewewa	Agri–horticulture
Holarrhena floribunda (G. Don) & Schinz	Apocynaceae	Sese	Carving
Holoptelea grandis (Hutch.) M.	Ulmaceae	Nakwa/Anakwa	firewood
Hymenostegia afzelii (Oliv.) H.	Leguminosae–Caes.	Takrowa	Timber, Medicine
Lannea acida A. Rich.	Anacardiaceae		Furniture
Lannea welwitschii (Hiern) Engl.	Anacardiaceae	Kum-Anini	Medicines
Lecaniodiscus cupanoides Planch.	Sapindaceae	Ankye (Dwindwera)	Food dye
Mansonia altissima (A.Chev.) A.Chev.	Sterculiaceae	Oprono	Valuable timber
Margaritaria discoidea (Baill.) Webster	Euphorbiaceae	Pepea/Duabo	Construction
Monodora myristica (Gaertn.)	Annonnaceae	Wedeaba	Spice, Medicine
Morinda lucda Benth.	Rubiaceae	Konkroma	Medicinal
Morus mesozygia Stapf	Moraceae	Woton	Food, Medicine
Napoleonaea vogelii Hook. & Planch	Lecythidaceae	Obua	Medicinal
Nesogordonia papaverifera (A. Chev.)R,Capuron	Sterculiaceae	Danta	Timber
Pterygota bequaertii de Wild.	Sterculiaceae	Kyere–bere	Bark fiber
Pterygota macrocarpa K.Schum.	Sterculiaceae	Kyerere	Medicinal
Rauvolfia vomitoria Afzel.	Apocynaceae	Kakapenpen	Medicine
Ricinodendron heudelotii (Baill.)	Euphorbiaceae	Wama	Pulp and paper
Sterculia rhinopetala K.Schum	Sterculiaceae	Wawabima	Medicinal
Sterculia tragacantha Lindl	Sterculiaceae	Sofo	Gun powder
Trichilia megalantha Harms	Meliaceae	Tanuro-kese	Medicinal
Trichilia monadelpha (Thonn.) J.J.de Wilde	Meliaceae	Kaka adukro	Fuel, Lighting
Trilepisium madagascariense DC.	Moraceae	Okure	Medicinal
Triplochiton scleroxylon K.Schum.	Sterculiaceae	Wawa	Timber, Plywood
Turraeanthus africanus (Wel.) Pel.	Meliaceae	Appapaye/Avodire	Timber
Vitex ferruginea Schu. & Thonn.	Verbenaceae	Otwentorowa	Firewood
Ximenia americana L.var. Amer.	Olacaeae		Medicinal
Xylia evansii Hutch.	Leguminosae–Mim.	Samantawa	Chewing sticks

Table 4. Tree Species diversity, distribution patterns and Importance value index (IVI) of Abasumba, GSBA.

