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Hanoi, September 2019

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ABSTRACT

In this study, we set up 9 sample plots, each covering 2.000 m^2 to analyze tropical moist evergreen broadleaf forest structure and tree species diversity in Tam Duong District, Lai Chau Province. Within each plot we identified, and measured height and diameter for all woody individuals with stem diameters > 6 cm. The results indicated that the mean diameter at breast height (DBH) varied from 11.55 cm to 18.30 cm. The standard deviation and variance of DBH ranged from 0.24 cm to 10.80 cm and 18.50 – 116.90 cm^2, respectively. The stand basal area was from 8.37 m^2/ha to 22.68 m^2/ha. The diameter distributions were all skewed to the left of the graph, with the total number of stems were concentrated in the first class or second class. The number of trees per DBH class for two important tree species, namely *Schima crenata* and *Litsea glusinosa* was inversely proportional to diameter sizes, which was a decrease in the number of stems as the diameter increased. In species diversity of the forest, total of 2188 species belonging to 81 species and 75 families. Tropical moist evergreen broadleaf forests in the study area was medium diverse with the species richness was from 14 to 37, Shannon - Weiner Index ranged from 1.2895 to 3.0262 and Simpson Index varied from 0.5018 to 0.9239, and Margalef index was from 2.2394 to 6.8542.

CHAPTER I

INTRODUCTION

Natural forest is the richest biological communities on earth and these forests have been recognized to harbor a significant proportion of global biodiversity (Myers et al 2000; Baraloto et al 2013). These forests provide many ecosystem services such as species conservation, prevention of soil erosion, and preservation of habitat for plants and animals (Armenteras et al 2009). Biotic factors such as seed quality, seedling survivorship, and recruitment are important in maintaining the tree composition of tropical forests (Connell 1971). Over exploitation has resulted in the rapid loss of forests and is recognized to be one of the biggest environmental and economic problems around the world (Mani and Parthasarathy 2006). Natural forest is disappearing at alarming rates worldwide, reducing annually by 1–4% of their current area (Laurance 1999). Relatively increased anthropogenic pressures have led to agricultural expansion and overgrazing of livestock (Anitha et al 2010).

Trees is an important component of vegetation, must therefore be constantly monitored and managed in order to direct successional processes towards maintaining species and habitat diversity (Turner 1987; Attua and Pabi 2013). Tree species diversity is an important aspect of forest ecosystem diversity (Rennolls and Laumonier 2000; Tchouto et al 2006) and is also fundamental to tropical forest biodiversity (Evariste et al 2010). Tree census plots have been established in forest types through tropical regions to monitor forest dynamics over time and to assess the effects of disturbance and climate change on plant demography (Condit et al 1996; Laurance et al 2004; Mohandass and Davidar 2009). Tree species diversity that influences the forests are climate, stand structure, species composition, and geomorphology. Forest stand structure is a key element in understanding forest ecosystems and also an important element of stand biodiversity (Ozcelik 2009). The rapid inventory of tree species that provides information on diversity will represent an important tool to enhance our ability to maximize biodiversity conservation that results from deforestation and degradation (Baraloto et al 2013). Information from this quantitative inventory will provide a valuable reference forest assessment and improve our knowledge by the identification of ecologically, useful species as well as species of special concern, thus identifying conservation efforts for sustainability of forest biodiversity.

Forest structure is the horizontal and vertical distribution of layers in a forest including the trees, shrubs, and ground cover. The structure, species composition and biodiversity of a forest can affect to environment quality, forest products quality, etc… understanding about the structure, composition and biodiversity can help forest managers better manage the forest. Well managed forest can bring many good effects for both human and environment especially in protection function of forest. Moreover, it can help in assessment and improve our knowledge by the identification of ecologically, useful species as well as species of special concern, thus identifying conservation efforts for sustainability of forest biodiversity.

In the world, many researchers had research on natural forest structure. "Features of the structure and natural regeneration have been many scientists around the world conducting research to establish a scientific basis and theoretical work in service of forest business. The study of the ecological structure of the rainforest was P. W. Richards (1952), G. N. Baur (1964), and etc conducted. These studies have raised perspective, the concepts and qualitative description of the composition, life forms and slab floor of the forest" (Huyen, 2009).

With Vietnam forest, the complexity shows the clearest in the structure of the tree species composition and second stories. The study of forest structure not only helps maintain the stability of the forest ecosystem, conditioning the structure factors, but creates an opportunity for managers to use and promote maximum sustainable benefits of forests for the economy, society and environment. Therefore, one of the important issues to be studied is to find out the rules of forest structure as a basis for proposing measures appropriate protect and develop forest resources sustainably in Vietnam.

Tam Duong is a mountainous district located in the northeast of Lai Chau province. The area of forest land in the district is 35,675.75 ha, accounting for 46.85% of the natural area, the coverage is 43%. In general, the forest resources of Tam Duong are mainly poor forests and rehabilitated forests after exploitation. However, in recent years, the direction of the Party and local authorities has been good in forest protection, as well as the implementation of 327, 661 programs, the new planted areas and new vegetation areas are being protected and rehabilitated. Besides, no adequate research on species structure and diversity has been conducted in Tam Duong district. No adequate research on species structure and diversity has been conducted in Tam Duong district. For those reasons, I conducted the topic: **"*Structure and tree species diversity of tropical moist evergreen broadleaf forest in Tam Duong District, Lai Chau Province*"**. The information on tree species structure and diversity can provide baseline information for conservation of the biodiversity of the tropical forest in the research area.

CHAPTER II

LITERATURE REVIEW

2.1. In the world

2.1.1 Structural composition

Structural composition is the participation of the trees in the forest, or in other words is the richness of species of plants receptor populations. According to Richards, P. W (1952), in the tropical rainforest at least 40 trees per 1 ha, and also cases above 100 species. The author has distinguished composition of rain forest plants into two categories: (i) the mixture of rain forest tree species complex tothanh; and (ii) the application offers rain forest tree species with a simple structure, the special terrain, rain forest offers only menu includes several species.

According Tolmachop, AL (1974), tropical plant ingredients are varied in that little show they account for 10% of the total number of species of flora and total percentage of 10 they the largest number of species only reach 40-50% of all species. In the mixed forest, many species of large trees distributed in proportion quite balanced, but mostly in a receptor populations often have 1-2 dominant species.

Baur, GN (1979) when studying the rainforest near Belem on the Amazon River, on a sample plot area of about 2 hectares have listed 36 plant families and on each sample plot area of> 4 ha Northern New South Wales also recorded the presence of 31 families not including vines, grasses and plant epiphyte.

Laura Klappenbach (2001) suggests that plant species composition related to the type of forest, some forest contains hundreds of species, including some woods only a few species. Forest always change and develop through a chain of succession, during which time the tree species composition of forests changes.

In Asia, in secondary forests tropical Shanxin - China, Zeng et al (1998) have listed about 280 species of medicinal plants, 80 species of oil plants and 20 species of plant fibers as well as some tree species have different values. Richness of plant ingredients in secondary forests in Nepal also Kanel KR and K. Shrestha (2001) study, over 6,500 flowering plants and 4,064 species of plants do not flower, over 1,500 species of fungi and over 350 lichen.

In summary, the studies to date ahead of the authors showed that natural forest stands say chungrat diversity of plant species composition. Overall, there are hundreds of trees in the area of 1 hectare, however, very few species accounting for over 10% of all species groups.

2.1.2 The distributed structure of trees by diameter

The relationship between the factors investigated in the forest is the basic rule in studying the structure of the forest is a lot of interest in the study author. Today, besides the research nature of qualitative studies of forest structure in recent decades tend to gradually shift from describing the qualitative to the quantitative with the aid of mathematical statistics and information learning, including modeling forest structure, establishing the relationship between forest structure factors has been much study authors. The problem of the structure of space and time are the authors of forest research focused most.

