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Dry Forest Vegetation Analysis and its Soil Properties

Research Article

Nay Myo Htike[1], San Thwin[2*] and Nyunt Khaing[3]

[1]*Forest Department, Head Office of Ministry of Natural Resources and Environmental Conservation, Nay Pyi Taw, Myanmar*

[2]*Department of Forestry, University of Forestry, Yezin, Nay Pyi Taw, Myanmar*

[3]*Forest Research Institute, Ministry of Natural Resources and Environmental Conservation, Nay Pyi Taw, Myanmar*

***Corresponding author:** San Thwin, Department of Forestry, University of Forestry, Yezin, Nay Pyi Taw, Myanmar; Email: santhwin@gmail.com

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Abstract

Thirty sample plots (40m×25 m) were randomly sampled from three different sites of the dry forest under different management practices; natural forest protected by local people (CF), protected natural forest (PNF) and primary forest (PF) in Shwesettaw Wildlife Sanctuary. A total of 44 species belonging to 23 families at the adult tree level were recorded in the study area. The PF was found the highest 29 species of 19 families, following 29 species of 16 families in PNF, 21 species of 11 families in CF respectively. *Tectona hamiltoniana* indicated the highest ecological significant species in the study area. Mimosaceae was the dominant in the study area. The structure described by diameter distribution was reversed J-shaped. Soil properties (BD, OM and pH) showed differences at significant level ($p< 0.05$) between CF and PF. By using PCA, the results showed that the species distribution is mainly related to soil compaction (BD) among the soil variable investigated at $p< 0.05$..

Keywords: Dry forest; Species composition; Diversity; Species distribution; Soil properties

Introduction

Dry Forests in the Central Myanmar are one of the ecological precious resources which regulate local climate, and provide basis needs of local people, habitat for wild flora and fauna. The sustainability of these forests is very important for the dry land ecosystem. Nowadays, the Central Myanmar has faced challenges in terms of land degradation and habitats loss because of rapid reduction in forest cover. So, dry forests require management intervention to maintain the overall biodiversity, productivity and sustainability. Insufficient up-to-date baseline data on dry forests makes it difficult to develop effective conservation strategies. Knowledge of species characteristics and stand structure is important in management of biodiversity conservation [1]. Thus, the study of floristic composition and structure of tropical forest becomes more imperative in the face of the ever increasing threat to the forest ecosystem. Knowledge of soil properties will provide as a useful tool in management practice for rehabilitation process [2]. Therefore, forest management practices need to monitor at the overall soil properties changes through the conservation of species composition. There exists little authentic quantitative analysis between soil-vegetation characteristics in Central Myanmar. For this reason, the present study attempts to analyze the species composition, diversity and species distribution in relation to soil properties of the dry forests under different management practices in Central Myanmar.

Material and Method

Study area

The two study sites; the Community Forest (CF) and the

Protected Natural Forest (PNF) were selected in Pwinbyu Township, which is ranging the altitude from 120-300 m and situated between 94' 22" to 94' 56" E and 20' 07" to 20' 30" N. The annual rainfall is 697.88 mm. The average highest and lowest temperatures of the study area are 33.07 **°C** and 20.84 **°C** respectively. CF implementation was conducted about 90 ha through the natural forest conservation system in 2003. PNF with the area of 2100 ha was established in 2005. By using the definition of FAO [3], the Primary Forest (PF) is selected in the Shwesettaw Wildlife Sancturay, which was established in 1940 and situated closely to the study sites, as a reference site for comparison of vegetation formation. All of these investigated forest stands represent the same forest formation of *Terminalia oliveri-Tectona hamiltoniana*.

Data collection

The study sites were demarcated using topographic maps, allocation of sample plots randomly and physiographic factors were measured by GPS. Sample plot design followed the procedure described by Lamprecht [4]. The 10 sample plots were set up in each study site. Sample plot size was (40m × 25 m), where of all trees with DBH ≥ 10 cm were measured in DBH and height. Within the plot, one quadrate (20m × 15 m) was set and then saplings with DBH < 10 cm and total height of ≥ 1.3 m were measured in DBH and height. Then, subplots (5m × 5 m) were nested at four corners of the plot and all seedlings (0.3 m < height ≤ 1.3 m) were recorded in species identification. Soil samples were taken at the center of the each sample plot from 2 layers, 0-10 cm and 40-50 cm respectively.