Species Name	Family	Basal area	Relative Frequency	(IVI)	Distribution Patterns
Albizia adianthifolia (Schum.) W.F Wight	Leguminosae–Mimosoideae	9.2	0.5	1.10	Random
Albizia zygia (DC.) J.F. Macbr.	Leguminosae–Mimosoideae	35.3	0.8	3.30	Random
Alstonia boonei De Wildeman.	Apocynaceae	2.5	0.8	1.80	Random
Antiaris toxicaria (Rumph. Ex Pers.) Leschen.	Moraceae	4.2	4.3	10.68	Random
Baphia nitida Lodd.	Leguminosae–Papilionoideae	5.3	0.8	1.73	Random
Blighia sapida K. D. Konig.	Sapindaceae	12.6	0.3	0.65	Random
Bridelia grandis Pierre ex Hutchinson.	Euphorbiaceae	21.9	0.3	0.82	Random
Ceiba pentandra (Linnne') Gaertn	Bombacaceae	3.7	3.0	15.56	Random
Celtis zenkeri Engl.	Ulmaceae	7.8	4.8	12.33	Random
Celtis mildbraedii Engl.	Ulmaceae	5.0	8.0	23.90	Aggregated
Cola gigantea A. Chevalier.	Sterculiaceae	2.7	0.8	2.15	Random
Cola millenii K. Schum.	Sterculiaceae	2.0	12.6	28.88	Random
Dacryodes klaineana (Pierre) H. J. Lam.	Burseraceae	11.3	0.5	1.39	Random
Dialium guineense Willd.	Leguminosae–Caesalpinioideae	8.9	0.3	0.79	Random
Dracaena arborea (Willd.) Link.	Dracaenaceae	3.1	2.4	7.53	Aggregated
Dracaena perrottetii Baker.	Dracaenaceae	4.4	0.3	0.63	Random
Erythrina senegalensis DC.	Leguminosae–Papilionoideae	2.0	2.0	2.23	Random
Ficus sur Forsskal.	Moraceae	3.2	3.2	0.60	Random
Hildegardia barteri (Mast.) Kosterm.	Sterculiaceae	13.2	13.2	8.11	Aggregated
Holarrhena floribunda (G. Don) Dur. and Schi.	Apocynaceae	34.2	34.2	0.83	Random
Holoptelea grandis (Hutch.) Mildbr.	Ulmaceae	4.1	4.1	1.24	Random
Hymenostegia afzelii (Oliv.) Harms	Leguminosae–Caesalpinioideae	4.6	10.9	26.30	Aggregated
Lannea acida A. Rich.	Anacardiaceae	6.8	1.1	2.99	Random
Lannea welwitschii (Hiern.) Engler.	Anacardiaceae	15.7	1.3	6.53	Random
Lecaniodiscus cupanoides Planchon ex Bentham.	Sapindaceae	3.2	1.7	4.46	Random

Table 4. Contd.

Species Name	Family	Basal area	Relative Frequency	(IVI)	Distribution Patterns
Mansonia altissima (A.Chevalier) A. Chevalier	Sterculiaceae	13.2	0.5	1.99	Random
Margaritaria discoidea (Baillon) Webster	Euphorbiaceae	10.6	0.4	0.83	Random
Monodora myristica (Gaertn.) Dunal.	Annonaceae	4.0	1.2	2.19	Random
Morinda lucida Bentham	Rubiaceae	3.5	1.7	4.01	Random
Morus mesozygia Stapf.	Moraceae	4.3	1.5	4.79	Random
Napoleonaea vogelii Hooker and Planch.	Lecythidaceae	7.4	2.8	6.02	Aggregated
Nesogordonia papaverifera (A. Chevalier) R. Capuron	Sterculiaceae	6.0	6.1	15.22	Random
Pterygota bequaertii de Wild.	Sterculiaceae	3.3	1.6	4.20	Aggregated
Pterygota macrocarpa K.Schum.	Sterculiaceae	8.3	0.8	2.06	Random
Rauvolfia vomitoria Afzelius.	Apocynaceae	3.3	0.3	0.74	Random
Ricinodendron heudelotii (Baillon) pierre ex Pax.	Euphorbiaceae	10.5	2.7	6.63	Random
Sterculia rhinopetala K. Schum.	Sterculiaceae	2.3	0.5	1.29	Random
Sterculia tragacantha Lindley	Sterculiaceae	4.1	2.1	4.75	Random
Trichilia megalantha Harms.	Meliaceae	2.0	1.6	3.93	Random
Trichilia monadelpha (Thonning) J.J.de Wilde.	Meliaceae	3.1	4.0	28.10	Random
Trilepisium madagascariense DC.	Moraceae	19.6	0.3	0.86	Random
Triplochiton scleroxylon K. Schum.	Sterculiaceae	12.9	7.1	37.61	Random
Turraeanthus africanus (Welwitsch ex C.D.C) Pellegrin	Meliaceae	3.3	2.7	6.37	Aggregated
Vitex ferruginea Schum. and Thonning	Verbenaceae	2.8	0.3	0.61	Random
Ximenia Americana L.var. Americana	Olacaceae	2.5	0.3	0.62	Aggregated
Xylia evansii Hutchinson	Leguminosae–Papilionoideae	3.8	0.3	0.65	Random
Total **46 Species**		**357.7**	**100.0**	**300.0**	

merated by Asase & Adeniyi (2021) in Ghana at the Apra Hills Sacred Grove within same southern marginal dry forest ecological zone.