To study the rule, most of the authors have used analytical methods, to find mathematical equations as many different probability distribution. Not to mention works as follows:

The first is the work of Meyer, H. A (1952) described the distribution N / D by mathematical equations with continuous reduction curve. This equation is called the equation Meyer.

Rollet (1971) demonstrated the relationship between height and diameter at breast height by jaw line regression; tree diameter distribution as probability distributions (manual documentation of Tran Van Son, 1991).

Richards PW (1952) in his book "Rainforests" also refers to distribution of trees by diameter class, he considered distribution form is a form of natural forest characteristics.

Then many authors used calculus equations to find the equation of the distribution curve as Balley (1973) Modeling the distribution structure of trees by diameter (ND) using the Weibull function. Prodan, M and Patatscase (1964), Bill and Cream, K. A (1964) distributed architecture approach N / D equation logarithm (tutorial document Tran Van Son, 1991).

In particular, to increase flexibility, some author or use other functions such as Loetschau (1973) (cited in Pham Ngoc Giao, 1997) used to repair Beta distribution function experiments. JLF and Docouto HTZ Batista (1992) while studying 19 sample plots with 60 species of tropical forests in Maranhoo, Brazil used to simulate the function Weibull distribution N / D1.3. Many other authors use Hyperbola function, Poisson function, logarithmic function and function Pearson.

Overall, the use of this function or other function to indicate rule is structured depending on the experiences of the author, as well as the different tree species grow and measurements practice. Do not stop the tree's diameter increases with age, so the diameter distribution of forest stands are also constantly changing with age. Therefore, from the mathematical model has identified, scientists have studied the variation of the distribution law under the age of trees (called forest structure dynamics).

2.1.3. Species diversity research

Raunkiaer (1934) gave the formula for determining the standard universal life forms to thousands of different species. According to this formula the standard universal life forms is determined according to the percentage between the number of individuals of each form of life than the total number of individuals in an area. To represent the diversity of species, some authors have developed the formula for determining the species diversity index as Simpson (1949), Margalef (1958), Menhinik (1964), ...

2.2. In Vietnam

2.2.1. Structural composition

These are factors influencing the decision to ecological structures and other forms of forest. Forest composition is an important indicator to assess the level of biodiversity, stability and sustainability of forest ecosystems. A lot of scientific works of many authors have focused on the structural features of the natural forest types in order to serve the conservation, development and long-term business.

Structural composition is essentially participatory components in populations of forest tree species. Study the structure of natural forests in Vietnam, in view of ecosystems, Thai Van Trung (1978, 1999) based on the number and biomass group dominant species in tropical moist forests Vietnam to identify the pros and complex case.

Group dominant species in favor of not more than 10 species, the proportion of individuals of each dominant species accounting for about 5% and the total number of individuals of 10 species of superiority which should account for 40-50% of the total number of individuals of the floor established populations in the population per unit area of investigation. Where the dominant species obviously not called complex.

Characterized by climate and soil favorable to many plants and development, so in the natural forest mixed tropical species rarely only a single dominant species forming populations such as the temperate zone. According to Nguyen Hong Quan (1983), in forests in Kon Ha Nung type IVB, on the 01 ha area has about 60 species, but species with the largest combined will not exceed 10%.

Nguyen Ngoc Lung (1991) surveys of forest type climate in Huong Son, Kon Ha Nung and some other localities, also said on the sample plot area of 1 hectare are usually from 23-25 species, with the number of trees lowest and the highest reaching 859 317 tree seedlings / 1 ha (tutorial document Tran Van Son, 1991).

Compared to other regions of the world, Pham Hoang Ho (1999) says: if in the Amazon, an average of about 90 species / 1 ha, in Southeast Asia to 160 species / 1 ha (tutorial document Tran Van Son, 2007).

To assess the composition of forests, many authors have used the formula composition on the rate of section 10 according to the number of trees, basal area or index IV%; which method composition ratio (IV%) according to the method of Daniel Marmil lod scientists often use in the study of forest structure.

Nguyen Manh Tuyen (2009) when studying the structures of stories tall trees of the SUF in Huong Son, My Duc, Hanoi showed that the number of species recorded are 79 species including forest conditions IIIA1 with the number of species 55 species, forest conditions IIB with the number of species was 40 species. Most of the plants involved in formula composition on the 2 state mainly tree species complex and fast growing pioneer light.

Vo Dai Hai (2014) when studying the structure of forest status IIA in the area of protection forests Yen Lap, Quang Ninh province showed that composition of natural forest status IIA in the study area is quite diverse with many species various trees, ranging from 28 to 45 species, of which only from 4-7 species involved in formula composition; read water species is dominant species of tree floors high.

Vo Hien Tuan (2017) when studying the structures of stories tall trees of state IIIA1, IIIA2 and IIIB in the central region of Vietnam showed that forest conditions IIIA1 with the number of species was 61 species, forest conditions IIIA2 there are 96 species of species and forest conditions IIIB has 81 species. Number of species involved in formula composition on the 3 status only 7 species and mostly less valuable species in economic terms but with good protection capacity.

Pham Quy Van (2018), when studying the structural composition of stories tall trees for state natural forests IIIA in An Lao District, Binh Dinh Province also shows status IIIA1 have some plants varied from 49 to 51 species and the number of species involved in formula composition only from 3-6 species, while state IIIA2 have species ranging from 51 to 56 species and species involved in formula composition fluctuations in the range of 5 - 6 species.

2.2.2. The role of distribution trees by diameter (N / D1.3)

Modeling structure D1.3trong diameter quantitative research forest structure are more people interested in the study and expressed in the form of probability distribution function vary, the typical works of authors such as:

Dong Sy Hien (1974), when scheduling standing volume of natural forests in northern Vietnam has studied stands on various local and come to general conclusions are: Since the extraction process selected coarse not follow rules, should distribution N / D is the distribution jagged edge. With this distribution pattern selected author Meyer and their function curves to describe Pearson.

Nguyen Hai Dog (1982) used the distribution reduction, distribution distances to perform diameter structure, height structure of secondary forests, and apply equations Pearson to study population structure.

Tran Van Son (1991), was used to simulate the Weibull distribution structure for Dipterocarps diameter in the Highlands.

Le Minh Trung (1991) via simulation testing distribution N / D of natural forests in Chiayi - Dak Nong with 4 type of function: Poisson, Weibull, Hyperbola and Meyer, has concluded: function Weibull have access distributed empirical great diameter. However, the determination of the two parameters of the equation is very complex, so used to calculate the function Meyer.

Research Wujin Pictures (1991) shows that can be used with two parameter Weibull function to indicate distribution N / D for some natural forest conditions.

Le Six (1996), confirmed the Weibull distribution best suited to describe the distribution N / D for all natural forest conditions, despite empirical distribution form continuous decrease or a peak.

Phung Van Khang (2014) when studying the characteristics foresters of evergreen moisture tropical area code Da Dong Nai shows: distribution N / D of the three states studied IIB, IIIA2 and IIIA3 are shaped distribution decreased..

Pham Quy Van (2018), the study of a number of structural features for state natural forests IIIA in An Lao, Binh Dinh showed can use Weibull distribution to simulate the distribution of experimental N / D1.3.

Statistical research works on natural forests in Vietnam for the results: Distribution N / D1.3 of floors tall ($D \geq 6$ cm) there are 2 main types: (i) is decreasing continuously and more serrated top side and (ii) form a shaped peak J.

For each specific format, the authors chose the appropriate mathematical models to simulate.

2.2.3. Research on tree species diversity

Phung Dinh Trung (2007), when comparing species diversity of the area north and south of the Hai Van Pass was based on the index varied: The richness of Kjayaraman index Shannon-Weiner , Simpson index, the index varied by information theory, only rational numbers and the author gives some comments: the level of style phucua species as well as the level of species diversity tree storeys and the uniform number of individuals in a species in the forest north than in the south high Hai Van Pass.