Data analysis

Species composition was evaluated by analyzing three parameters: abundance, frequency and dominance of the species [5]. For the species diversity analysis, Shannon and Simpson's index [6] was used as the index affected by both species richness and evenness of the population. Sorensen index [4] was used to indicate similarity of shared species between two communities. Soil properties were analyzed in the texture, bulk density (BD), moisture content (MC), soil reaction (pH) and organic matter (OM). All statistical analyzes were performed by using Excel 2007, Statistica 9 and PC-ORD (version 5.10) for Window.

Results

Tree species composition and species diversity

The study of species composition in a community is of paramount important to effective conservation planning. Curtis and McIntosh pointed out Important Value Index (IVI) [7]. The ecological significant species in a community can be known by the species owned value called IVI. In the CF, *Tectona hamiltoniana* and *Terminalia oliveri* were the most ecological significant species based on their IVI values (Table 1). These species were approximately 33% of total abundance with the basal area 0.69 m^2/ha in the forest. The CF belonged to 21 species and 11 families. Mimosaceae was the dominant family in the study site.

There were 16 families at the adult stage in the PNF. Fabaceae and Combretaceae were dominant by occupying about 25% of the total families found in this site. The PNF had the higher numbers of individuals and basal area, and thus approaching to the PF. About 29 species were found per hectare (Table 2). *Tectona hamiltoniana* with the highest density value was found to be the dominant species having maximum IVI value of 77.54; taking 34% of total abundance and basal area of the investigated forest stand.

In the PF, about 19 families represented and thus these numbers were the highest number of families among the study sites (Table 3). The two families, Fabaceae and Mimosaceae, were the most frequently found families, contributing about 13% of total occurrence in this study site. There were 29 species in the PF. The highest total basal area among three study sites, 9.60 m^2 /ha was found in this study site. *Tectona hamiltoniana* showed the highest IVI value of 93.59 and occupied approximately 43% in total abundance and 41% in total basal area. So, it can be said that the forest is a single species dominated stand, and thus this factor seems to be an indicator of the PF.

Species diversity

Species diversity is a function which incorporates information on

Table 1: Ecological significant species for all trees ≥10 cm dbh in the CF.

Species	Abundance (no. of trees)	Frequency (%)	Dominance (BA)	IVI
Tectona hamiltoniana	26	40	0.46	47.96
Terminalia oliveri	12	50	0.23	30.00
Terminalia tomentosa	11	60	0.16	28.47
Melanorrhoea usitata	16	10	0.26	25.43
Shorea obtusa	4	20	0.26	17.30
Shorea siamensis	6	20	0.17	15.81
Dipterocarpus tuberculatus	3	10	0.30	15.67
Diospyros burmanica	4	20	0.20	15.09
Lannea coromandelica	5	30	0.10	14.69
Others	23	170	0.48	75.03
Total	117		2.72	300

Table 2: Ecological significant species for all trees ≥10 cm dbh in the PNF.

Species name	Abundance (no. of trees)	Frequency (%)	Dominance (BA)	IVI
Tectona hamiltoniana	149	90	3.92	93.59
Dalbergia paniculata	40	80	1.07	31.58
Terminalia oliveri	15	80	1.03	24.01
Lannea coromandelica	25	80	0.73	23.74
Bombax malabaricum	17	50	0.24	13.05
Albizzia lebbek	12	30	0.53	12.34
Diospyros burmanica	9	50	0.37	12.10
Stereospermum fimbriatum	7	50	0.19	9.63
Boscia variabilis	4	30	0.25	7.17
Morinda tinctoria	5	40	0.09	6.84
Others	67	305	1.19	65.96
Total	350		9.6	300

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Table 3: Ecological significant species for all trees ≥10 cm dbh in the PF.

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species richness and evenness. The diversity is usually carried out in order to examine its linkage to others community properties such as productivity and stability, or to the facing environmental conditions [8]. Similarity indices indicate how species distribute between two communities [9]. The Sorenson's index is based on the number of species (K_s) and dominance (K_d). Table 4 shows the diversity values observed in all investigated stands. The CF had the highest tree species richness (H') and most even distribution (E) of the species among the study sites. The PF was found the lowest diversity indices. The PNF presented moderate value of diversity indices among all investigated stands.

