THE RELATIONSHIPS OF TAXONOMIC AND STRUCTURAL ATTRIBUTES ON ABOVE GROUND CARBON BIOMASS OF TROPICAL DRY FORESTS IN PHOU KHAO KHOUAY NATIONAL PARK, LAOS

Khamphet Phomphoumy[1,2], Cao Thi Thu Hien[1], Nguyen Hong Hai[1*]
[1]*Vietnam National University of Forestry*
[2]*National University of Laos*

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ABSTRACT

Forest ecosystems play an integral role in climate regulation through carbon sequestration and storage. Tropical forests in Laos have undergone major degradation which threatened the standing biomass and carbon sequestration potential of these forests, apart from altering the dynamics of the ecosystem. In this study, species diversity and forest structure were assessed through 32 of 0.25-ha study plots representing 3 major forest types in Phou Khao Khouay Nation Park, Laos. The findings found a total of 5,477 individuals, 188 species belonging to 57 families. *H. pierrei* was the most dominant tree species (IVI =9.29%) among 138 species in DEF; *A. grandis* and *L. fenestratus* were the most co-domimant species (IVI=8.57%) among 126 species of MDF and *P. merkusii* covered the grestest IVI (20.02%) among 54 species in MCF. Individual tree distribution was inversed J-shape in all forest types suggesting good regeneration and recruitment potential. Significant differences of taxonomic and structural between 3 forest types showed through Kruskal-Wallis test with p-value < 0.05. Above ground carbon biomass decreased with decreasing species richness, basal area and volume through forest types, specifically 184.00±66.79 Mg/ha in DEF; 107.57±7.90 Mg/ha in MDF and 110.99±7.69 Mg/ha in MCF. Taxonomic and structural attributes contributed positive effects on above ground carbon biomass. Biodiversity conservation should be a key component of the UN Reducing Emission from Deforestation and Degradation strategy (REDD+).

Keywords: carbon biomass, REDD+, species diversity, tree size structure, tropical dry forest.

1. INTRODUCTION

Tropical forests cover 7% of the earth's land surface and constitute more than haft of the world tree species [1]. Moreover, tropical forests provide many benefits to human including material products (timbers, water, foods, medicines, raw materials, etc.) and protection functioning such as shelter, natural hazards prevention, and ecosystem services such as carbon sequestration and climate regulation [2]. They are often referred as the major carbon sink and have high standing biomass and greater productivities [3], however these forests have been currently disappearing at an alarming rate. Tropical forest degradation in Laos is caused by illegal logging, agricultural extension, forest fires and infrastructure development leading to negative impact on forest ecosystems [4].

Recent studies suggested that forest structure is important for understanding the role of species coexistence and long term ecological processes in uneven aged natural forest ecosystems [5]. Structure and density of major canopy tree species can help to understand status of regeneration of species as well as management history and ecology of the forest [6]. Stand structure and species composition assist to understand forest ecosystems and biodiversity [7]. To characterize complexity of forest structure, the floristic composition, diversity and vegetation structure are key elements [8].

The UN Reducing Emission from Deforestation and Degradation (REDD+) aims to conserve carbon storage of tropical forest while safeguarding biodiversity [9]. Importantly, an higher biodiversity enhances carbon sequestration and storage [10]. Forest

*Corresponding author: hainh@vnuf.edu.vn

functioning may be determined not only by species identity of the vegetation but also by structural attributes and differed among forest types [9]. The roles of biodiversity in ecosystem properties, ecological processes and services have been emphasized in previous studies [9, 11-13]. Specifically, species richness is assumed to enhance productivity via: (i) niche complementary where species have different niches and are able to access more of the available environmental resources or facilitate each other, therefore facilitating overall productivity [12]; (ii) the selection effect, as by chance a very productive species contributing major part of stand bimomass is contained in the community [13]; and (iii) the insurance effect, as one species contributes more to ecosystem productivity in one year and another species in another year [13]. These hypotheses about the relationship between species richness and productivity could also apply to standing carbon biomass, as higher productivity may lead to faster accumulation of carbon biomass [14].

Not only taxonomic attributes but also structural attributes such as stem diameter, tree height, tree density determine biomass, resource capture and productivity. Tree structure contributes directly to stand carbon biomass but variation in structure, for example different forest types, may also enhance light capture and carbon gain [9]. Structural properties may vary more strongly than taxonomic attributes within forest community and between forest communities, therefore they may have a larger direct impact on biomass and ecosystem processes. The question is different taxonomic and structural attributes of forest types may explain for variation in above ground biomass and carbon storage [9].

