STRUCTURAL AND BIODIVERSITY CHARACTERISTICS OF NATURAL FORESTS IN MUONG PHANG HISTORICAL MONUMENT, DIEN BIEN PROVINCE

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SUMMARY

Forest ecosystem of the Historical and Environmental Landscape Muong Phang is located in Muong Phang Commune and Pa Khoang Commune, Dien Bien district, Dien Bien province which is a tropical moist broadleaf forest. The studied results on 9 plots with the area of 2,500m^2 in IIA, IIB and IIIA$_2$ showed that the composition of canopy layers is diversified, in which state IIA consists of 10 species with average density 291 trees/ha, state IIB has an average density of 303 trees/ha including 13 species; state IIIA2 encompasses 18 species with density of 209 trees/ha. State IIB and IIIA$_2$ have three main canopy layers A$_1$, A$_2$ and A$_3$ with crown cover of 0.52 and 0.61, respectively, while state IIA has two main storeys A$_2$, A$_3$ with crown cover of 0.45. In particular, the highest species diversity belongs to state IIIA$_2$. Diameter and height of canopy layers are significantly different between three forest states expressed in Sig. value < 0.05. Regeneration density ranges from 828 trees/ha in state IIA to 995 trees/ha in state IIIA$_2$. Species diversity of regeneration layers under state IIIA2 is the highest in three states.

Keywords: Ecosystem forest, forest state, regeneration, species biodiversity, species composition.

1. INTRODUCTION

Natural forests not only provide habitation and livelihood to human but also supply us diversified resources for food, medicine, and fuel materials. In particular, natural forest with diverse species composition is an important reservoir for reducing greenhouse gas emissions and maintaining biodiversity (Hans Lamprecht, 1989).

Dien Bien is a mountainous province in the North of Vietnam with a total natural land area of 956,290 ha including mainly mountainous terrain with complicated terrain. Therefore, natural forests play an important role for local people (Doan Thi Hoa, 2015). At present, about 5,238.6 ha of Muong Phang Historical Monument (MPHM) in Muong Phang Commune and Pa Khoang Commune, Dien Bien District, Dien Bien Province are being protected, preserved and developed by the Forest Management Board. There are only a few types of forest ecosystems named a tropical moist evergreen broadleaf forest with mainly secondary forests including state IA, IB, IC, IIA, IIB, IIIA$_2$.

Currently, because of the unregulated exploitation of timber and non-timber forest products, the forests have reduced their reserves, area and quality. On the other hand, slash-and-burn practices and conversion of agricultural land-use purposes to residential land intensify deforestation strongly. Moreover, the forest in the study area is in the process of aging, so biodiversity as well as landscape and environmental values are drastically reduced (Doan Thi Hoa, 2015).

However, there is limited research to find out the forest ecosystem in studied area. Full research on the silvicultural characteristics of the natural forest ecosystem in this studied area is an important basis for proposing technical solutions for the sustainable recovery and development of forest resources. The paper will focus on: (i) analysis of species composition and structure of canopy layers; (ii) analysis of the composition and quality of regeneration layers; (iii) analysis the level of species diversity of both canopy and regenerated species in three states.

2. RESEARCH METHODOLOGY

2.1. Document inherent

This study inherited of documents on forest resources, management as well as protection from Forest Management Board in MPHM, Dien Bien province.

2.2. Data collection in the field

All data were collected in 03 forest states: State IIA, State IIB, and State $IIIA_2$. 03 plots were established randomly in each forest state with an area of 2,500 m^2 (50 m x 50 m) because tratified ramdon sampling methoed was applied (Barry D. Shiver and Bruce E. Borders, 1996). Data were collected on plots of states IIA, IIB and $IIIA_2$ about: species name, growth parameters including diameter at breast height, tree height, canopy diameter and crown cover following by forest survey and silvicutural processes to ensure the reliability of the data set.

Investigation of regeneration layers with $D_{1.3}$ < 6 cm: In each plot, five sub-plots were arranged in four corners and centre (Vu Tien Hinh and Pham Ngoc Giao, 1996). Each plot has an area of 25 m^2 (5 m x 5 m). Some parameters were collected in each sub-plot including: species name, tree height, regeneration quality in three levels: good, medium, bad.