The coefficient of similarities for three study sites is shown in Table 5. A total of 14 species in the CF were similar to the PNF. This similarity index indicated that 56% of tree species found in the CF were similar to that of the PNF. The similar trend was observed between the PNF and the PF. The K_d indicated that approximately 80% of the species found in the PF were shared with the CF and the PNF. The PF and the PNF were highly similar; K_d was 91%, demonstrating that these forest stands were remarkably similar. The higher similarity between these forest stands may be due to the occurrence of the species, *Tectona hamiltonia*, which occupied approximately 44% of total basal area the PF and amounted to 37% in the PNF.

Horizontal stand structure by diameter frequency distribution

The horizontal structure of a forest can be measured by diameter size distribution of tree species considered individually or as a community [10]. In the CF the largest number of trees, i.e. 262 stems (53% of total abundance), occurred in the smallest diameter class ( ). Although the largest trees in the Community Forest attained a diameter class of 30- 35 cm, there were only two individuals in the largest diameter class. In the PNF, the smallest diameter class (0-5 cm) presented 273 individuals. At the diameter class of 5-10 cm, the tree density suddenly dropped into 88 stems.

A sudden decreasing of tree density in this diameter class may be due to the mortality of seedlings by natural or anthropogenic disturbances. The PF exhibited a diameter frequency distribution of reverse J-shaped. The tree densities were 880 individuals, and thus the PF had the highest tree density that widely distributed in all dbh classes up to 50 cm, in comparing to the CF and the PNF. The smallest diameter class, i.e. 0-5 cm, contained 404 stems which amounted to 46% of the total abundance. The PF showed favorable results by mean of well stocked and diameter-frequency distribution.

Table 4: Diversity indices for the investigated stands, DBH≥ 10 cm in the subplot A.

Study site	Diversity indices		
	Shannon index (H')	Shannon evenness (E)	Simpson index (1/D)
CF	2.61	0.86	10.52
PNF	2.45	0.73	6.42
PF	2.32	0.69	4.83

Table 5: Coefficient of similarity between forest stands investigated by Sorensen (K_s), and (K_d).

Study site	CF		PNF		PF	
	K_s	K_d	K_s	K_d	K_s	K_d
CF	-	-	-	-	56	77.57
PNF	56	80.15	-	-	-	-
PF	-	-	55.17	91.28	-	-

Table 6: Distribution of tree species, tree abundance, and basal area by strata in three study sites.

Study sites	Strata	Tree height(m)	Tree species		Tree abundance		Basal area	
			No.	%	No.	%	m²/ha	%
CF	Upper	>14.22m ≤21.34m	5	23.81	5	4.27	0.45	16.54
	Middle	>7.11m ≤14.22m	19	90.48	78	66.67	1.73	63.61
	Lower	<7.11m	14	66.67	34	29.06	0.54	19.85
PNF	Upper	>9.34m ≤14.02m	5	17.24	10	5.10	0.42	9.11
	Middle	>4.67m ≤9.34m	27	93.10	160	81.63	3.82	82.86
	Lower	<4.67m	14	48.28	26	13.27	0.37	8.03
PF	Upper	>15.24m ≤22.86m	7	24.14	61	17.43	3.31	34.48
	Middle	>7.62m ≤15.24m	22	75.86	221	63.14	5.31	55.31
	Lower	<7.62m	20	68.97	68	19.43	0.98	10.21

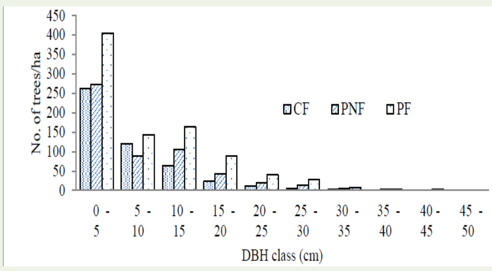

Figure 1: Diameter-frequency distribution in three study sites.

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Table 7: Soil properties in three study sites.