Vo Hien Tuan (2017) compared a number of structural characteristics and species diversity of stories tall trees of state IIIA1, IIIA2 and IIIB in the central region also use the index diversity to compare species diversity between state forest together, the results show that the volatile species in the 6 plots measuring from 62 to 102 species. Species diversity in tree layer of different forest conditions also differ, the degree of diversity of state IIIB is the largest, followed by the state and the lowest IIIA2 IIIA1 state.

Pham Quy Van (2018), the study of a number of structural features for state natural forests IIIA in An Lao District, Binh Dinh Province also use the indicators varied and records diverse to compare diverse trees of the forest status IIIA, results show that the form of state IIIA2da most tree species, status and IIIA3 IIIA1 different not much of index component species diversity but species differ markedly.

CHAPTER III

GOALS AND OBJECTIVES

3.1. Goal

To analyze the structural characteristics and assess tree species diversity of tropical moist evergreen broadleaf forests in Tam Duong District, Lai Chau Province.

3.2. Objectives

- **The specific objectives of this research are as follows:**
  - To give several descriptive statistics of tropical moist evergreen broadleaf forests in Tam Duong District, Lai Chau Province.
  - To show some characteristics of forest structure of tropical moist evergreen broadleaf forests in the study site.
  - To provide tree species composition and diversity of tropical moist evergreen broadleaf forests in the study site.

CHAPTER IV

STUDY SITE AND METHODS

4.1. Study site

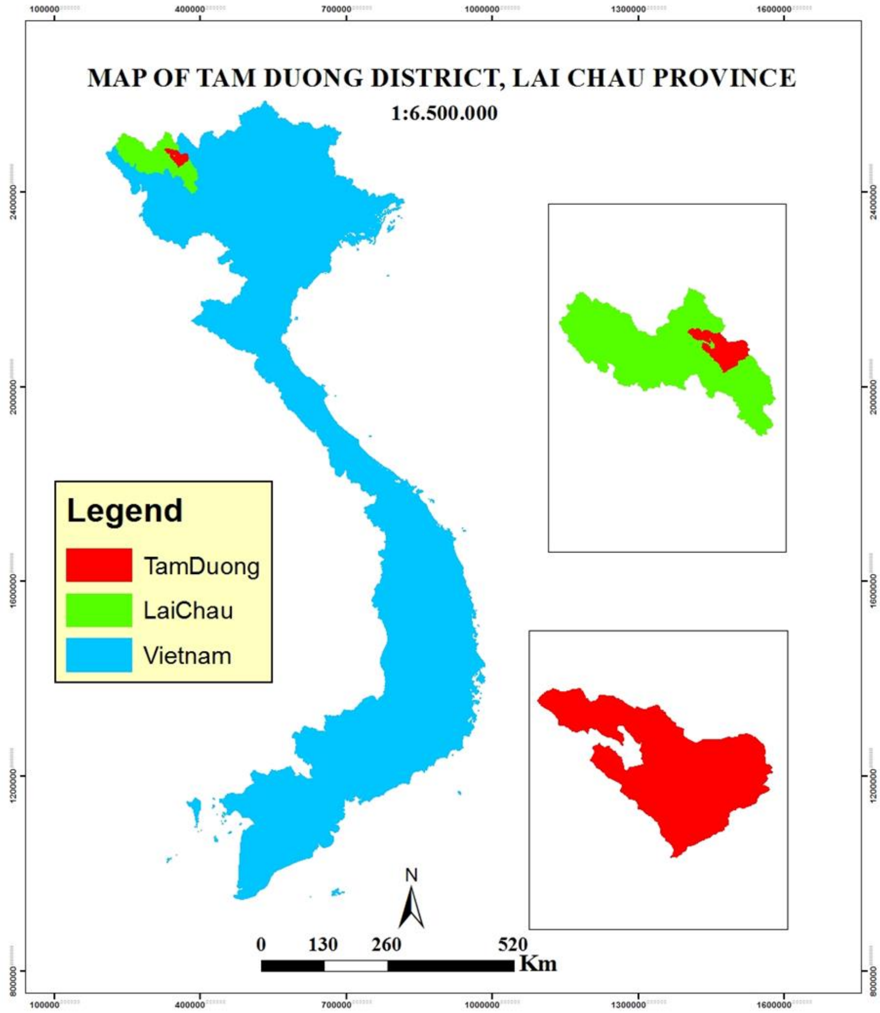

Figure 4.1. The map of study site in Tam Duong District, Lai Chau Province

4.1.1. Geographic location

Tam Duong is a highland district located in the northeast of Lai Chau province. As of 2009 the district had a population of 46,767. The district covers an area of 758 km². Geographic coordinates from $22^0$10'00'' to $22^0$30'00'' North latitude; from $103^0$18' to $103^0$46' East longitude.

The east borders Sapa district, Lao Cai province. The west borders Sin Ho district and Lao Cai city. The south borders Sin Ho district, and Tan Uyen district. The north borders Phong Tho district, Lai Chau province, and Bat Xat district, Lao Cai province. The total area of Tam Duong district is 68,742.56 ha of natural area. Tam Duong is quite convenient compared to other districts in the Lai Chau province because it has a national highway 4D running through and 25km from Lai Chau city center. The district has tourist sites such as: Tien Son cave and community tourism sites. The districts also have a village to make vermicelli, these factors create favorable conditions for the development of the economy and local tourism service. Therefore, Tam Duong district has conditions to promote resources for socio-economic development.

4.1.2. Topographic

Tam Duong is a district with a complex terrain, composed of long mountain ranges in the direction of Northwest - Southeast. In the northeast is the Hoang Lien Son range stretching over 80 km with Phan Xi Phang peak of 3,143 m high, in the Southeast is Pu Sam Cap range of about 60 km long. Alternating between high mountains are valleys and rivers such as:

- Tam Duong Valley - Ban Giang: 3,500 ha, the slope is from North to South, average height is 900 m.
- Tam Duong Valley - Then Sin runs along Nam So stream: 500 ha.
- Binh Lu valley - Na Tam - Ban Bo: 1,800 ha, altitude 600 - 800 m. These are areas with potential for agricultural development and key areas for food crops and industrial crops.

4.1.3. Climate

Located in the tropical monsoon region, divided into two distinct seasons, the rainy season from April to September, concentrating mainly on June, July and August, accounting for 75-80% of the total rainfall in the year, averaging from 1,800 - 2,000 mm/year, the highest 2,500 mm/year, hail appears, averaging 1.6 times/year.

The dry season lasts from October to March of the following year, the weather is dry, less rainy, cold and often appears fog, hoarfrost in December and January in highland areas such as: Sa Pa Pass, Giang Ma Pass.

The amplitude of heat fluctuation is quite strong, averaging about 8 – 9oC, in the winter it reaches 9 – 10oC, there are places from 11 to 120C. However, in some places with a height of over 1,000 m, the value of day and night amplitude decreases, averaging about 7 - 8oC, in winter the temperature is about 8 – 9oC. Annual average temperature is from 22 – 26oC, heat The highest temperature is 35oC, the lowest temperature can be below 0oC.

- Sunny mode: The average number of sunshine hours is from 2,100 to 2,300 hours/year.
- Humidity: The average air humidity is 83%, the lowest humidity is 56%.
- Wind direction: the main wind direction is southeast, the average wind speed is 1-2m/s, in the thunderstorm can reach 30 - 40m/s.
- Evaporation: average annual evaporation is 889.6 mm
- Thunderstorms appear most often in May with swirling winds

4.1.4. Hydrology

The system of rivers and streams is relatively evenly distributed with 2 main river and stream systems:

Nam Mu River: Flowing through Na Tam, Ban Bo is formed from 4 main streams: Nam Ke Stream from the top of Sapa, Na Da stream from Ho Thau, Nam Dinh stream from Khun Ha, Nam Mu stream from Ban Hon, here. are the streams of Da river watershed, mainly supplying water for Ban Chat hydropower, Huoi Quang hydropower and Son La hydropower.