Shrubs were investigated on: species composition, average height, growth and cover.

2.3. Data analysis

2.3.1. Composition formula

Composition formula was calculated using following methodology (Vu Dinh Hue, 1969; Dao Cong Khanh, 1996; Edward K. Mengich et al., 2013):

$$IV\% = \frac{N\% + G\%}{2}$$

Where: IV%: the composition ratio (important index) of i^{th} species;

N%: % according to the number of the i^{th} species in the stand;

G%: % according to the total basal area of i^{th} species in the stand.

2.3.2. Layer structure

The profile method was applied to draw layer structure chart for three forest states (Hans Lamprecht, 1989; P. W. Richards, 1996). The layer structure chart is defined on a typical plot for each state with an area of 500 m^2 (10 m x 50 m) and ratio 1/200.

2.3.3. Diameter and height growth of canopy layers in forest states

+ Differences in diameter and height between three forest states

Analyzing mixed model to define the differences in diameter and height between three forest states the by using the following syntax in SPSS version 20 (Robert Ho, 2013):

```
MIXED D1.3 (Height) BY Forest_type
  /CRITERIA=CIN(95)  MXITER(100)  MXSTEP(10)  SCORING(1)  SINGULAR(0.000000000001)
HCONVERGE(0, ABSOLUTE) LCONVERGE(0, ABSOLUTE) PCONVERGE(0.000001, ABSOLUTE)
  /FIXED= Forest_type | SSTYPE(3)
  /METHOD=REML
  /PRINT=SOLUTION
  /RANDOM= Forest_type | COVTYPE(VC).
```

+ Frequency distribution by diameter and height:

```
GGRAPH
  /GRAPHDATASET NAME="graphdataset"
    VARIABLES=Diameter[LEVEL=ratio] Height[LEVEL=ratio]
    MISSING=LISTWISE REPORTMISSING=NO
  /GRAPHSPEC SOURCE=VIZTEMPLATE(NAME="3-D Density"[LOCATION=LOCAL]
    MAPPING( "x"="Diameter"[DATASET="graphdataset"]
"z"="Height"[DATASET="graphdataset"]))
    VIZSTYLESHEET="Traditional"[LOCATION=LOCAL]
    LABEL='3-D DENSITY: Height-Diameter'
    DEFAULTTEMPLATE=NO.
```

2.3.4. Biological diversity of plant communities in forest states

The species diversity of canopy and regeneration layer was assessed through four indices: Margalef (d), Pielou (J '), Simpson (D) and Shannon – Weiner (H’) (Roeland Kindt and Richard Coe, 2005; Thomas A. Spies and Jerry F. Franklin, 1996).

+ *Biodiversity index of Margalef (d):*

$$d = S - 1/\log N$$

Where: S: number of tree species encountered;

N: total individuals of tree species.

+ *Biodiversity index of Pielou:*

$$J' = H'/\log_2 S$$

Where: S: number of tree species encountered;

H': Shannon – Weiner index.

+ *Biodiversity index of Simpson (D), 1949:*

$$D = 1 - \sum_{i=1}^{S} P_i^2 = 1 - \sum_{i=1}^{S} \left(\frac{n_i}{N}\right)^2$$

Where: S: number of tree species encountered;

N: total individuals of tree species;

P_i: the relative abundance of the i^{th} species;

n_i: the individuals of i^{th} ($i = 1 \div S$).

+ *Biodiversity index of Shannon – Weiner, 1963:*

$$H' = \sum_{i=1}^{S} \left(\frac{n_i}{N} \times \log \frac{n_i}{N}\right)$$

Where: N: total trees in plot;

n_i: the individuals of i^{th}.

2.3.5. Analysis methodology for regeneration layer

+ *Composition formula:* $K_i = \frac{n_i}{m} \times 10$

Where:

K_i: coefficient composition of i^{th} species

n_i: the individuals of i^{th};

m: total number of individuals investigated

+ *Regeneration quality:* $N\% = \frac{n}{N} \times 100$

Where:

N%: percentage of good, medium and bad trees;

n: total number of good, medium and bad trees;

N: total number of regenerated trees.