Study site	Depth (cm)	Texture	BD	MC	OM	pH
CF	0 – 10	Sandy loam	1.53 ±0.24[a]	4.79 ±3.38	1.79± 0.71[b]	7.46± 0.97[a]
	40 - 50	Sandy loam	-	5.67 ±4.65	1.42± 0.71[b]	-
PNF	0 – 10	Sandy loam	1.40± 0.15[ab]	5.01 ±3.16	2.22± 0.47[ab]	6.82± 0.18[c]
	40 - 50	Sandy loam	-	6.33± 4.12	1.85± 0.55[ab]	-
PF	0 – 10	Sandy loam	1.27 ±0.07[b]	6.09± 1.87	2.67± 0.53[a]	7.16± 0.97[b]
	40 - 50	Sandy loam	-	6.45± 1.86	2.30 ±0.53[a]	-

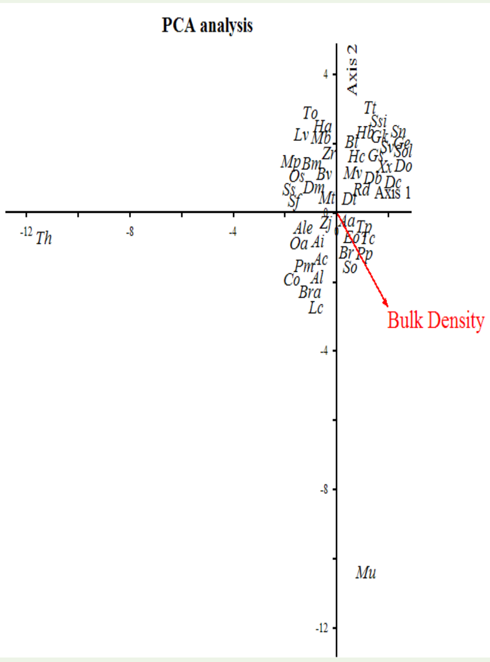

Figure 2: PCA ordination diagram of the species distribution related to the soil properties.

Stratification of forest canopy by IUFRO classification scheme

The forest canopy can be flexibility stratified by IUFRO classification scheme. According to IUFRO classification scheme, forest vertical structure is composed of three strata [4]; upper (tree height> 2/3 top height), middle (2/3>tree height >1/3) and lower (<1/3 of top height). The classification scheme informs some ecological traits of tree species of a stand: species with a regular vertical distribution, i.e. a particular tree species occurred in three strata; and species with uncertain natural regeneration, i.e. occurrence of species only in the upper canopy, etc.

As shown in Table 6, the upper strata consisted of the minimum number of species, tree abundance and basal area in all study sites. The species with regular vertical distribution were *Tectona hamiltoniana, Terminalia oliveri, Shorea obtuse, Dipterocarpus tuberculatus* in CF; *Tectona hamiltoniana, Terminalia oliveri, Lannea coromandelica* in PNF; *Tectona hamiltoniana, Lannea coromandelica, Albizzia lebbek, Stereospermum fimbriatum, Dalbergia paniculata* in PF respectively. By showing regular vertical distribution, these species are expected to certain in natural regeneration and long term sustainability.

Forest soil properties

The knowledge of soil is very important to understand the growth and regeneration of forest. There is a dynamic process in soil formation and associated forest vegetation over long period of time through a complex sequence of interconnected events [11].

Numbers are the means with standard deviation (Mean ± SD). Different small letters indicate significant differences ($p<0.05$) in Turkey HSD test.

Overall study of soil texture, there was no large variation of particle size distribution between soil layers, among all study sites (Table 7). According to the soil texture triangle, three investigated forests possessed sandy loam in two soil layers. The CF belonged to the highest mean value of BD (1.53 g/cm^3) among three investigated sites. Comparing with the findings of Arshad et al., [12], the mean values of BD showed the ideal level for plant growth. The top soil layer (0-10 cm) was more richness OM than subsoil layer (40-50 cm) in all study sites. The MC in all forests observed lower value in topsoil layer than subsoil layer. According to soil moisture range chart [13], the MC in both soil layers of all forests was below the wilting point. According to the general relationship between soil pH and availability of plant [14], the current findings in pH were also optimum level for plant growth. By regarding Turkey HSD comparison test, the findings significantly different at 5% level was observed in the case of BD and OM between CF and PF, and pH in all study sites.

Species distribution in relation to soil properties

The study of species-environment relationship has always been a critical issue in ecosystem [15]. All species have grown on their particular niche and a tendency to be rich around their favorable environmental condition. The main focus of PCA is to determine the most effective environmental factors in the dispersion of vegetation data and to find the relationships between the existing plants and environmental factors [16].