Nam So streams from Ta Leng through San Thang commune (Lai Chau town), Than Sin commune merges with Nam Na stream. This is the main water supply source for urban areas of Lai Chau town and for neighboring communes. Because the terrain of the district is relatively complicated, the rivers have a steep slope, so it is possible to build small and medium-sized hydropower stations.

According to the assessment, the area of Tam Duong district has Diep Dong Giao limestone floor, which is often met with Castes caves, and the underground water source is relatively abundant, but there is no specific exploration result yet, the exploitation is still limited.

4.1.5. Population and ethnic

Tam Duong district has 46,767 people with 7,017 households, including 4,874 people in urban areas, accounting for 11.05% of the population of the district, rural population has 39,234 people, accounting for 88.95% of the population of district and household size is 5.68 people/household, the average population density is 68 people/km2.

Tam Duong district has 12 ethnic groups living together, of which ethnic minorities make up the majority, over 84% the lives of ethnic minorities are still difficult, the poverty rate is high.

4.1.6. Forest resources

The area of forest land in the district is currently 35,675.75 ha, accounting for 46.85% of the natural area, the coverage is 43%, of which forested land is 29,154.41 ha, land for forest regeneration is 8,422 ha, all of which are protective forests, distributed in communes such as: Binh Lu, Ban Bo, Ta Leng, Ho Thau and etc.

In general, the forest resources of Tam Duong are mainly poor forests and rehabilitated forests after exploitation. However, in recent years, the direction of the Party and local authorities has been good in protecting forests, as well as implementing programs. New plantation areas and vegetation are being protected and rehabilitated.

4.2. Methods

4.2.1. Sampling design

Samples are parts of population and be used to estimate for population's parameters. Thus, selecting sample is very important as the first step that affect to our precision and accuracy of estimates.

Firstly, survey the study site was conducted. The simple random sampling was used to set up sample plots in the study site.

9 sample plots were set up, each covering 2000m2 (40m of length x 50m of width) for forest inventory.

The steps for setting up the sample plot are as follows:

Step 1. Determine the direction of the sample plot, quick survey (or estimate) if that direction could contain the entire sample plot area.

- Step 2. Locate the first point of the sample plot. It should be one of the four corners.

Step 3. Use length tape to measure distance from the first point to others. Make sure that they form 90-degree corner by using a compass. In case of lacking compass, the Pythagoras rule could be applied. Similarly, repeat these works for the next corners.

Note: in natural forest (or closed forest), sometime it is invisible from this corner to others. So good skills at using a compass (or Pythagoras rule) will be very helpful to ensure that the sample plot is 100% square (or rectangle) and therefore, in the right area.

- Step 4. Mark all these four corners and then bound sample plot by using color line

4.2.2. Data collection

All trees in the plot with a diameter at breast height from 6 cm (DBH ≥ 6 cm) were marked and, identified by species; their diameter was measured at 1.3 m from the ground. Calipers with a precision of 0.5 cm was used to measure diameter at breast height. Using Blumeleiss hypsometer (accuracy 0.1 m) to randomly measure total tree height of 30 trees in each plot. Canopy closure was determined by app Canopeo or GLAMA (Gap Light Analysis Mobile App).

The measured data was recorded in the following table.

Table 4.1. Forest structure investigation

Forest type: Plot number:

Canopy cover (%): Geographic location:

Surveyor: Date:

Tree No.	**Species**	**$D_{1.3}$ (cm)**	**Total H (m)**	**Crown dia. (m)**		**Note**
				NS	**EW**	
1						
2						
…						

4.2.3. Data analysis

a. Descriptive statistics

Descriptive statistics on forest structure was computed for each sample plot, including:

- Mean diameter
- Stand basal area
- Stand density

b. Forest structure

Excel were used to determine and draw the graph about:

- Frequency distributions
- Species composition

The IVI% was calculated as formula

$$IVI\% = (RD + RBA)/2 \quad (3.1)$$

In which: RD: Relative Density; RBA: Relative Basal Area

$$\text{Relative density} = \frac{Number\ of\ individuals\ of\ the\ species}{Number\ of\ individuals\ of\ all\ the\ species}\ 100\% \quad (3.2)$$

$$\text{Relative basal area} = \frac{Basal\ area\ of\ individual\ of\ the\ species}{Total\ basal\ area}\ 100\% \quad (3.3)$$

The IVI varies from 0% to 100%, trees with IVI% ≥ 5% are important species. According to Daniel Marmillod, the tree species have IVi %> 5%, is important in terms of ecology and presented in composition formula. On the other hand, according to Thai Van Trung (1970), in a forest stand, the tree species group occupy 50% of individuals total of upper tree layer that is considered dominant species groups.

c. Species diversity

Tree diversity indices are also good quantitative descriptors of forest structures (Lexerod and Eid, 2006). Diversity indices are also important input variables for the reconstruction of forest structures used in spatially explicit growth models and computer visualisations (Pommerening, 2006). In general, the species diversity of a community is made up of two components: species richness (or the number of species present) and the evenness, species equitability, or abundance of each species.

To assess tree species diversity for forest states, diversity indices were used, namely species richness, Shannon-Wiener index, Simpson index, Margalef index.

- Species count
- Shannon Index (H’) = $-\sum_{i=1}^{s} p_i \ln p_i$ (3.4)

Where: H’: The Shannon and Weiner index

p_i: The proportion of individuals belonging to species i

ln: The natural log

The Shannon index is an information statistic index, which means it assumes all species are represented in a sample and that they are randomly sampled. In the Shannon index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), ln is the natural log, Σ is the sum of the calculations, and s is the number of species.

- Simpson’s diversity index (D)

- Simpson Index (D) = $1 - \sum_{i=1}^{s} p_i^2$ (3.5)

The Simpson index is a dominance index because it gives more weight to common or dominant species. In this case, a few rare species with only a few representatives will not affect the diversity. In the Simpson index, p is the proportion (n/N) of individuals of one particular species found (n) divided by the total number of individuals found (N), Σ is still the sum of the calculations, and s is the number of species.

- Margalef’s diversity index: $D_{Mg} = \frac{(S-1)}{lnN}$ (3.6)

Where N = the total number of individuals in the sample and S = the number of species recorded.

d. Density

Density formula: N/ha = $\frac{n}{S}$ x 10.000 (3.7)

n is total number of individuals in sample plot; S is sample plot area.

CHAPTER V

RESULTS AND DISCUSSION

5. Results

5.1. Descriptive statistics

Table 5.1. Descriptive statistics of 9 plots

	1	2	3	4	5	6	7	8	9
Mean (cm)	18.30	18.10	12.39	16.15	11.55	19.34	15.37	13.51	14.80
Standard Deviation	10.80	9.80	0.24	0.58	0.26	0.68	0.55	0.51	0.59
Sample Variance	116.90	95.50	18.50	77.91	23.30	102.72	55.89	48.08	65.99
Kurtosis	2.80	2.10	0.31	0.41	7.82	0.43	0.18	1.61	7.87
Skewness	1.70	1.20	0.84	0.98	2.06	0.98	0.89	1.42	2.33
Range	52.80	60.80	21.96	38.52	35.65	51.25	34.06	35.33	54.43
No. trees/ha	1280	1240	1660	1155	1665	1120	940	925	955
Basal area (m^2/ha)	22.68	20.54	11.21	15.35	10.24	20.95	10.77	8.37	10.68

Stem density ranged from 925 tree/ha to 1660 tree/ha (Table 4.1). The mean diameter at breast height (DBH) varied from 11.55 cm to 18.30 cm. The standard deviation and variance of DBH ranged from 0.24 cm to 10.80 cm and 18.50 – 116.90 cm2, respectively. The stand basal area was from 8.37 m2/ha to 22.68 m2/ha.