3. RESULTS AND DISCUSSIONS

3.1. Species composition and structure of canopy layers

3.1.1. Species composition and species importance in canopy layers

Forest state $IIIA_2$ has an average density of 209 trees/ha. This density is lower than forest states IIA and IIB with an average density of 291 and 303 trees/ha, respectively (see Table 1).

Table 1. Species composition and tree density of canopy layers

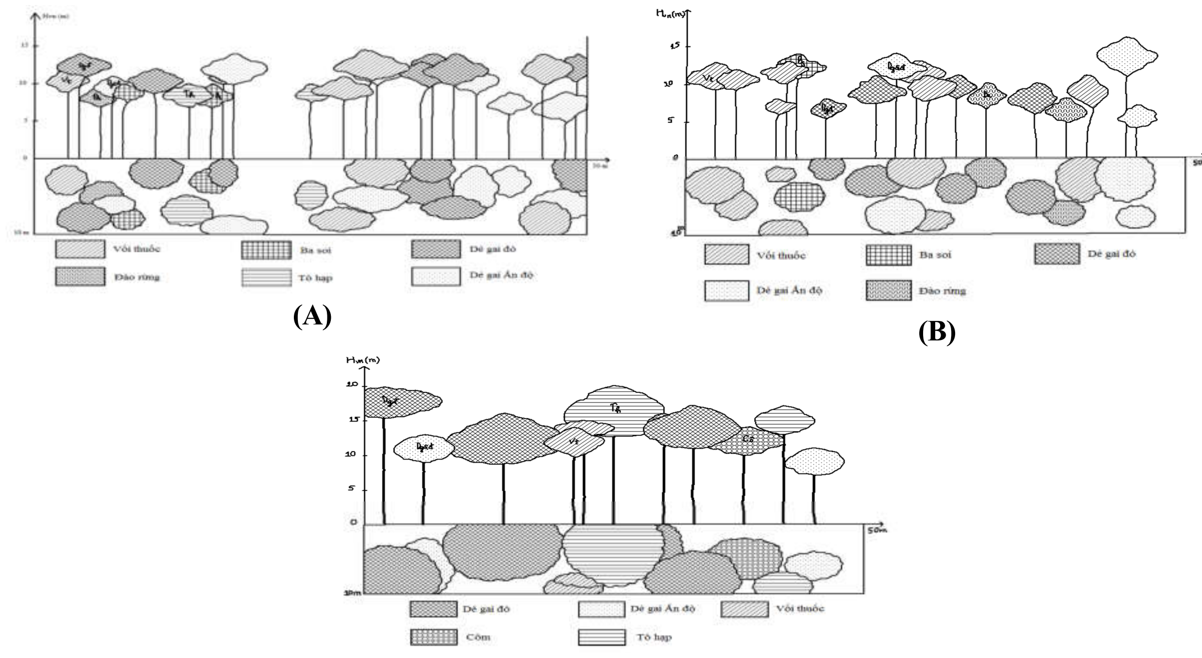
No.	State IIA			State IIB			State $IIIA_2$		
	Species	Density (tree/ha)	IV%	Species	Density (tree/ha)	IV%	Species	Density (tree/ha)	IV%
1	*Schima wallichii*	93	32.96	*Schima wallichii*	107	35.58	*Castanopsis hystrix*	65	37.98
2	*Mallotus cochinchinensis*	57	18.36	*Castanopsis hystrix*	84	32.96	*Altingia siamensis*	33	18.29
3	*Castanopsis hystrix*	57	21.62	*Castanopsis indica*	36	10.19	*Castanopsis indica*	25	9.63
4	*Castanopsis indica*	32	10.33	*Mallotus cochinchinensis*	25	7.19	*Schima wallichii*	23	8.77
5	*Altingia siamensis*	31	10.45				*Gironniera subequalis*	13	6.04
	Total	**291**	**100**	**Total**	**303**	**100**	**Total**	**209**	**100**

However, species composition in forest state $IIIA_2$ includes 18 species. It is higher than states IIA and IIB (10 species and 13 species respectively). In addition, the species number involved in the species composition is 5 species including *Castanopsis hystrix, Altingia siamensis, Castanopsis indica, Schima wallichii* and *Gironniera subequalis* in state $IIIA_2$. They are higher than the others with 4 species. On the other hand, the dominant species of state $IIIA_2$ are different from other states (see Table 1). It is explained that *Schima wallichii* and *Castanopsis hystrix* are two dominant species in states IIA and IIB. Meanwhile, state $IIIA_2$ has two mainly different species including *Castanopsis hystrix* and *Altingia siamensis* with IV% > 50%. *Altingia siamensis* is an endemic species of the studied area. Therefore, it is necessary to take measures to manage and preserve this species.