In this study, we aim to assess the relationships of the taxonomic attributes (such as species richness and diversity, community composition) and structural attributes (such as diameter, height, volume and above ground biomass) of the three major forest types in Phou Khao Khouay National Park of Laos. We address a main question: what are the relationships of taxonomic and structural attributes on above ground carbon biomass in the three major forest types including dry evergreen forest, mixed deciduous forest and mixed coniferous forest in the study area.

2. RESEARCH METHODOLOGY

2.1. Study area

Phou Khao Khouay (PKK) National Park is one of 24 sites in Laos legally established since 1993, with total area of 191,942 ha. PKK national park is located from 18°14’ - 18°32’ N and 102°38’ - 102°59’ E (Figure 1). Forest types in PKK national park are classified to the mixed deciduous forest - MDF, dominated by Meliaceae; dry evergreen forest - DEF, dominated by Lythaceae; evergreen forest -EF, dominated by Dipterocarpaceae and mixed coniferous forest -MCF, mainly Pinaceae [4].

Elevation varies from 100 m to nearly 1,700 m a.s.l [4]. The average annual rainfall in PKK is about 1,769 mm and divided into two seasons. The rainy season lasts from April to October with the highest rainfall usually in August of about 494.2 mm and the average temperature is from 20.6°C - 31.8°C [15]. The dry season lasts from November to March with the lowest rainfall of about 2.5 mm in February and the average temperature is around 16.8°C - 24.6°C. The national park is covered by typical tropical red to brown soils of orthic acrisols and lithosols with textures from sandy to sandy loam and poorly organic matter [4].

2.2. Data collection

In this study, data was collected from 32 permanent plots, these plots were established by the Institude Recherche pour le Development (IRD) France and Faculty of Forestry Science (FFS), National University of Laos (NUoL) in 2009 [4, 16]. The plots vary in different elevations from 390 m to 816 m and cover all three main forest types (Figure 1). Each plot of

0.25 ha (50 x 50 m) was divided into 25 subplots of 10 by 10 m. In 2022, all tree individuals with diameter at breast height - dbh at 1.3 m ≥ 5 cm were identified and recorded. Dbh of tree species were measured by using diameter tape tree height by Blume-leiss Hypsometer; relative coordinates of trees were determined by the Laser distance measurer Leica Disto D2 and compass. Tree specimens were collected to confirm identification at herbarium of Faculty of Forestry Science, National University of Laos.

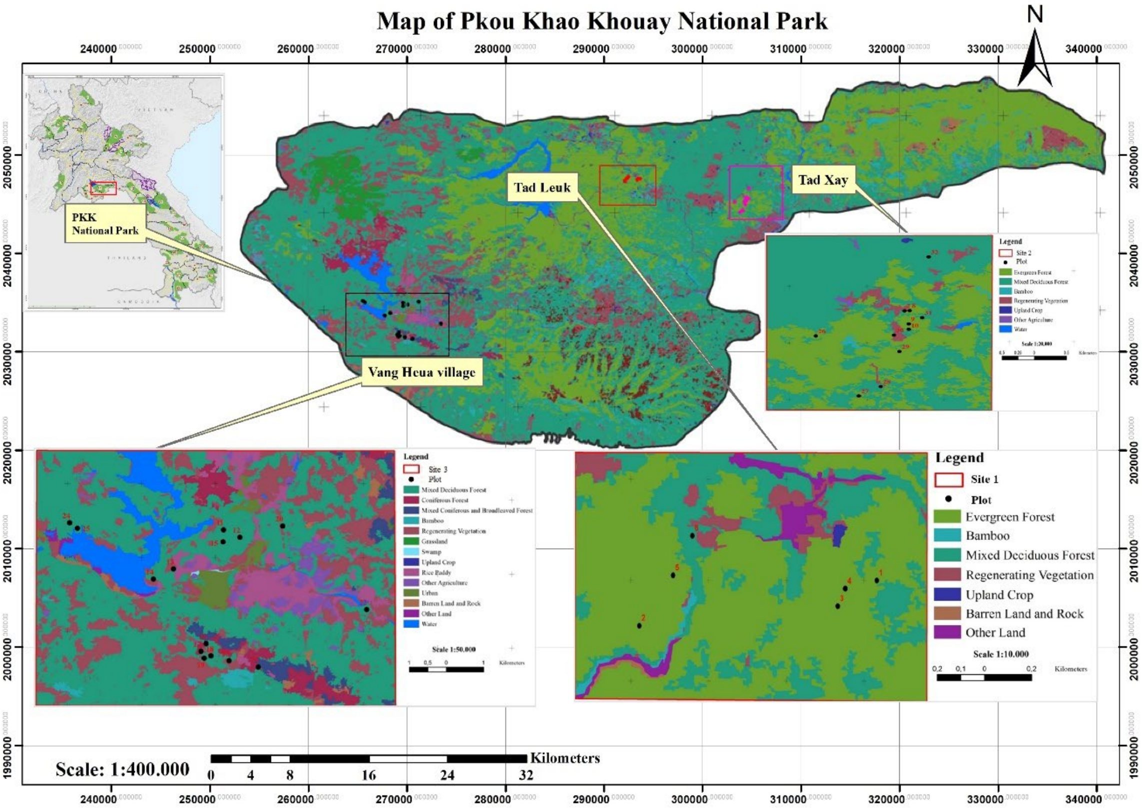

Figure 1. Maps of PKK national park and the location of sample plots

2.3. Data analysis

Tree basal area (BA, m^2): was calculated by:

$$BA = \frac{\pi dbh^2}{4}$$

where, dbh is Diameter at breast height (cm).

Tree volume (m^3): was estimated by 0.45 x H x BA [17], where, H is total tree height (m).

Species composition: was explained by Important Value Index (IVI) calculated by relative density (RD), relative dominance (RDo) and relative frequency (RF) for each species as follows [18]:

$$IVI = \frac{RD + RDo + RF}{3}$$

Relative Density was calculated as follows: $RD = \left[\frac{n_i}{N}\right] \times 100\%$

where,

n_i = number of individuals of species i;

N = total number of individuals in the entire sampled population.

Relative Dominance was calculated as follows: $RDo = \left[\frac{BA_i}{\sum BA_n}\right] \times 100\%$

where,

BA_i = Basal area of all species individuals i;

BA_n = Stand basal area.

Relative Frequency was calculated as follows: $RF = \left[\frac{F_i}{F_n}\right] \times 100\%$

where,

F_i = Frequency of species i encountered;

F_n = Total frequency of all species.

Species diversity: was described by diversity indices as follows:

Shannon's index (*H'*) refers to species diversity and is calculated as follows [18]:

$$H' = -\sum pi \times lnpi$$

where, p_i = the proportion of abundance (individuals) of the i^{th} species.

Simpson's index (*D*) refers to species dominance calculated by equation as follows [18]:

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

where,

n = abundance contributed by by species;

N = total species abundance.

Pielou's evenness index (*J*) refers to the degree of relative dominance of each species calculated by equation as follows [19]:

$$J = \frac{H'}{\ln(S)}$$

where,

H' = Shannon-Wiener index;

S = species richness.

Species richness; $S = a \times \left(1 + \frac{n}{a}\right)$

Bray-Curtis index (C_N) (Bray and Curtis, 1947), a similarity coefficient, is used to measure similarity between forest types.

$$C_N = \frac{2jN}{aN + bN}$$

where,

C_N = the Bray-Curtis index;

aN=individual numbers of forest type A;

bN=individual numbers of forest type B;

jN= the sum of less individual numbers of each species common in forest types A and B.

Relationship between height and diameter: We used eleven theoretical models embedded in IBM SPSS version 20 software, including:

(1) Linear: $y = b_0 + b_1*x$;

(2) Logarithmic: $y = b_0 + b_1*\ln(x)$;

(3) Inverse: $y = b_0 + b_1/x$;

(4) Quadratic: $y = b_0 + b_1*x + b_2*x^2$;

(5) Cubic: $y = b_0 + b_1*x + b_2*x^2 + b_3*x^3$;

(6) Power: $y = b_0*x^{b1}$ or $\ln(y) = \ln(b_0) + b_1*\ln(x)$; (7) Compound: $y = b_0*b_1^x$ or $\ln(y) = \ln(b_0) + [\ln(b_1)]*x$;

(8) S: $y = \exp(b_0 + b_1/x)$ or $\ln(y) = b_0 + b_1/x$;

(9) Logistic: $y = 1/[(1/u) + (b_0*b_1^x)]$ or $\ln[(1/y) + (1/u)] = \ln(b_0 + [\ln(b_1)]*X$;

(10) Growth: $y = \exp(b_0 + b_1*x)$ or $\ln(y) = b_0 + b_1*X$;

(11) Exponential: $y = b_0*\exp(b_1*X)$ or $\ln(y) = \ln(b_0) + b_1*X$;

The Akaike Information Criteria (AIC) may aid in the selection of model. Lower values for AIC imply a better fit, adjusted for number of parameters. All diversity indices and diameter-height relationships were analyzed by using PAST 4 (Paleontological Statistics) software (https://www.nhm.uio.no/english/research/resources/past/).

Above Ground Biomass (AGB) of three forest types was estimated using allometric model for pan-tropical forests [20], as follows:

$$AGB_{est} = 0.0673 \times (\rho D^2 H)^{0.976}$$

where, *D* is dbh (cm), *H* is height (m) and *p* is wood density in (g cm^3). Wood density (WD) data were compiled from published sources [21]. Subsequently, AGB was converted to above ground carbon biomass -AGCB (Mg/ha) by multiplying AGB with a conversion factor of 0.47 assuming that 47% of the total tree biomass is C biomass [22].