The skewness of plot 1, plot 2, plot 5, plot 8, and plot 9 was greater than +1, that means the distribution is highly skewed. For remaining four plots, the skewness was between +1/2 and +1, this shows that the distribution is moderately skewed. Besides, the positive value of skewness of all 9 plots, this means the "tail" of the distribution points to the right. All 9 plots had a positive kurtosis value, this indicates that the distribution has heavier tails than the normal distribution.

5.2. Forest structure

5.2.1. Species composition

The species composition refers to the composition and level of participation of plant components in the community, the object is the tree species. The tree species composition of a forest indicates the number of tree species and the proportion of each tree species that make up the forest.

The tree species composition in forest stands not only reflects the biodiversity or the stability of the forest stands, but also gives an indication of the economic value of the forest, thereby proposing silvicultural measures to impact on the forest to improve productivity and forest quality.

The results of tree species composition of tropical moist evergreen broadleaf forests were shown in Table 5.2.

Table 5.2. Important Value Index of tree species in 9 plots

Plot	Species	Scientific name	Basal area (%)	Density (%)	IVI (%)
1	Chò xót	*Schima crenata*	35.05	40.23	37.64
	Cáng lò	*Betula alnoides*	27.45	6.25	16.85
	Bời lời	*Litsea glusinosa*	7.09	17.19	12.14
	Kháo	*Machilus thunbergii*	11.67	12.50	12.09
	Sp2	*Sp2*	6.48	13.28	9.88
	Others	*Others*			11.40
2	Sp3	*Sp3*	12.44	19.76	16.10
	Chò xót	*Schima crenata*	15.60	12.10	13.85
	Sp2	*Sp2*	6.44	5.24	5.84
	Sến đất	*Mimosops elengi*	8.12	3.23	5.68

	Kháo	*Machilus thunbergii*	5.15	5.24	5.19
	Others	*Others*			53.34
3	Chò xót	*Schima crenata*	58.1	41.9	49.96
	Bời lời	*Litsea glusinosa*	15.3	21.4	18.34
	Sp2	*Sp2*	12.7	19.3	16.01
	Trâm tía	*Syzygium zeylanicum*	4.9	6.9	5.89
	Others	*Others*			9.80
4	Chò xót	*Schima crenata*	66.7	46.3	56.49
	Bời lời	*Litsea glusinosa*	16.7	20.4	18.54
	Sp2	*Sp2*	8.2	11.3	9.72
	Others	*Others*			15.25
5	Chò Xót	*Schima crenata*	72.3	69.7	70.97
	Thành ngạnh	*Cratoxylum cochinchinense*	5.1	6.6	5.87
	Sp3	*Sp3*	6.9	6.0	6.44
	Others	*Others*			16.72
6	Chò Xót	*Schima crenata*	53.9	39.7	46.82
	Sp2	*Sp2*	6.9	8.9	7.93
	Sp3	*Sp3*	8.6	6.7	7.63
	Bời lời	*Litsea glusinosa*	4.6	9.4	6.99
	Kháo	*Machilus thunbergii*	3.7	6.7	5.17
	Others	*Others*			25.46
7	Chò xót	*Schima crenata*	64.1	54.3	59.17
	Trâm tía	*Syzygium zeylanicum*	8.2	6.4	7.28
	Others	*Others*			33.55

8	Chò Xót	*Schima crenata*	18.6	26.0	22.26
	Sp3	*Sp3*	23.4	15.1	19.29
	Dẻ trắng	*Lithocarpus dealbatus*	13.8	10.3	12.02
	Sp2	*Sp2*	6.1	6.5	6.30
	Others	*Others*			40.13
9	Sp3	*Sp3*	14.1	21.5	17.80
	Kháo	*Machilus thunbergii*	9.8	10.0	9.88
	Bời lời	*Litsea glusinosa*	11.7	5.8	8.71
	Thành ngạnh	*Cratoxylum cochinchinense*	4.4	8.9	6.63
	Dung giấy	*S. chapaensis*	5.0	7.3	6.19
	Sữa	*Alstonia scholaris*	7.6	4.2	5.88
	Dẻ trắng	*Lithocarpus dealbatus*	4.5	6.8	5.65
	Others	*Others*			39.26

The value of the important value index IVI% of the important species ranged from 5.17% (Machilus thunbergii in Plot 6) to 70.97% (Schima crenata in Plot 5) (Table 4.2 and Figure 4.1). The species composition in the composition formula of 9 sample plots was not much different, but the IVI% of each species was different and there were few species having high economic value. The important tree species in the study area were Schima crenata, Litsea glusinosa, Machilus thunbergii, Sp2, Sp3, ….

The important tree species group appeared in 8 out of 9 plots and the number of important tree species varied in each plot, the lowest number of important tree species was in plots 7 with 2 tree species, the reason may be caused Schima crenata accounted for the high percentage (59.17%), the highest number of important tree species was in plot 9 with 7 species.

In general, the tree species composition in the study area has many tree species, the number of tree species in the forest stand was high, the number of tree species and the number of individuals of each important tree species appeared in each plot were differences, trees having economic valuable was insufficient numbers to participate in the species composition.