3.1.2. Layer structure and crown cover of canopy layer

One of the competition results among the tree species in forests is the development of layer structure. That is the arrangement of the vertical distribution of tree components (Hoang Kim Ngu and Phung Ngoc Lan, 2005). Specially, the three forest states are secondary forest, so that the competition between species in the vertical space is more obvious. Therefore, the height of the tree layers are divided clearly in each state, as follows:

In state IIA, the tree height ranges from 8 to 15.5m. The forest layers are divided into two main forest layers A_2 and A_3. A_2 layer includes a medium tree height from 12.77 to 13.04m, accounting for 40.32 – 47.95%. The dominant trees of this layer include *Castanopsis hystrix, Castanopsis indica* and *Schima wallichii*. A_3 layer encompasses individuals with average height ranging from 10.16 to 10.30m, accounting for 50.04% - 59.68%. The storey includes some individuals of *Altingia siamensis, Mallotus cochinchinensis* and *Prunus zippeliana var crassistyla*. The trees in the IIA state have a distinct stratification. The crown cover of this state is 0.45 (see Figure 1).



(A) (B) (C)

Figure 1. Layer structure of state IIA (A), IIB (B), IIIA$_2$ (C)

The tree height in state IIB varies from 5 to 17 m and the stratification is clear. Canopy layers include A_1, A_2 and A_3. A_1 layer has an average tree height ranging from 15.70 - 16.25 m, accounting for 2.74 - 6.95%. Some main species of A_1 layer are *Castanopsis hystrix, Schima wallichii*. Storey A_2 consists of trees with average height ranging from 12.33 to 12.65 m, comprising the largest percent of 73.61 - 90.41%. *Castanopsis hystrix, Castanopsis indica* and *Schima wallichii* are representable individuals of this layer. The lower layer A_3 has an average tree height varying from 7.65 to 8.80 m, accounting for 6.85 - 20.73%. Some main species in A_3 layer are *Altingia siamensis, Mallotus cochinchinensis* and *Prunus zippeliana var crassistyla* (see Figure 1).

Three main layers are appeared in state IIIA$_2$ with average tree height from 9 to 22 m. Firstly, A_1 layer has average height varies from 21.25 to 21.50 m, making up 3.45 to 6.82%. *Castanopsis hystrix* and *Altingia siamensis* are the main species of this layer. Secondly, layer A_2 accounts for the greatest percent (60 – 61.36%) with average height ranging from 17.00 - 17.42 m. Major individuals of this layer contain *Castanopsis hystrix, Elaeocarpus sylvestris* and *Gironniera subequalis.* Lastly, A_3 canopy varies from 10.5 to 12.29 m in tree height, comprising to 31.82 – 36.21%. *Castanopsis indica, Choerospondias axillaris* and *Dalbergia assamica* are principal species of A_3 layer. The state has the crown cover of 0.61.

3.1.3. Diameter and height growth of canopy layers in forest states

* *Differences in diameter growth, height between three forest states*

Diameter of canopy layers is significantly different between three forest states with Sig. < 0.05 (see Table 2).

This conclusion is consistent with reality because the secondary forest conditions differ in species composition. Therefore, the diameter growth rate of the tree species is clearly different.

Table 2. Estimates of fixed effects of diameter

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	27.729	.528	599	52.439	.000	26.690	28.767
[Forest_type=IIA]	-12.733	.693	599	-18.361	.000	-14.095	-11.371
[Forest_type=IIB]	-5.658	.687	599	-8.228	.000	-7.009	-4.308
[Forest_type=IIIA$_2$]	0^b	0	.	.	.	.	.