The feature differences among three forest types for each variable such as density; basal area; diameter class and aboveground biomass were evaluated by using a nonparametric test (Kruskal-Wallis test) after verification for the assumptions of normality and equal variances. Mann-Whitney test was performed for comparison of differences between the two forest types. The statistical analyses were performed by using IBM SPSS version 20 software.

3. RESULTS

3.1. Taxonomic attributes

A total of 5,477 individuals with stem diameter at breast height (dbh) of ≥ 5 cm representing 188 different species and 57 families were recorded in 32 permanent plots of the 3 forest types (Table 1) including dry evergreen forest (DEF), mixed deciduous forest (MDF), and mixed coniferous forest (MCF).

Table 1. Main characteristics of three forest types (mean±standard deviation)

Variables	Forest types		
	DEF	MDF	MCF
Number of plots	18	8	6
Number of species	138	126	54
Number of families	52	51	36
Density (trees/ha)	705±9.14	754±7.18	530±16.7
Shannon-Wiener (H')	4.95±0.27	5.08±0.25	4.66±0.27
Simpson (D)	0.99±0.003	0.99±0.002	0.99±0.003
Evenness (J)	0.83±0.07	0.87±0.05	0.83±0.03
DBH (cm)	19.07±14.33	17.86±11.31	20.34±14.20
Height (m)	13.71±7.75	11.95±5.48	12.80±6.98
Basal area (m^2/ha)	31.50±5.71	26.47±1.19	25.61±0.46
Volume (m^3/ha)	358.81±111.54	236.85±15.20	253.39±20.73
AGB (Mg/ha)	368.01±133.59	215.14±15.81	221.99±15.39
AGCB (Mg/ha)	184.00±66.79	107.57±7.90	110.99±7.69

In 18 plots of DEF, a total of 3,173 individuals was counted with 176 ± 42 trees/plot belonging to 138 species (28 ± 7) and 52 families (19 ± 4) (table 2). The most dominant tree species in the DEF were *H. pierrei* with IVI value of 9.29%, *H. ilicifolia* (4.60%), *G. nervosa* (4.30%), *S. wallichii* (4.12%), *A. gaudichaudiana* (3.86%), and *C. formosum* (3.25%) and 132 other species belonged to 46 different families (table 2).

A total of 1,509 individuals (188 ± 35), 126 species (33 ± 10) and 51 families (22 ± 6) in eight plots MDF (Table 2). Dominant tree species were *A. grandis* (4.85%), *L. fenestratus* (3.72%), *L. calyculata* (2.72%), *S. syzygioides* (2.62%), *S. cinereum* (2.51%) and *A. gaudichaudiana* (2.36%) and 120 other species belonging to 46 different families (table 2).

There were 795 individuals (132 ± 35), 54 species (16 ± 4) and 36 families (13 ± 4) in six plots MCF (table 2). The dominant species were *P. merkusii* (20.02%), *S. wallichii* (8.28%), *D. elatum* (7.80%), *D. obtusifolius* (7.75%), *S. cinereum* (5.41%) and *S. norounhae* (4.41%) and 48 other species belonging to 31 different families (Table 2).

Table 2. The species composition of three forest types

Forest type	Dominant species	Family	RD (%)	RDo (%)	RF (%)	IVI (%)
Dry evergreen forest	*Hopea pierrei*	Dipterocarpaceae	8.76	17.76	1.36	9.29
	Hydnocarpus ilicifolia	Flacourtiaceae	5.89	5.00	2.92	4.60
	Gironniera nervosa	Cannabaceae	3.81	7.34	1.75	4.30
	Schima wallichii	Theaceae	5.36	4.27	2.72	4.12
	Alphonsea gaudichaudiana	Annonaceae	5.61	3.82	2.14	3.86
	Cratoxylum formosum	Hypericaceae	4.79	3.02	1.95	3.25
	Syzygium syzygioides	Myrtaceae	2.55	3.80	2.53	2.96
	Syzygium cinereum	Myrtaceae	2.93	2.27	2.72	2.64
	Vatica harmandiana	Dipterocarpaceae	2.33	2.29	2.92	2.51
	Nephelium hypoleucum	Sapindaceae	2.84	1.97	2.33	2.38
	128 other species	44 other families	55.12	48.48	76.55	60.08