Trees having dbh ≥ 10 cm ranged from 3–28 per ha^{-1} in Vindhyan tropical dry forest, India (Sagar & Singh 2005). Stem density of 374 ha^{-1} in Abasumba, GSBA was in the array of stems 276–905 ha^{-1} reported for tropical forests by (Pandey & Shukla 2001). White & Hood (2004) recorded a basal area of 20.7 m^2 ha^{-1} and 28.4 m^2 ha^{-1} in the humid dry forest of North Central Yucatan while, Gillespie & Jaffré (2003) recorded basal area of 32.7, 32.3 m^2 ha^{-1} for Ouen–Toro and Pindai in the dry humid forest of New Caledonia. We recorded basal area of 2 to 35.3 m^2 ha^{-1} and it compared well to the basal area for other tropical dry forests. The comparable basal area can be attributed to the existence of huge number of lower diameter class species in Abasumba, GSBA. As Abasumba is characterized by abundant small trees with dbh below 60 cm (as 62.0% of all individual trees sampled were in the ranges of 10–30 cm). This pattern is not unusual for primary forests, which are not or are only weakly affected by human exploitation showing a high potential of regeneration (Whitmore 1984). The relatively small number of trees with dbh ≥ 60 cm might be due to a limited number of species that naturally grow up to such diameters (Hartshorn 1990). As seedlings need to meet optimal conditions or locations for growth, in order to out-compete other fast-growing species (Khurana & Singh 2001). Although, the floristics composition is relatively low in the southern marginal dry forests of Ghana (Asase & Adeniyi 2021) they are usually made up of important species of management interest. In our present research, one of the enlisted tree species *Nesogordonia papaverifera* is enumerated as an endangered species in the IUCN Red List (www.iucnredlist.org) for been vulnerable or scarce tree. The findings of this study show that Abasumba, GSBA is a shelter for the protection of endangered tree species and essential for the maintenance of species biodiversity.

According to designation of trees that belong to storeys in tropical dry forests, three storeys are distinguished viz. uppermost (40–60 m), middle (18–30 m) and lower (4.5–18 m) storeys (Cloudsley-Thompson 1967; Lamprecht 1989). The tallest trees were *T. scleroxylon*, *C. mildbraedii*, *C. pentandra*, and *N. papaverifera*. Linares-Palomino & Alvarez (2005) discovered in the dry humid forests of Cerros de Amotape Cordillera, Peru that majority of the trees inventoried was in the (5–10 m) stratum. The second (10–15 m) covered trees and the third comprised of emergent trees above 15 m with few greater than 20 m. The majority of trees measured in Abasumba, GSBA fell in the middle and lower storeys whilst few were in the upper storey, this pattern is characteristic of tropical dry forests where most trees do not grow into the upper storey Swaine et al. (1990).

Trees with highest IVI were *T. scleroxylon*, *C. millenii*, *H. afzelii*, and *C. mildbraedii* belonging to Sterculiaceae, Meliaceae and Leguminosae families, respectively. This is consistent with (Cloudsley-Thompson 1967) description of Leguminosae, Sterculiaceae, Rubiaceae and Meliaceae as it has been the dominant family's composition in West African forests. Sterculiaceae, Leguminosae and Moraceae were the frequently occurring families as in the 10 most species–rich families in Africa, Asian and Neotropical forests (Huston 1994). Bombacaceae, Burseraceae, Annonaceae, Rubiaceae, Lecythidaceae, Verbenaceae and Olacaceae were the least frequent tree families within the plots. This is in contrast to Gentry (1995) who stated that the families Bombacaceae and Fabaceae were the dominant family in the Peruvian and the Neotropical dry forest ecosystem. The frequently encountered tree species were *C. millenii*, *T. scleroxy-*

lon, *N. papaverifera*, *C. gigantea*, *M. altissima*, *H. barteri*. *A. adianthifolia*, *A. zygia*, *B. nitida*, *D. guineense*, *E. senegalensis*, *H. afzelii*, *A. toxicaria*, *F. sur*, *M. mesozygia* and *T. madagascariense*. This is consistent with Asase & Adeniyi (2021), that frequently encountered *C. millenii*, *H. barteri*, *C. pentandra* and *D. aborea* trees in the Apra Hills Sacred Grove, Ghana.