The results of the PCA ordination are presented Figure 2. The adult trees of 50 species and 5 soil variables (Texture, BD, MC, OM and pH) were used in the analysis. Tabachnick and Fidell recommend an inspection of the correlation matrix for evidence of coefficients greater than 0.3 [17]. McCune and Grace reported that it is pleased to explain more than 50% of the variation with two axes [18]. The first two principal components (PC1 and PC2) resolutely captured more variance than expected by chance, together accounted for 76.047 % of the total variance in data set, contribution being 68.709% and 7.338% variance respectively.

Species distribution according to soil properties by the PCA showed significantly correlation with BD. Axis 1 (explained variance = 68.709%) of species data correlated with BD ($r=0.521$) at $p< 0.05$. The analysis results 8 species in positive correlation, 13 species in

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negative correlation and 29 species in no correlation with the BD. Axis 2 (explained variance = 7.338%) provided little information in the data set. Combretaceae family was dominant among 5 families at the positive correlation with soil compaction. On the other hand, Mimosaceace was dominant at 21 families in no correlation with soil compaction. Understanding the main factors affecting in the distribution of species in the study area is applied in recommendation adaptable species for reclamation of the area.

Each species is identified by a code indicating its taxonomic significance, as follows: *Mu*, *Melanorrhoea usitata; Pp, Premna pyramidata; Tc, Terminalia chebula; So, Shorea obtuse; Aa, Anogeissus acuminate; Tp, Terminalia pyrifolia; Br, Bridelia retusa; Eo, Emblica officinalis;*

Dm, Diospyros montana; Lv, Lagerstroemia villosa; Bm, Bombax malabaricum; Mb, Millettia brandisiana; To, Terminalia oliveri; Mp, Millettia pendula; Sf, Stereospermum fimbriatum; Bv, Boscia variabilis; Ss, Schrebera swietenioides; Zr, Ziziphus rugosa; Mt, Morinda tinctoria; Ha, Holarrhena antidysenterica; Os, Olax scandens; Th, Tectona hamiltoniana; Lc, Lannea coromandelica; Al, Albizzia lebbek; Sv, Sterculia versicolor; Gk, Gentiana kurroo; Rd, Randia dumetorum; Hc, Hesperethusa crenulata; Sol, Schleichera oleosa; Xx, Xylia xylocarpa; Ge, Grewia eriocarpa; Tt, Terminalia tomentosa; Do, Dalbergia oliveri; Ssi, Shorea siamensis; Hb, Hiptage benghalensis, Db, Diospyros burmanica; Sn, Strychnos nux-blanda; Bl, Buchanania Lanzan; Dc, Dalbergia cultrata; Dt, Dipterocarpus tuberculatus; Mv, Miliusa velutina; Ale, Acacia leucophloea; Ai, Azadirachta indica; Co, Corton sp; Oa, Osyris arborea; Ac, Albizzia chinensis; Pm, Pterocarpus macrocarpus;Bra, Bauhinia racemosa; Gs, Gardenia sootepensis;Zj, Ziziphus jujube.

Discussion

Tectona hamiltoniana indicated the highest ecological significant among the species in the study area. It may be its peculiar characters such as strong coppicing power, drought resistant, survival on very poor infertile soils [19]. Based on the result of species composition, there were 44 species and 23 families at the adult tree level in the study area. In the regards of diameter class, dbh size classes of all forests are examined as reversed J shaped. This situation implies that the younger trees can replace into the mature trees by means of sustainability. By dominating *Tectona hamiltoniana* with 43% of total tree density and higher numbers of rare species in the PF, the species richness (H') was lowest and species distribution (E) was uneven in the case of the PF. Based on the PCA, 8 species; *Premna pyramidata, Shorea obtuse* etc., showed positive correlation with BD. These species have high resistance soil compaction and have a tendency to distribute widely in high BD area. The distribution of 13 species such as *Terminalia oliveri* and *Bombax malabaricum* indicated negatively correlation with the BD so that these species decrease with increasing BD.

Conclusion

Tectona hamiltoniana is found to be ecological significant species in the study area. Mimosaceae is observed to be the most dominant family in all stands. The forest will be sustained. In the study area, it is obviously found that soil compaction can dramatically alter species distribution than other soil properties investigated.

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