Forest type	Dominant species	Family	RD (%)	RDo (%)	RF (%)	IVI (%)
Mixed deciduous forest	*Aglaia grandis*	Meliaceae	4.04	8.09	2.41	4.85
	Lithocarpus fenestratus	Fagaceae	5.37	3.72	2.07	3.72
	Lagerstroemia calyculata	Lythraceae	4.37	2.74	1.03	2.72
	Syzygium syzygioides	Myrtaceae	2.52	3.27	2.07	2.62
	Syzygium cinereum	Myrtaceae	2.58	2.86	2.07	2.51
	Alphonsea gaudichaudiana	Annonaceae	3.11	2.25	1.72	2.36
	Alstonia scholaris	Apocynaceae	1.52	3.72	1.72	2.32
	Aralia chinensis	Araliaceae	1.59	3.26	2.07	2.31
	Hydnocarpus ilicifolia	Flacourtiaceae	2.45	2.21	2.07	2.25
	Cratoxylum formosum	Hypericaceae	2.32	2.91	3.18	2.20
	116 other species	42 other families	70.11	64.97	81.38	72.15
Mixed coniferous forest	*Pinus merkusii*	Pinaceae	15.47	38.47	6.12	20.02
	Schima wallichii	Theaceae	9.69	9.02	6.12	8.28
	Dacrydium elatum	Podocarpaceae	12.08	9.30	2.04	7.80
	Dipterocarpus obtusifolius	Dipterocarpaceae	9.43	9.72	4.08	7.75
	Syzygium cinereum	Myrtaceae	6.92	3.18	6.12	5.41
	Schima noronhae	Theaceae	6.54	2.62	4.08	4.41
	Lithocarpus fenestratus	Fagaceae	3.02	2.18	4.08	3.09
	Garcinia multiflora	Clusiaceae	2.26	3.06	1.02	2.11
	Parinari anamensis	Chrysobalanaceae	2.01	1.19	3.06	2.09
	Syzygium lineatum	Myrtaceae	1.38	0.91	3.06	1.78
	44 other species	28 other families	31.19	20.36	60.20	37.25

In terms of the Bray-Curtis index (Figure 2), the most similar was found in the DEF with 82.10% indicating that this forest type was the major forest type in the study area. MDF covered 72.30% and MCF was 55.57% similarity of species richness, respectively. These results showed a significant difference in species composition of the forest types in the PPK national park.

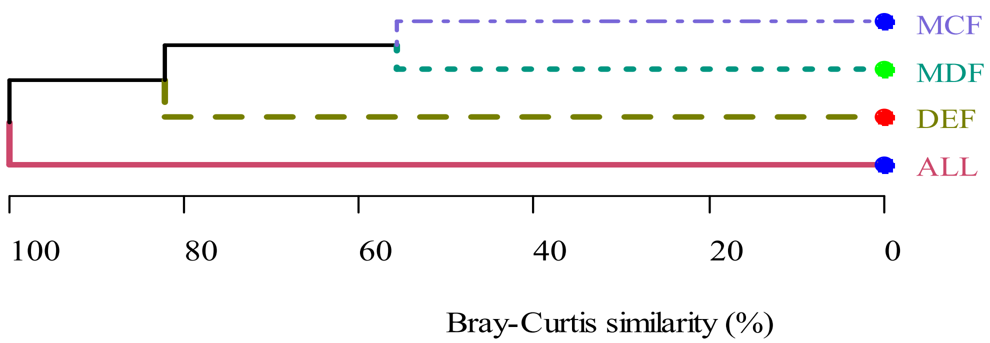

Figure 2. Species similarity of three forest types

The Kruskal-Wallis tests showed that species composition and diversity were significantly different among 3 forest types, except species evenness (Table 3), specifically containing the mean density (Chi-Square = 7.124, Sig. = 0.028 < 0.05), number of species (Chi-Square =11.088, Sig. = 0.004 < 0.05), number of family (Chi-Square = 9.435, Sig. = 0.009 < 0.05), Shannon-Wiener index (Chi-Square = 8.101, Sig. = 0.017 < 0.05) and Simpson index (Chi-Square = 6.434, Sig. = 0.040< 0.05).

Table 3. Results of Kruskal-Wallis test among three forest types

Properties	Chi-Square	Asymp. Sig	p-value
Density (trees/plot)	7.124	0.028*	0.05
Number of species	11.088	0.004*	0.05
Number of family	9.345	0.009*	0.05
Shannon-Wiener (H’)	8.101	0.017*	0.05
Simpson (D)	6.434	0.040*	0.05
Evenness (J)	2.918	0.232	0.05
DBH (cm)	2.297	0.317	0.05
Height (m)	6.893	0.032*	0.05
Basal area (m^2/ha)	14.289	0.001*	0.05
Volume (m^3/ha)	5.372	0.068	0.05
AGB (Mg/ha)	3.372	0.185	0.05
AGCB (Mg/ha)	2.427	0.297	0.05