The mean Shannon diversity index for the Abasumba GSBA was 1.44 this is below 1.67 recorded by Swaine et al. (1990) in Shai Hills, a humid dry forest in South–East Ghana but it is comparable to values obtained for other humid dry forests. In Kumaun dry forest, Himalaya a Shannon index of 0.8–2.3 was obtained by Garkoti (1992), while Srivastava (2002) reported 0.2-0.9 for the central Himalayan dry forests and Linares-Palomino and Alvarez (2005) reported 1.08–2.55 for the humid forests of Cerros de Amotape Cordillera, Peru. The mean Simpson's Diversity index of dominance 0.07 in this study is lower indicating low dominance of occurring species. Srivastava (2002) reported 0.20–0.90 in the central Himalayan forests India, additionally Linares-Palomino and Alvarez (2005) reported 0.51–0.91 for the humid forests of Cerros de Amotape Cordillera, in Tumbes, Peru.

Previous studies have revealed that uniform spreading of species is seen in limited species whiles, spreading of species is haphazard or gathered in nature. In a study of the highly diverse (87 tree species) of dry forest of Guanacaste Province in Costa Rica, Hubbell (1979) discovered that, trees were aggregated or haphazardly dispersed, with intermittent trees been aggregated compared to the frequent trees. In our research, uniform distribution was not exhibited, however 17.4% of trees showed aggregation whiles 82.6% displayed random dispersion. These indicates the environment in which the trees grow was homogeneous with many related factors acting on the population (Ewusie 1980) whiles rejuvenation near seed origin, asexual propagation, presence of 'sheltered sites' or anthropogenic disturbances caused aggregation (Augspurger 1984; Beatty 1984; Menaut et al. 1990).

CONCLUSION

The Abasumba GSBA is a tropical dry forest and remnants of the Awutu forest within the costal-–savanna–ecological–zone of Ghana. The forest structure and the species diversity indices coupled with the presence of a rare tree species shows the uniqueness for the conservation of plant biodiversity hence the demarcation as a Globally Significant Biodiversity Area. Some of the sampled plots were rich in tree species as they had many species, with a few individual trees. An active management regime including the restoration of species with low Importance Value Index is required from the plant conservationist view because they are the least dormant and rare species. The incorporation of local knowledge, practices and skills in the administration of the Abasumba, GSBA will enhance development of sustainable conservation methods. Further work on the effects of land and human caused factors on tree species diversity and distribution patterns will enhance our understanding of the location, spread and abundance of tress species for the purposes of biodiversity conservation. This study would be a starting point for the characterization of all the GSBA's in the Bawjiase district in particular and the southern dry forest reserves as a whole.

AUTHORS CONTRIBUTION

F.T.K. considered the ideas, and designed the sampling methods; F.T.K. and D.W. gathered the data and analysed; F.T.K. and D.W. contributed to the writing of the manuscript, and preparation for submission. All the writers contributed equally to the drafts and gave final approval for publication.

ACKNOWLEDGMENTS

We are thankful to the Chief Executive of the Ghana Forestry Commission, the Winneba District Forestry Manager, the Bawjiase Zonal Range officer, Traditional leaders and the Communities living around Abasumba, GSBA. My sincere appreciations also go to Messer J.Y. Amponsah a worker of the University of Ghana Herbarium for the support in the field.

CONFLICT OF INTEREST

The authors do not have any conflict of interest to declare, financial or otherwise, that could have influenced this paper.