Height of canopy layers is also very different between forest states with Sig. < 0.05 (see Table 3).

Table 3. Estimates of fixed effects of height

Parameter	Estimate	Std. Error	df	t	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Intercept	15.633	.192	599	81.095	.000	15.255	16.012
[Forest_type=IIA]	-4.264	.252	599	-16.866	.000	-4.761	-3.767
[Forest_type=IIB]	-3.724	.250	599	-14.852	.000	-4.216	-3.231
[Forest_type=IIIA2]	0^b	0	.	.	.	.	.

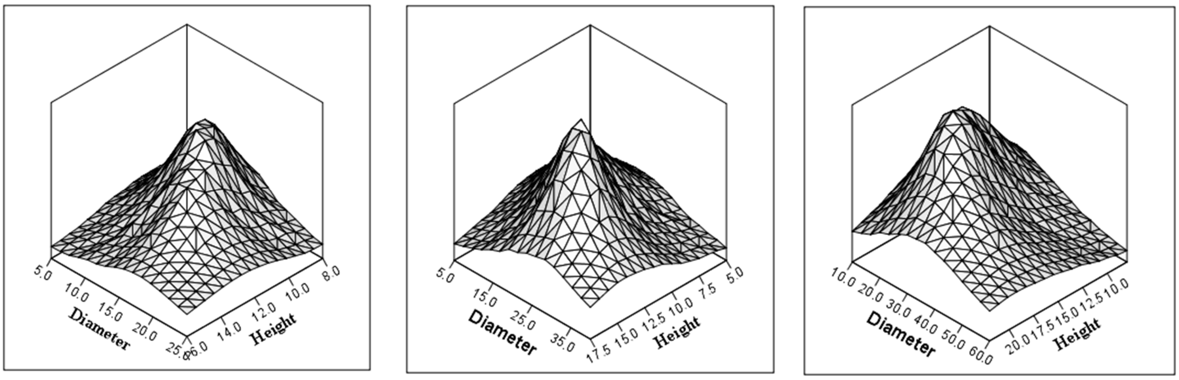
* *Some descriptive statistics and frequency distribution by diameter and height*

Descriptive statistics for diameter and height parameters of three forest states are shown in table 4.

Table 4. Descriptive statistics for diameter and height in 3 forest states

Statistics	Diameter			Height		
	IIA	IIB	IIIA2	IIA	IIB	IIIA2
N	218	227	157	218	227	157
Range	17.0	27.5	44.0	7.5	12.0	13.0
Minimum	7.5	9.0	10.0	8.0	5.0	9.0
Maximum	24.5	36.5	54.0	15.5	17.0	22.0
Mean	14.995	22.070	27.729	11.369	11.910	15.634
Std. Deviation	3.1721	6.1090	10.0252	1.5892	2.3927	3.2554
Variance	10.062	37.320	100.505	2.525	5.725	10.597
Skewness	.299	-.014	.691	.387	-.515	-.195
Kurtosis	-.180	-.586	.043	-.557	-.299	-.700

Generally, the results indicate that tree diameter increase from IIA, IIB to IIIA$_2$ with average diameters of 14.995, 22.070 and 27.729 cm, respectively. Similarly, tree height also goes up from state IIA, IIB and IIIA2 with mean tree height of 11.369, 11.910 and 15.634 respectively. This is explained that the older forests, the greater differences in tree diameter and height (also see Figure 2).



(A) (B) (C)

Figure 2. Tree frequency distribution by diameter and height in state IIA (A), IIB (B), IIIA$_2$ (C)

Besides, tree frequency distribution in diameter and height are clear in three forest states (see Figure 2). In state IIA, the tree diameter distribution is mainly in group of 10 - 20 cm. Meanwhile, tree diameter mainly distributed in greater groups of 15 - 25 cm (states IIB) and 20 - 40 cm (state IIIA$_2$). The variation in tree diameter varies greatly (100.505 cm) in state IIIA$_2$ while this parameter fluctuates smaller in state IIA (10.062 cm) and IIB (37.320 cm). Similarly, tree height in state IIA and IIB is major in small group 7.5 - 12.5 cm whereas this parameter distributes in greater group (12.5 - 17.5 cm) in state IIIA$_2$. However, the tree height fluctuation is not significant between three forest states.