3.2. Structural attributes

The structural properties of three forest types were shown in Table 1. Tree size attributes generally decreased from DEF to MDF and MCF, respectively. Tree diameter (DBH) slightly differed among forest types, it was 19.07±14.33 cm in DEF, 17.86±11.31 cm in MDF, and 20.34±14.20 cm in MCF, respectively. Total tree height (H) also slightly differed among forest types, it was 13.71±7.75 m in DEF, 11.95±5.48 m in MDF, and 12.80±6.89 m in MCF. Total basal area (BA) was highest in DEF with 31.50±5.71 m^2/ha, and it was similar in the two other types with 26.47±1.19 m^2/ha in MDF and 25.61±0.46 m^2/ha in MCF. The total volume varied widely among forest types. It was 358.81±111.54 m^3/ha in DEF, 236.85±15.20 m^3/ha in MDF, and 253.39±20.73 m^3/ha in MCF, respectively. The AGB estimation was differently among forest types as well. It was 368.01±133.59 Mg/ha in DEF, 215.14±15.81 Mg/ha in MDF, and 221.99±15.39 Mg/ha in MCF, respectively. Above ground carbon biomass decreased from 184.00±66.79 Mg/ha in DEF to 107.57±7.90 Mg/ha in MDF and 110.99±7.69 Mg/ha in MCF.

Structural properties among three forest types were also significant different via Kruskal-Wallis tests including tree height (Chi-Square = 6.893, Sig. = 0.032< 0.05), basal area (Chi-Square = 14.289, Sig. = 0.001< 0.05), except DBH, Volume and above ground carbon biomass-AGCB (Table 3).

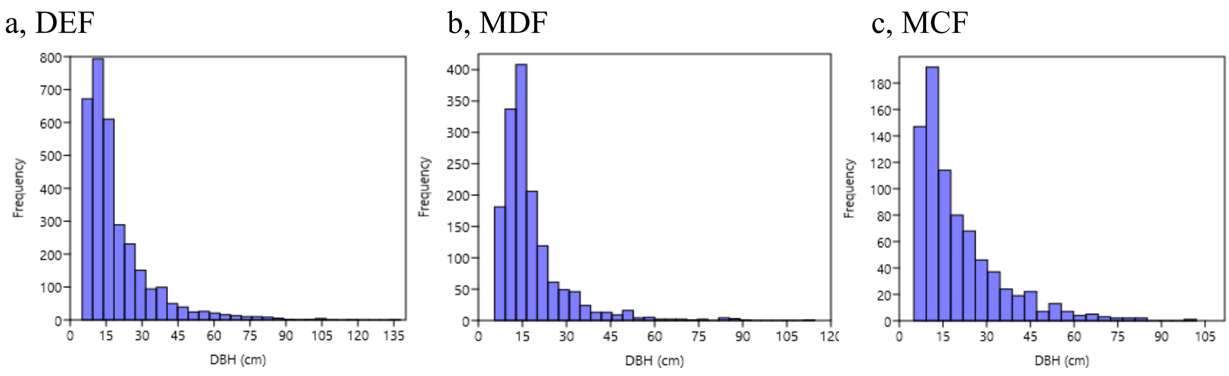

Figure 3. Tree diameter distribution of three forest types

All three forest types, DBH distributions formed reverse J-shape patterns (Figure 3). In DEF, tree DBH ranged from 5 – 137.7 cm with mean DBH = 19.07 ± 14.32 cm and skewness of 2.49. Similarly, tree DBH of MDF ranged from 5.5 – 114.5 cm with mean DBH = 17.85 ± 11.31 cm and skewness = 2.93. Also, in MCF, tree DBH ranged from 5 – 102 cm with mean DBH = 20.34 ± 14.19 cm and skewness of 1.78. These results indicated that number of trees decreased with increasing DBH classes, therefore it allows to replace removed trees by smaller size trees through forest succession process.

The Quadratic model was the best fit model for diameter-height relationship of all forest types including DEF, MDF and MCF, respectively (Table 4). The best fit models were selected based on the lowest Akaike information criterion (AIC) values. The strong relationships between diameter and height of all forest types were shown by high coefficients R^2>0.8. The diameter-height relationships of three forest types were presented in Figure 4.