REFERENCES

Acheampong, E.O. et al., 2019. Deforestation is driven by agricultural expansion in Ghana's forest reserves. *Scientific African*, 5, e00146. doi: 10.1016/j.sciaf.2019.e00146

Asase, A. & Adeniyi, A., 2021. Plant diversity and tree community structure along an elevation gradient in Apra Hills Sacred Grove, Ghana. *West African Journal ofApplied Ecology*, 29(2), pp.47-58. ajol.info/index.php/wajae/article/view/220056

Asigbaase, M. et al., 2019. Tree diversity and its ecological importance value in organic and conventional cocoa agroforests in Ghana. *PloS one*, 14(1), e0210557. doi: 10.1371/journal.pone.0210557

Augspurger, C.K., 1984. Seedling survival of tropical tree species: interactions of dispersal distance, light-gaps, and pathogens. *Ecology*, 65 (6), pp.1705-1712. doi: 10.2307/1937766

Baker, D.J. & Willis, S.G., 2014. Projected impacts of climate change on biodiversity in West African protected areas. *UNEP-WCMC technical report.*

Beatty, S.W., 1984. Influence of microtopography and canopy species on spatial patterns of forest understory plants. *Ecology*, 65(5), pp.1406-1419. doi: 10.2307/1939121

Bentsi-Enchill, F. et al., 2022. Impact of anthropogenic disturbance on tree species diversity, vegetation structure and carbon storage potential in an upland evergreen forest of Ghana, West Africa. *Trees, Forests and People*, 8, 100238. doi: 10.1016/j.tfp.2022.100238

Brobbey, L. et al., 2020. Drivers of cocoa encroachment into protected forests: the case of three forest reserves in Ghana. *International Forestry Review*, 22(4), 425-437. doi: 10.1505/146554820831255533

Cabin, R.J. et al., 2000. Effects of long-term ungulate exclusion and recent alien species control on the preservation and restoration of a Hawaiian tropical dry forest. *Conservation Biology*, 14(2), pp.439-453. doi: 10.1046/j.1523-1739.2000.99006.x

Cloudsley-Thompson, J.L., 1967. Plant Life in West Africa. G. W. Lawson. *The Quarterly Review of Biology*, 42(3), pp.434-435.

Cottam, G. & Curtis, J.T., 1956. The use of distance measures in phytosociological sampling. *Ecology*, 37(3), pp.451-460. doi: 10.2307/1930167

DryFlor et al., 2016. Plant diversity patterns in neotropical dry forests and their conservation implications. *Science*, 353(6306), pp.1383-1387. doi: 10.1126/science.aaf5080

Ewusie, J.Y., 1980. *Elements of Tropical Ecology: with Reference to the African, Asian, Pacific and New World Tropics*, London: Heinemann.

FAO, UNEP, 2020. The State of the World's Forests 2020. *Forests, biodiversity and people*, pp.82-85.

Garkoti, S.C., 1992. *High altitude forests of Central Himalaya: productivity and nutrient cycling*. Kumaun University.

Gentry, A.H., 1982. Patterns of neotropical plant species diversity. In *Evolutionary biology.* Boston: Springer. doi: 10.1007/978-1-4615-6968-8_1

Gentry, A.H., 1995. Diversity and floristic composition of neotropical dry forests. In *Seasonally dry tropical forests.* Cambridge: Cambridge University Press, pp.146-194. doi: 10.1017/CBO9780511753398.007.

Ghartey, K., 1989. Results of the national forest inventory, Planning Branch. *Forestry Department, Kumasi–Ghana.*

Gillespie, T.W. & Jaffré, T., 2003. Tropical dry forests in New Caledonia. *Biodiversity & Conservation*, 12(8), pp.1687-1697. doi: 10.1023/A:1023649831355

Green, C., 1974. Quantitative and dynamic plant ecology: KA Kershaw. Edward Arnold, London, 1973, 2nd edn, 308 pp., 164 figures, 33 tables,£ 5.60: Elsevier. *Agro-Ecosystem*, 1, pp.359-360 doi: 10.1016/0304-3746(74)90043-2

Hall, J.B. & Swaine, M.D., 1981. *Distribution and ecology of vascular plants in a tropical rain forest*, Springer Dordrecht. doi: 10.1007/978-94-009-8650-3

Hartshorn, G.S., 1990. An overview of neotropical forest dynamics. In *Four neotropical rainforests.* New Haven and London: Yale University Press, pp.585-599.