3.2. The species composition and quality of the regeneration layer

3.2.1. Species composition

Table 5. Species composition and tree density of regeneration layer

No.	State IIA			State IIB			State IIIA$_2$		
	Species	Density (tree/ha)	Ki	Species	Density (tree/ha)	Ki	Species	Density (tree/ha)	Ki
1	*Schima wallichii*	205	2.48	*Schima wallichii*	219	2.55	*Altingia siamensis*	316	3.18
2	*Castanopsis hystrix*	167	2.01	*Castanopsis hystrix*	191	2.23	*Castanopsis hystrix*	301	3.03
3	*Castanopsis indica*	143	1.72	*Castanopsis indica*	116	1.36	*Castanopsis indica*	147	1.47
4	*Altingia siamensis đb*	141	1.71	*Archidendron clypearia*	119	1.39	*Schima wallichii*	51	0.51
5	*Mallotus cochinchinensis*	76	0.92	*Mallotus cochinchinensis*	89	1.04	*Hypericum japonicum*	23	0.23
6	*Archidendron clypearia*	60	0.72	*Diospyros rubra*	36	0.42	*Baccaura sapida*	21	0.21
7	3 other species	36	0.43	10 other species	87	1.01	12 other species	136	1.37
8	Total 9 species	828	10	Total 16 species	856	10	Total 18 species	995	10

Regeneration compositions of 3 forest states are as follows:

- State IIA: 2.48Sw + 2.01Ch + 1.72Ci + 1.71As + 0.92Mc + 0.72Ac + 0.43Os

- State IIB: 2.55Sw + 2.23Ch + 1.39Ac + 1.36Ci + 1.04Mc + 1.43Os

- State IIIA$_2$: 3.18As + 3.03Ch + 1.47 Ci + 0.51Sw + 1.81Os

Where: Sw: *Schima wallichii*; Ch: *Castanopsis hystrix;* Ci: *Castanopsis indica*; As: *Altingia siamensis;* Mc: *Mallotus cochinchinensis;* Ac: *Archidendron clypearia;* Os: *Other species.*

The studied results (see Table 5) show that the number of regeneration species is 9 species in forest state IIA. Therein, 6 species are involved in the composition formula: *Schima wallichii, Castanopsis hystrix, Castanopsis indica, Altingia siamensis, Mallotus* *cochinchinensis* and *Archidendron clypearia*. *Schima wallichii* has the highest composition coefficients (2.48). Forest state IIB which are richer than forest state IIA has 16 tree species. Nevertheless, the species number involved in the composition formula is less, only 5 species including *Schima wallichii, Castanopsis hystrix, Archidendron clypearia, Castanopsis indica, Mallotus cochinchinensis* and *Schima wallichii*. They are dominant species with a coefficient of 2.55.

Therefore, the regeneration composition species is low in the state IIA and IIB. These species are mainly light-fast growing species with insignificant values. Endemic species such as *Altingia siamensis* which were found in state IIA has a good coefficient (3.18). This species is not participated in the composition in state IIB. State $IIIA_2$ has the highest diversity of regeneration species (18 species), but the species involves in composition are lower than the other states. In which, *Altingia siamensis* has the greatest number of trees. This species is an endemic which has great value in research and genetic conservation. In general, regenerated species in all forest states are similar to that of canopy layer so that the species composition will not change significantly in the future.

The results in table 5 also indicate that regeneration density is not significantly different and accounts for less than 1000 trees/ha. This demonstrates that the regeneration rate in all forest states is not sufficient. Specifically, the average regeneration density of trees in IIA, IIB and $IIIA_2$ was 828, 856 and 995 trees/ha, respectively. Therefore, applying suitable silviculture solutions to promote regeneration layers and preserve species diversity in the study area is extremely necessary.

3.2.2. Quality of regeneration layers

The regeneration layer is an important factor for species diversity of canopy layers in the future. Success or failure in forest regeneration depends on several constituents. The first is the number and quality of seed sources dispersed from canopy layers. Secondly, environmental conditions are essential for regeneration germination, growth and development (Nguyen Van Son, 2002). The living conditions under canopy layer in three different forest states IIA, IIB and $IIIA_2$ results in to different growth rate of regeneration layer (see Figure 3).