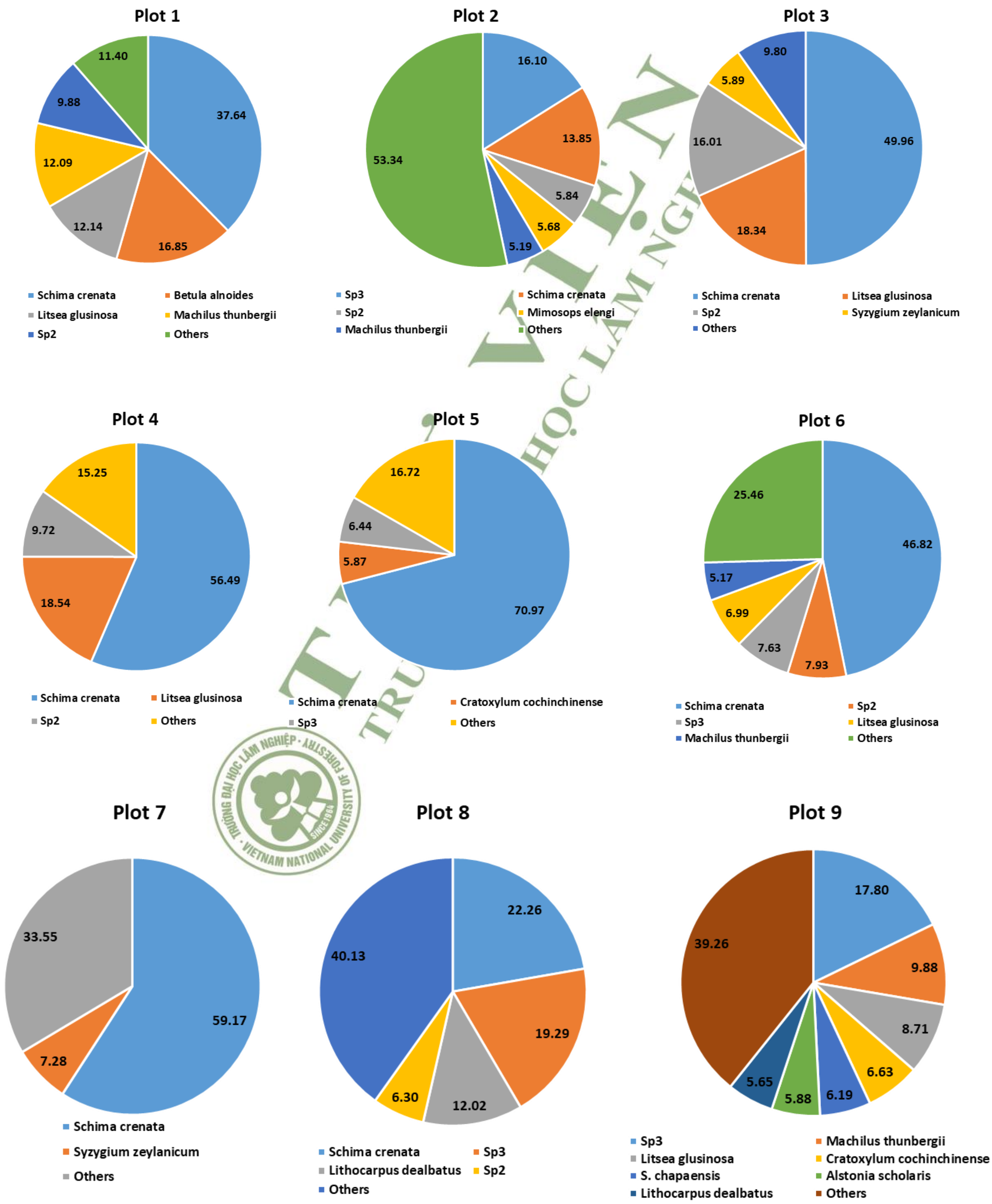

Figure 5.1. Percentage of important species in 9 plots

5.2.2. The number of trees per DBH class

The distribution of the number of trees per diameter class reflects the arrangement rules of the components that make up the tree population in space and time. This is an important basis for statistical and forecasting of forest reserves and yields, so it is an important rule in the structure of forest stands. From this structural rule, we can assess the structure of the forest, propose appropriate silvicultural measures to build plant communities with high productivity and stability. Through the density of each diameter class, we can know the state of the forest and the future development trend. The results of the number of trees per diameter class of tropical moist evergreen broadleaf forests were summarized in Table 5.3 and illustrated in Figure 5.2.

Table 5.3. Status of tree species in the 9 plots according to diameter (cm)

DBH class (cm)	Plot 1	Plot 2	Plot 3	Plot 4	Plot 5	Plot 6	Plot 7	Plot 8	Plot 9
8	46	57	122	75	145	45	52	68	58
12	71	47	103	49	108	38	47	58	48
16	44	45	69	19	53	42	32	22	42
20	36	21	30	34	16	27	19	10	15
24	14	25	6	21	8	19	18	13	10
28	13	18	2	14	0	14	11	7	10
32	9	23		8	1	15	6	6	4
36	5	4		4	0	9	2	0	0
40	5	2		4	2	6	1	1	0
44	2	3		3		7			1
48	2	1				1			2
52	5	1				0			0
56	3					1			0
60	1								1

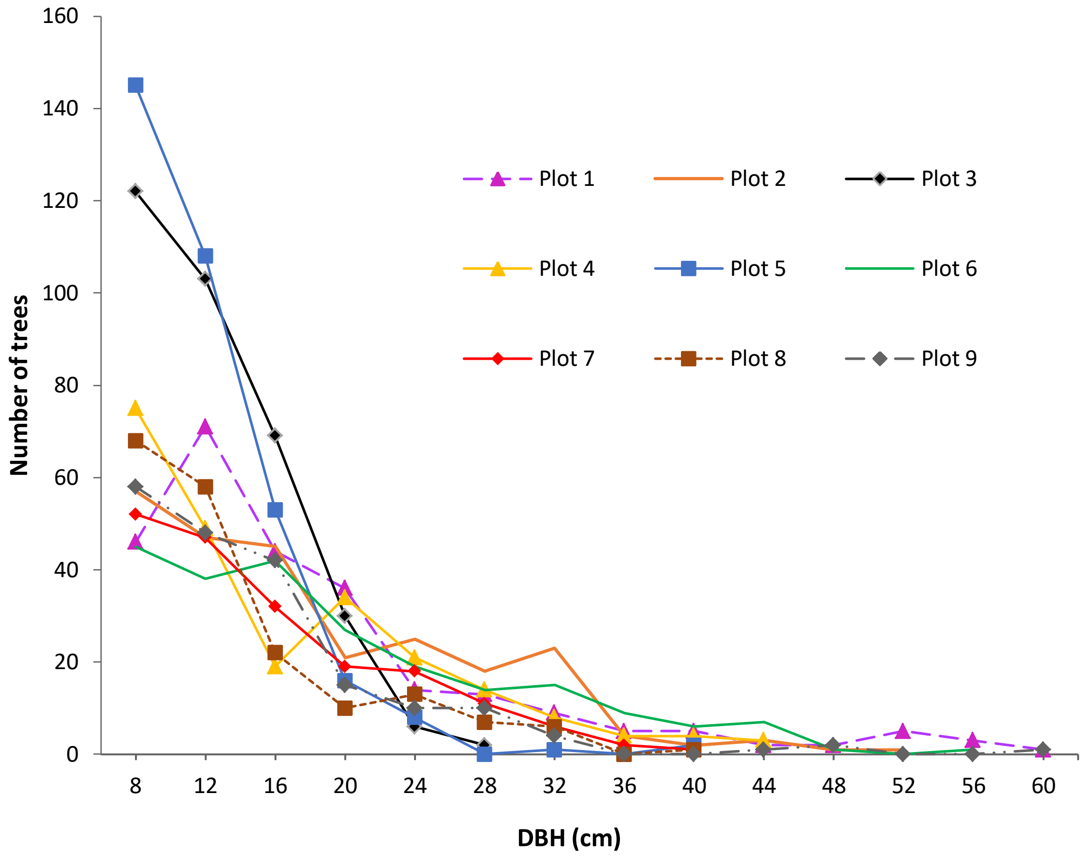

Figure 5.2. Diameter distribution of tropical moist evergreen broadleaf forests in 9 plots

There was virtually no difference in the frequency distributions of the DBH across the nine plots, those distributions were all skewed to the left of the graph (Table 4.3 and Figure 5.2), with the total number of stems were concentrated in the first class or second class that is sufficient enough to replace trees in the upper dbh class in the future (i.e. when the big trees are harvested or when they die) (Aigbe and Omokhua, 2014) or another word, the type of decreasing distribution in tropical rainforests indicates that the regeneration is continuously happening as a consequence of the species' ability to adapt to environments (Ferreira et al. 2015). The implication of this is that the forests are still undergoing regeneration and recruitment, which are vital indicators of forest health and vigour (Jimoh et al. 2011). This is consistent with other reports for two other tropical rainforests (Boubli et al., 2004; Bobo et al., 2006) In addition, all nine plots were lacking large stems (over 70-

cm DBH). This is similar to findings of Pham Quy Van, 2018; Cao Thi Thu Hien and Nguyen Hong Hai, 2018; Nguyen Quang Phuc, 2019; Nguyen Thuy Hong, 2019.

5.2.3. Number of trees per DBH class of important tree species

The important tree species in this study were *Schima crenata* and *Litsea glusinosa*.