Hawthorne, W., 1990. *Field guide to the forest trees of Ghana.* London, UK: Overseas Development Administration. cabdirect.org/cabdirect/abstract/19920657419

Hawthorne, W. & Musah, A. J., 1993. *Forest protection in Ghana*, Gland, Cambridge: IUCN.

Hawthorne, W. & Abu-Juam, M., 1995. *Forest protection in Ghana: with particular reference to vegetation and plant species* (Vol. 15). IUCN. iucn.org/resources/publication/forest-protection-ghana-particular-reference-vegetation-and-plant-species

Hawthorne, W., 2006. *Photoguide for the forest trees of Ghana: a tree-spotter's field guide for identifying the largest trees.* Oxford Forestry Institute, Department of Plant Sciences.

Hawthorne, W.D. & Jongkind, C.C., 2006. *Woody plants of Western African forests, A guide to the forest trees, shrubs and lianes from Senegal to Ghana*, UK: Royal Botanic Gardens, Kew, p.1023.

Huang, W. et al., 2003. Species diversity, forest structure and species composition in Tanzanian tropical forests. *Forest Ecology and Management*, 173(1-3), pp.11-24. doi: 10.1016/S0378-1127(01)00820-9

Hubbell, S.P., 1979. Tree Dispersion, Abundance, and Diversity in a Tropical Dry Forest. *Science*, 203(4387), pp.1299-1309. jstor.org/stable/1747305#metadata_info_tab_contents

Huston, M.A., 1994. Biological diversity: The coexistence of species on changing landscapes, Cambridge, UK: Cambridge University Press.

Hutchinson, J. & Dalziel, J. M., 1927. *Flora of west tropical Africa*, London, UK: Crown Agents for the Colonies. https://www.cabdirect.org/cabdirect/abstract/20057002922

International Plant Nomenclature Index (IPNI), 2008. International plant nomenclature index, viewed 10 June 2022, from ipni.org

Jacobson, A.P. et al., 2019. Global areas of low human impact ('Low Impact Areas') and fragmentation of the natural world. *Scientific Reports*, 9(1), pp.1-13. doi: 10.5061/dryad.z612jm67g

Kacholi, D.S., 2019. Assessment of Tree Species Richness, Diversity, Population Structure and Natural Regeneration in Nongeni Forest Reserve in Morogoro Region, Tanzania. *Tanzania Journal of Science*, 45(3), pp.330-345. doi: 10.4314/TJS.V45I3

Keenan, R.J. et al., 2015. Dynamics of global forest area: Results from the FAO Global Forest Resources Assessment 2015. *Forest Ecology and Management*, 352, pp.9-20. doi: 10.1016/j.foreco.2015.06.014

Khurana, E. & Singh, J., 2001. Ecology of seed and seedling growth for conservation and restoration of tropical dry forest: a review. *Environmental conservation*, 28(1), pp.39-52. doi: 10.1017/S0376892901000042

Klitgaard, B.B. et al., 1999. Composición florística y estructural del bosque petrificado de Puyango. Herbario LOJA, 3, pp.25-49.

Lamprecht, H., 1989. *Silviculture in the tropics: Tropical forest ecosystems and their tree species-possibilities and methods for their long-term utilization*, Germany: Deutsche Gesellschaft für Technische Zusammenarbeit.