Table 4. The relationships between diameter-height relationship of the three forest types

Forests Type	Models	Parameter estimates			AIC	R^2
		a	b	c		
DEF	Quadratic	-0.003312	0.71969	1.8729	37304	0.804
MDF	Quadratic	-0.0024936	0.60209	2.3089	8617	0.810
MCF	Quadratic	-0.0024523	0.60746	1.9473	6343.1	0.836

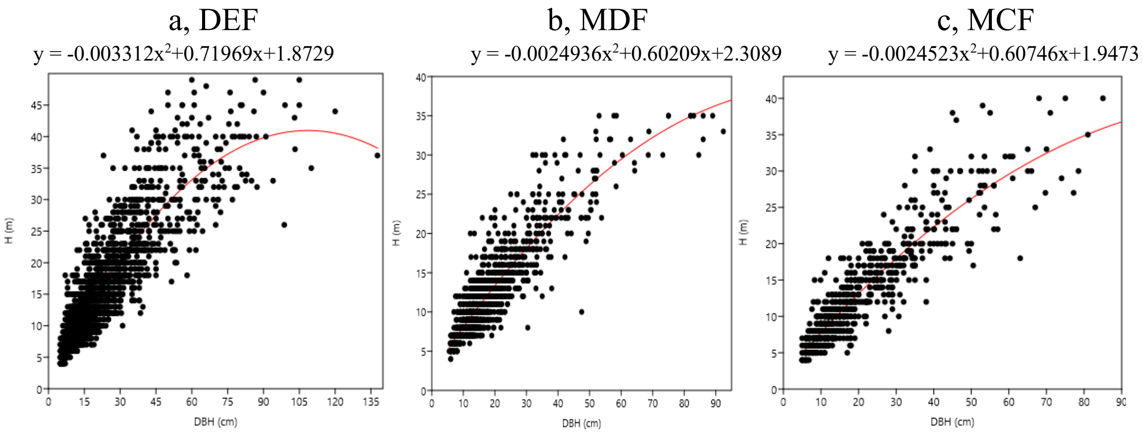

Figure 5. Tree diameter-height relationship of the three forest types

4. DISCUSSION

Taxonomic attributes

In total, 5,477 individuals with dbh≥ 5 cm belonging to 188 species and 57 families were recorded in this study. The important value index (IVI) showed that *H. pierrei* (Dipterocarpaceae) was the dominant species in DEF , *A. grandis* (Meliaceae) and *L. fenestratus* (Fagaceae) were the dominant species in MDF, and *P. merkusii* was the dominant species in MCF. These results are along with findings of previous studies in where? [23].

The individual density, species richness and species diversity decreased from DEF (705 individuals/ha, 138 species and 52 families), to MDF (754 individuals/ha, 126 species and 51 families) and MCF (530 individuals/ha, 54 species and 36 families), respectively. These numbers were greater than reported findings of previous studies carried out in this area [4, 16, 23]. Previous studies in the study area, Satdichanh, Millet [16], Soukhavong, Yong [23], Chanthalaphone [24] found in total of 145; 123; 76 species, respectively. The stand densities of three forest types ranging from 530 trees/ha to 754 trees/ha, are greater than those reported in this area is 467; 744 trees/ha [4, 24]. The overall stand densities of the three forest types exhibited the reverse J-shaped diameter class distribution, suggesting a stable population structure. This is similar to those reported in this area [23], in Vietnam [25], Malaysia [26]. Moreover, in our study, the species diversity indices, such as Shannon-Wiener index (*H'*) ranging from 4.66 to 5.08, Simpson's index ranging from 0.99 to 0.99, Pielou's evenness index (*E*) ranging from 0.83 to 0.87, are also greater than those reported by Lucas et al., 2013, Chanthalaphone 2020 in the same study area. That may be caused by our threshold of measured dbh which was greater than 5 cm comparing to threshold of greater than 10 cm from their studies.

Structural attributes

In the present study, the mean basal area (BA) of tree species varying from 25.61 to 31.50 m^2/ha in 3 forest types, was lower than other findings in Laos of 35; 38.9 m^2/ha [4, 27]. The estimation of mean above ground Carbon biomass varied widely among forest types from 107.57 Mg/ha (in MDF) to 184.00 Mg/ha (in DEF). This may be caused by illegal logging of local people reported by forest rangers and missing trees found in our study plots.

The allometry of tree diameters and heights has been receiving a great deal of attention for long time because inaccurate estimates of tree heights can seriously affect the estimation of carbon stock in a forest [28]. Therefore, an accurate diameter-height model is essential of tree volume and biomass estimation and hence stand level carbon stocks of forests. Developing a diameter-height model presented for each forest type is proved to be a suitable approach to avoid the bias [29]. In our study, three diameter-height models which are ….derived from ten theoretical models and practical data based on a lowest AIC value were proposed for three forest types.