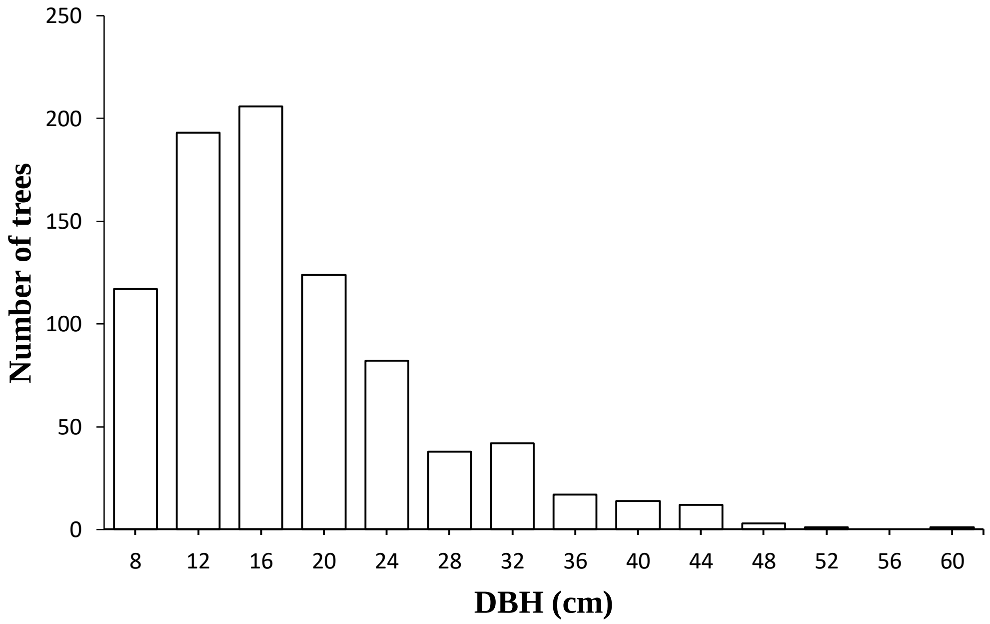

Figure 5.3. Diameter distribution of Schima crenata

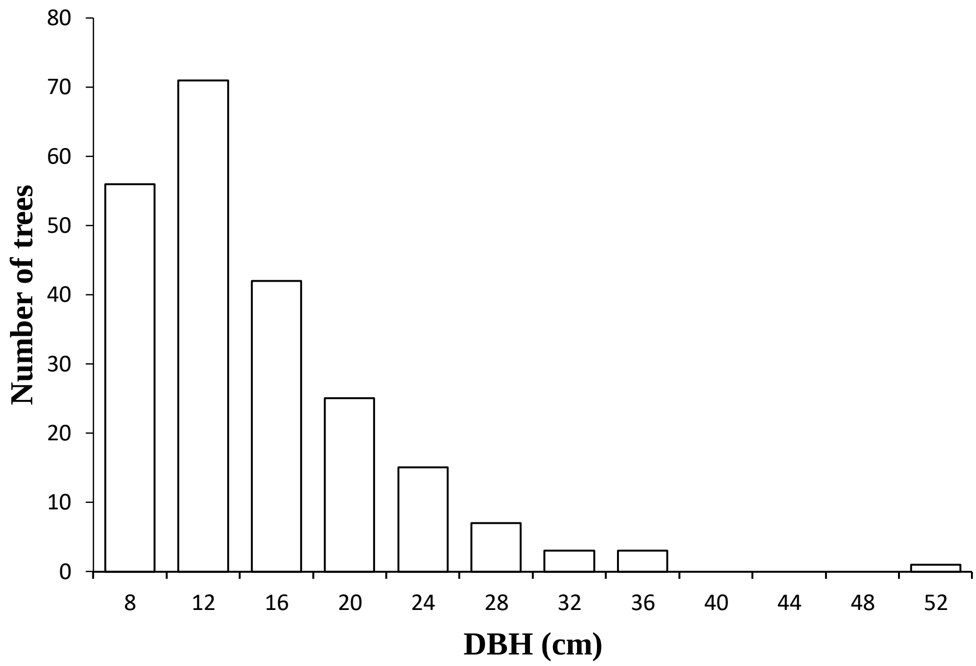

Figure 5.4. Diameter distribution of Litsea glusinosa

Figure 5.3 and Figure 5.4 illustrate the number of trees per DBH class for two tree species, namely Schima crenata and Litsea glusinosa. As typical of tropical forest, the number of stems of Schima crenata and Litsea glusinosa was inversely proportional to diameter sizes, which was also evidenced from the reverse J pattern of the DBH class frequency distribution (Figure 5.3 and Figure 5.4), indication of a healthy recruitment of the individuals in the forest stand. As the diameter increased, there was a decrease in the number of stems (Figure 5.3 and Figure 5.4). The 12 or 16-cm DBH classes which accounted for the highest number of stems, only one or two individuals were encountered in the diameter class of 50 - 60 cm (Figure 5.3 and Figure 5.4).

5.3. Tree species diversity

Tree diversity indices are also good quantitative descriptors of forest structures (Aguirre et al., 2003; Lexerod and Eid, 2006). Diversity indices are also important input variables for the reconstruction of forest structures used in spatially explicit growth models and computer visualisations (Pommerening, 2006a). In general, the species diversity of a community is made up of two components: species richness (or the number of species present) and the evenness, species equitability, or abundance of each species (Pielou, 1966; Patil and Rao, 1994).

5.3.1. Total number of species and families

The number of tree species in 9 sample plots ranged from 14 to 34 tree species, the number of families varied from 12 to 25 families (Table 5.4). The total number of tree species and families was 81 species and 75 families.

Table 5.4. The number of tree species and families for tropical moist evergreen broadleaf forests in 9 plots

Plot	**No. Trees**	**No. Species**	**No. Families**
1	256	19	14
2	248	37	25
3	332	14	12
4	231	22	22
5	333	17	12
6	224	19	12
7	188	26	18
8	185	32	21
9	191	37	23
Total		**81**	**75**

5.3.2. Diversity indices: species richness, Shannon-Wiener index, Simpson index

To assess the tree species diversity of tropical moist evergreen broadleaf forests, diversity indices were used: namely species richness, Shannon-Wiener index, Simpson index, and Magalef index. The result was presented in Table 4.5.

Table 5.5. Diversity indices for tropical moist evergreen broadleaf forests in 9 plots

Plot	Species richness	Shannon-Wiener Index	Simpson Index	Magalef Index
1	19	1.8689	0.7703	3.2461
2	37	3.0262	0.9239	6.5295
3	14	1.6460	0.7352	2.2394
4	22	1.8310	0.7263	3.8586
5	17	1.2895	0.5018	2.7548
6	19	2.1783	0.8062	3.3262
7	26	1.9846	0.6897	4.7742
8	32	2.6779	0.8833	5.9383
9	37	2.9178	0.9135	6.8542

Species richness ranged from 14 to 37 species in tropical moist evergreen broadleaf forests; and the Shannon-Wiener index, Simpson index and Margalef index varied from 1.2895 to 3.0262, from 0.5018 to 0.9239, from 2.2394 to 6.8542, respectively.