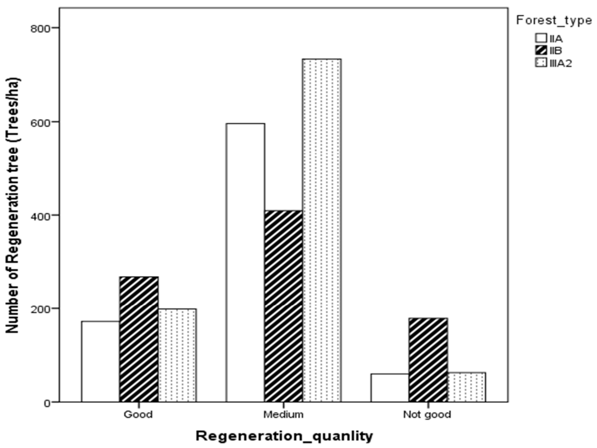


Figure 3. Quality of regenerated trees of three forest states

Regenerated trees have good quality ranged from 19.97% to 31.31%, average quality making up from 47.82% to 73.73% and from 6.30% to 20.87% for bad quality. The highest quality of regeneration belongs to state IIB and the lowest is in state $IIIA_2$. Thus, we conclude that the majority of regenerated trees have medium quality and the good quality remains low. Therefore, some silvicultural measures to improve the quantity and quality of regenerated trees are proposed:

Firstly, promotion of natural regeneration because all forest states are lacking regenerated trees in both quantity and quality. In addition, there should be enhanced regeneration by protecting tree individuals which are capable of sowing.

Secondly, opening forest canopy by removing old trees, treating shrubs, vines, seedlings, or replanting in areas where the density of regenerated trees is too low. It is necessary to facilitate the regeneration of endemic trees such as *Altingia siamensis* because this species has great value in preserving forest gene sources.

3.3. Biological diversity of plant communities in forest states

3.3.1. Biological diversity of canopy layers

Biodiversity is one of the most important indicators for assessing the species richness and biodiversity conservation (Bui Manh Hung, 2016). The species diversity of canopy storey was assessed through three indices: Margalef (d), Pielou (J ') and Simpson (D).

Table 6. Species diversity of canopy layers in three forest states

No.	Diversity index	State			Total
		IIA	IIB	$IIIA_2$	
1	Number of species (S) (Species/3 plots)	10	13	18	41
2	Number of tree (N) (Trees/3 plots)	218	227	157	602
3	Margalef (d)	9.572	12.576	17.545	39.693
4	Pielou (J')	0.719	0.642	0.665	2.027
5	Simpson (D)	0.784	0.763	0.815	2.362

Tree species number in state IIA, IIB and $IIIA_2$ are 10, 13 and 18 species, respectively. The total species in 3 forest states are 41 species (see Table 6).

The results show that tree species abundance and tree species number are significantly different in three states. In which, to the species richness (d index of Margalef), state $IIIA_2$ has the highest species diversity (d = 17.545), followed by state IIB (d = 12.576) and the lowest at state IIA (d = 9.572). The species number of canopy covers is different as shown by the J' index in 3 states IIA, IIB, $IIIA_2$, respectively: 0.719, 0.642, 0.665. The species diversity index (D) indicates that state $IIIA_2$ has the highest diversity (0.815) compared to state IIA (0.784) and state IIB (0.763). Therefore, forest state $IIIA_2$ has the highest number of tree species, species abundance and species diversity, followed by state IIA and state IIB.