Carbon storage and biomass are essential analytical aspects of forest ecosystems. Assessment of biomass demonstrates the extent of carbon that a forest can hold and is an essential element for national development planning of carbon budget [30]. Our findings indicated a relative high C storage in PKK forests ranging from 107.57±7.90 Mg/ha (in MDF) to 184.00±66.79 Mg/ha (in DEF). There were no large differences in aboveground C biomass of PKK forests and other regions, for example in Asian sites with 141.8 ± 15.2 Mg/ha, Neotropical regions with 193.8 ± 12.3 Mg/ha, and African sites with 170.1 ± 14.5 Mg/ha [31]. DEF dominated by Dipterocarpaceae and was the richest species forest type stores highest C biomass due to productive species facilitate light capture and light use efficiencies in association with complex tree size structures [9]. In contrary, MDF had lower species diversity and no dominant productive species leading to lower C biomass achievement. Our fundings support for the hypotheses of niche complementary and the selection effects related to the role of biodiversity in ecosystem properties [9].

5. CONCLUSION

The research on species diversity, stand structure and community composition of tropical forests was conducted in Phou Khao Khouay Nation Park, Laos. We collected data in total of 8 ha from 32 plots 50 x 50 m (0.25 ha) with all stems dbh ≥ 5 cm. The results showed that a total of 5,477 individuals representing 188 different species and 57 families in 3 forest types. Species diversity indices and quantities of tree size structure decrease from DEF to MDF and MCF, respectively. The majority of forests in PKK are natural and are maintained according to competent management plans, which satisfy the criteria of SFM of REDD+. We suggest that as REDD+ idea of "Conservation of forest carbon stocks", forest conservation is needed to encourage biodiversity conservation in the study area. Moreover, the third REDD+ option, sustainable forest management (SFM), may help to build forest carbon reserves and assure the ongoing flow of other ecosystem services in the PKK national park as well.

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QUAN HỆ GIỮA CÁC ĐẶC TRƯNG ĐA DẠNG LOÀI VÀ CẤU TRÚC VỚI SINH KHỐI CÁC BON TRÊN MẶT ĐẤT CỦA RỪNG NHIỆT ĐỚI KHÔ Ở VƯỜN QUỐC GIA PHOU KHAO KHOUAY, LÀO

Khamphet Phomphoumy[1,2], Cao Thị Thu Hiền[1], Nguyễn Hồng Hải[1*]

[1]Trường Đại học Lâm nghiệp

[2]Trường Đại học Quốc gia Lào

TÓM TẮT

Các hệ sinh thái rừng có một vài trò thiết yếu trong điều tiết khí hậu thông qua quá trình tích trữ các bon. Rừng nhiệt đới ở Lào đang bị suy thoái đe dọa đến sinh khối cây đứng và khả năng tích trữ các bon của rừng, như là một phần của sự biến động các hệ sinh thái rừng. Trong nghiên cứu này, đa dạng loài cây và cấu trúc quần xã rừng được đánh giá thông qua 32 ô tiêu chuẩn 0.25-ha đại diện cho ba trạng thái rừng chủ yếu ở vườn quốc gia Phou Khao Khouay Nation Park, Lào. Kết quả cho thấy, tổng cộng 5.477 cây thuộc 188 loài và 57 họ được ghi nhận. *H. pierrei* là loài ưu thế nhất (IVI =9,29%) trong số 138 loài của rừng thường xanh khô (DEF); *A. grandis* và *L. fenestratus* là đồng ưu thế nhất (IVI=8,57%) trong số 126 loài của rừng hỗn giao cây họ Dầu (MDF) và *P. merkusii* chiếm ưu thế lớn nhất với IVI =20,02% trong số 54 loài của rừng hỗn giao cây lá kim (MCF). Phân bố số cây theo đường kính có dạng chữ J ngược ở cả ba trạng thái rừng cho thấy tiềm năng tốt trong quá trình tái sinh và bổ sung của diễn thế rừng. Sự khác biệt có ý nghĩa của đặc trưng đa dạng loài và cấu trúc của ba trạng thái rừng được thể hiện qua phép kiểm tra Kruskal-Wallis với p-value < 0,05. Sinh khối các bon trên mặt đất giảm cùng với sự suy giảm của độ nhiều loài, tiết diện ngang và trữ lượng gỗ, với 184,00±66,79 Mg/ha ở DEF; 107,57±7,90 Mg/ha ở MDF và 110,99±7,69 Mg/ha ở MCF. Các đặc trưng đa dạng loài và cấu trúc có ảnh hưởng theo chiều thuận với sinh khối các bon trên mặt đất ở khu vực nghiên cứu. Bảo tồn đa dạng sinh học được coi là vấn đề then chốt của chiến lược giảm phát thải từ phá rừng và suy thoái rừng (REDD+) của liên hợp quốc.

Từ khóa: cấu trúc kích thước, đa dạng loài, REDD+, rừng nhiệt đới khô, sinh khối các bon.

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