Lelli, C. et al., 2019. Biodiversity response to forest structure and management: Comparing species richness, conservation relevant species and functional diversity as metrics in forest conservation. *Forest Ecology and Management*, 432, pp.707-717. doi: 10.1016/j.foreco.2018.09.057

Linares-Palomino, R. & Alvarez, S.I.P., 2005. Tree community patterns in seasonally dry tropical forests in the Cerros de Amotape Cordillera, Tumbes, Peru. *Forest Ecology and Management*, 209(3), pp.261-272. doi: 10.1016/j.foreco.2005.02.003

Menaut, J.C. et al.,1990. Tree community dynamics in a humid savanna of the Cote-d'Ivoire: modelling the effects of fire and competition with grass and neighbours. *Journal of biogeography*, 17(4/5), pp.471-481. doi: 10.2307/2845379

Ocón, J.P. et al., 2021. Global tropical dry forest extent and cover: A comparative study of bioclimatic definitions using two climatic data sets. *PloS One*, 16(5), e0252063. doi: 10.1371/journal.pone.0252063

Owusu, E.H. et al., 2018. The secondary impact of mining on primates and other medium to large mammals in forest reserves in southwestern Ghana. *The Extractive Industries and Society*, 5(1), pp.114-121. doi: 10.1016/j.exis.2017.11.007

Padalia, H. et al., 2004. Phytosociological observations on tree species diversity of Andaman Islands, India. *Current Science*, 87(6), pp.799-806. jstor.org/stable/24109360

Pandey, S.K. & Shukla, R.P., 2001. Regeneration strategy and plant diversity status in degraded sal forests. *Current Science*, 81(1), pp.95-102. jstor.org/stable/24105011

Phillips, E.A., 1959. *Methods of vegetation study*, Holt, Rinehart and Winston.

Riggio, J. et al., 2020. Global human influence maps reveal clear opportunities in conserving Earth's remaining intact terrestrial ecosystems. *Global Change Biology*, 26(8), pp.4344-4356. doi: 10.1111/gcb.15109

Sagar, R. & Singh, J., 2005. Structure, diversity, and regeneration of tropical dry deciduous forest of northern India. *Biodiversity & Conservation*, 14(4), pp.935-959. doi: 10.1007/s10531-004-0671-6

Sahu, S. et al., 2007. Phytosociological study of tropical dry deciduous forest of Boudh district, Orissa, India. *Research journal of forestry*, 1, pp.66-72. doi: 10.3923/RJF.2007.66.72

Shannon, C. & Weiner, W., 1963. *The mathematical theory of communication*, Urbana, US: The University of Illinois Press.

Simpson, E.H., 1949. Measurement of diversity. *Nature*, 163, 688. doi: 10.1038/163688a0

Siyum, Z.G., 2020. Tropical dry forest dynamics in the context of climate change: syntheses of drivers, gaps, and management perspectives. *Ecological Processes*, 9, 25. doi: 10.1186/s13717-020-00229-6.

Srivastava, A., 2002. *Forest vegetation and tree regeneration in a species-rich sub montane transect of central Himalaya*. Kumaun University.

Suratman, M.N., 2012. Tree species diversity and forest stand structure of Pahang National Park, Malaysia. *Biodiversity enrichment in a diverse world*, 19, pp.45-56. doi: 10.5772/50339

Swaine, M.D, Lieberman, D. & Hall, J.B., 1990. Structure and dynamics of a tropical dry forest in Ghana. *Vegetatio*, 88(1), pp.31-51. doi: 10.1007/BF00032601

Thammanu, S. et al., 2021. The influence of environmental factors on species composition and distribution in a community forest in Northern Thailand. *Journal of Forestry Research*, 32(2), pp.649-662. doi: 10.1007/s11676-020-01239

Vogt, P. et al., 2019. FAO-State of the World's Forests: Forest Fragmentation, *Luxembourg: Publications Office of the European Union*. doi: 10.2760/145325

White, D. & Hood, C. 2004. Vegetation patterns and environmental gradients in tropical dry forests of the northern Yucatan Peninsula. *Journal of Vegetation Science*, 15(2), pp.151-160. doi: 10.1111/j.1654-1103.2004.tb02250.x

Whitmore, T., 1984. *Tropical rain forests of the Far East 2nd Ed.*, Clarendon Press.