3.3.2. Biological diversity of regeneration layers

The four indices including Margalef (d), Pielou (J '), Simpson (D) and Shannon-Weiner (H'_{log2}) were used to access regeneration biodiversity. The assessment results of regenerated species diversity are shown in table 7:

Table 7. Diversity index of regeneration trees in 3 forest states

No.	Diversity index	Forest state			Total
		IIA	IIB	$IIIA_2$	
1	Number of species (S) (Species/3 plots)	9	16	18	43
2	Number of tree (N) (Trees/3 plots)	621	642	746	2009
3	Margalef (d)	8.642	15.644	17.652	41.938
4	Pielou (J')	0.808	0.700	0.628	2.137
5	Simpson (D)	0.809	0.828	0.775	2.412
6	Shannon – Weiner (H'_{log2})	2.562	2.801	2.620	7.982

In summary, the regenerated natural species number under canopy in forest state IIA, IIB and $IIIA_2$ are 9, 16 and 18 species respectively. State $IIIA_2$ has the highest regenerated abundance. Meanwhile, the species similarity and diversity of regeneration layer are the lowest. Regenerated species in state IIB reaches at average level, but the regenerated diversity (D index and H' index) is the highest. Lastly, state IIA is more abundant in regenerated tree species than the others but species diversity are the lowest.

4. CONCLUSIONS

The composition of the canopy layer is diverse. This characteristic is similar in state IIA and IIB. These states have some ecologically important species in the community including *Schima wallichii, Mallotus cochinchinensis, Castanopsis hystrix* and *Castanopsis indica*... State IIA consists of 10 species with an average density of 291 trees/ha; state IIB has an average density of 303 trees/ha including 13 species; state $IIIA_2$ encompasses 18 species with density of 209 trees/ha.

Forest state IIB and $IIIA_2$ have 3 main canopy layers A_1, A_2 and A_3 with crown cover of 0.52 and 0.61, respectively. Meanwhile, forest state IIA has 2 main canopies A_2, A_3 with crown cover of 0.45. Diameter and height of canopy layers are significantly different between three forest states with Sig. < 0.05.

Natural regeneration under forest canopy is deficient in quantity and quality. Tree regeneration density ranges from 828 trees/ha (state IIA) to 995 trees/ha (state $IIIA_2$). The ratio of good quality regenerated trees in the stands remains low.

The tree species diversity of three states in canopy layers and regeneration layers is different. Therein, state $IIIA_2$ has the highest in species number, species abundance, and species diversity in canopy layers while the similarity and diversity of regeneration layer are the lowest.

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ĐẶC ĐIỂM CẤU TRÚC VÀ TÍNH ĐA DẠNG SINH HỌC RỪNG TỰ NHIÊN TẠI KHU DI TÍCH MƯỜNG PHĂNG, ĐIỆN BIÊN

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Hệ sinh thái rừng khu Di tích lịch sử và Cảnh quan môi trường Mường Phăng (KDT) thuộc xã Mường Phăng và xã Pa Khoang, huyện Điện Biên, tỉnh Điện Biên là kiểu rừng kín thường xanh mưa ẩm á nhiệt đới núi thấp. Kết quả nghiên cứu trên 9 ô tiêu chuẩn với diện tích 2500m^2 ở các trạng thái IIA, IIB, IIIA$_2$ chỉ ra rằng: tổ thành tầng cây cao tương đối đa dạng, trong đó trạng thái rừng IIA gồm 10 loài với mật độ trung bình 291 cây/ha, trạng thái rừng IIB bao gồm 13 loài với mật độ trung bình 303 cây/ha, trạng thái rừng IIIA$_2$ bao gồm 18 loài với mật độ trung bình 209 cây/ha. Trạng thái rừng IIB và IIIA$_2$ đều có 3 tầng tán chính A$_1$, A$_2$, A$_3$ với độ tàn che lần lượt là 0,52 và 0,61, trong khi đó, trạng thái rừng IIA có 2 tầng tán chính A$_2$, A$_3$ với độ tàn che là 0,45. Trong đó, tính đa dạng loài tầng cây cao trạng thái IIIA$_2$ cao nhất. Đường kính và chiều cao của tầng cây cao có sự khác biệt đáng kể giữa ba trạng thái rừng thể hiện ở giá trị Sig. <0,05. Mật độ cây tái sinh dao động từ 828 cây/ha ở trạng thái IIA đến 995 cây/ha ở trạng thái IIIA$_2$. Mức độ đa dạng loài cây tái sinh của trạng thái rừng IIIA$_2$ cao nhất trong 3 trạng thái rừng.

Từ khoá: Hệ sinh thái rừng, mức độ đa dạng loài, tái sinh, tổ thành loài, trạng thái rừng.

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