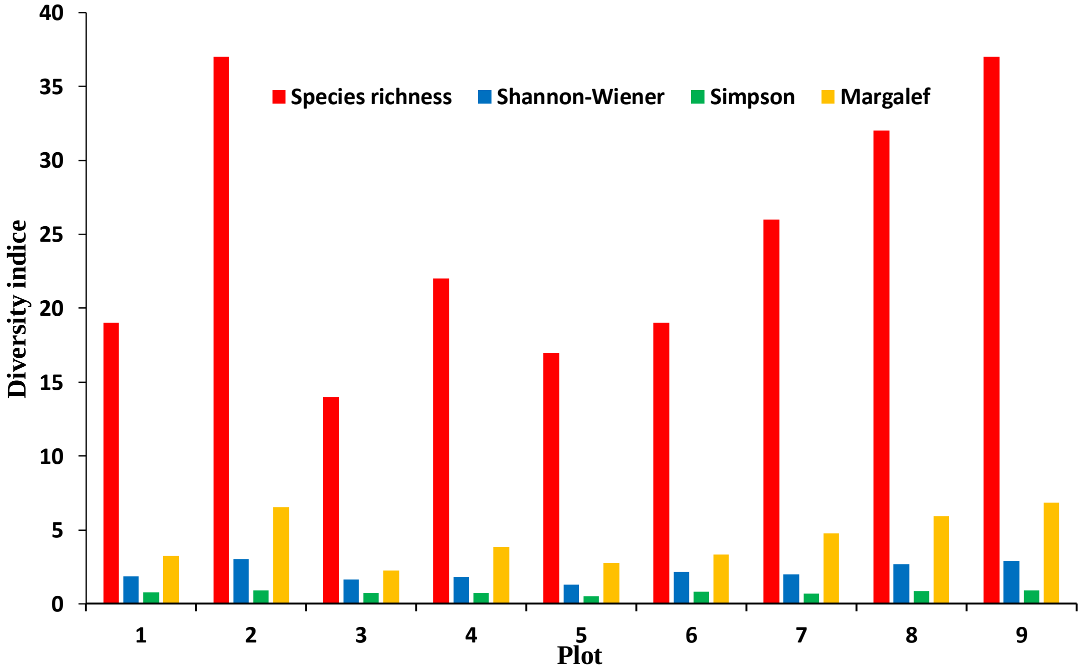

Figure 5.5. Diversity indices in 9 plots

Species diversity of plot 2 and plot 9 is the highest value of 37 species, while the lowest one of 14 belonged plot 3 (Table 4.5 and Figure 4.5). The Shannon – Weiner Index (H') of plot 2 is the highest value of 3.0262, while the lowest one of 1.2895 belonged plot 5. Simpson index of plot 2 is the highest value of 0.9239, while the lowest one of 0.5018 belonged plot 5. Margalef index of plot 9 is the highest value of 6.8542, while the lowest one of 2.2394 belonged plot 3 (Table 4.5 and Figure 4.5).

The four species diversity indices showed that: The abundance as well as the species diversity of natural forest in the study area were relatively high. The forests are distributed close to the living areas of ethnic minorities, therefore, forests were impacted stronger than forests far from residential areas. From the current status of the survey, it is shown that: People exploited rare and valuable timber species, having high economic value and medicinal plants. The exploitation process took place many years ago and was conducted from the foot to the top of the mountains, so the loss of rare and precious species. Therefore, in the process of investigation, it was found: The rate of rare and high-value trees was very little, and the remaining tree species were mainly of low economic value.

6. Discussion

It can be said that the density of from 925 to 1660 stems/ha is much higher than that other tropical rainforests in some nations located in Asia. Lu et al. (2010) witnessed that a total of 428 stems/ha in tropical rainforest of Xishuangbana, China while Small et al. (2004) got 422 stems/ha in Borneo rainforest. In addition, the stand density of the study is higher than those reported from other tropical forests, it also higher than the range of 245 stems/ha and 467 stems/ha stems ha recorded for tropical forests, and 347 stems/ha in tropical deciduous forest located Mexico. According to the research (Kim, 2017), the density of trees of about 650 stems/ha in natural forest in Sin Ho, Lai Chau Province is much less than that of tropical moist evergreen broadleaf forest. Compare to the study (Toan, 2017), the density of this research is much higher than that of in Son La Province of 540 stems/ha. Additionally, the density of tropical moist evergreen broadleaf forest in Tam Duong district, Lai Chau province is nearly the same with the nature forest in Vinh Son, Commune, Vinh Thach district, Binh Dinh province (Duc, 2017).

DBH class distributions in this study fit the reverse J-shaped pattern, with most of the trees in the smaller size classes and fewer in the larger ones. The size class distributions in this study suggest that the forest is at a crucial stage of regeneration and the lack of individuals in the larger size classes could be due to illegal logging of bigger trees by the locals for timber and construction purposes or the fact that the forest has limited species that grow larger than these diameters (Hadi et al., 2009). In an evergreen forest located in

Popa Mountain Park, Myanmar, the study found that lower size classes; 5 - 10 cm and 10 - 15 cm, contributed more than 50% of total tree density in the investigated forests. As well, the lowest size class, DBH 5 - 10 cm, possessed the highest species richness in all of the forests. The higher numbers of species were found in the lower size class in all forest types. The difference in terrain, gradient and slope direction causes differences in the soils, water and microclimate which causes differences in species adaptability (Aye, Y.Y., Pampasit, S (2014).

Diversity indices revealed that the extremely rich forest was more diverse than that of rich forest. Species richness was with about 75 species in tropical moist evergreen broadleaf forest and the Shannon-Wiener index, Simpson index and Magalef index varied from 1.2895 to 3.0262 (medium diversity), from 0.5018 to 0.9239 (medium diversity), from 2.2394 to 6.8542, respectively. The Shannon diversity index values obtained in this study are much lower than those obtained in other studies both in the Republic of Congo and in other tropical forests in the Congo basin compared to other tropical countries. For example, in the forest of centre-west of Republic of Congo in Mbomo-Kelle (Republic of Congo), Shannon diversity index varies from 5.91 to 5.95 in bloc 4 and bloc 9, respectively (Koubouana et al. in press). In the tropical forest of southwest of the Republic of Congo, Koubouana et al. (2015) noted an old secondary forest that the Shannon diversity index was about 3.08, it seems to be similar in this kind of forest in Tam Duong district, Lai Chau Province. In addition, the figure of this study is higher than that of the research in Sin Ho, Lai Chau, about 1.88-2.22 (Kim, 2017). In terms of Simpson index, in tropical moist evergreen broadleaf forest of 0.5018 - 0.9239, lower than the study in Sin Ho, Lai Chau of 0.74-0.84 (Kim, 2017). Regarding Magalef index of from 2.2394 to 6.8542, the value in this study is lower than that of nature forest in Vinh Son, Commune, Vinh Thach district, Binh Dinh province with the number of from 8.404 to 9.103 (Duc, 2017).

CHAPTER VI

CONCLUSIONS, LIMITATIONS AND RECOMMENDATIONS

After researching the structural characteristics and species diversity of tropical moist evergreen broadleaf forests in Tam Duong District, the main findings were included:

In structural characteristics of the tropical moist evergreen broadleaf forests, Stem density ranged from 925 tree/ha to 1660 tree/ha (Table 4.1). The mean diameter at breast height (DBH) varied from 11.55 cm to 18.30 cm. The standard deviation and variance of DBH ranged from 0.24 cm to 10.80 cm and 18.50 – 116.90 cm^2, respectively. The stand basal area was from 8.37 m^2/ha to 22.68 m^2/ha. The diameter distributions were all skewed to the left of the graph, with the total number of stems were concentrated in the first class or second class (8 cm or 12 cm).

The number of trees per DBH class for two important tree species, namely *Schima crenata* and *Litsea glusinosa* was inversely proportional to diameter sizes, which was a decrease in the number of stems as the diameter increased.

In species diversity of the forest, total of 2188 species belonging to 81 species and 75 families with important tree species are *Schima crenata, litsea glusinosa, Sp2* and *Sp3*. Tropical moist evergreen broadleaf forests in the study area was medium diverse with the species richness was from 14 to 37, Shannon - Weiner Index ranged from 1.2895 to 3.0262 and Simpson Index varied from 0.5018 to 0.9239, and Margalef index was from 2.2394 to 6.8542.

Limitations

The sample size of this research was small due to lacking of budget and human resource. The forest structure and tree species diversity were not studied according to the different forest states. Some tree species were not identified.

Recommendations

The further studies should be researched in this study about the changes in forest dynamics along with altitudes. Researches should be conducted with larger sample size and bigger plots.

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APENDIX

Apendix 1. Importance Vegetation Index (IVI%) of 9 plots

Name	Latin name	Density	Basal area (%)	N (%)	IVI %5)
Chò xót	*Schima crenata*	850	42.09	38.85	40.47
Bời lời	*Litsea laucilimba*	223	6.97	10.19	8.58
Sp3		164	6.74	7.50	7.12
Sp2		175	5.86	8.00	6.93
Kháo	*Machilus sp*	93	4.60	4.25	4.42
Trâm tía	*Syzygium zeylanicum*	96	3.30	4.39	3.85
Cáng lò	*Betula alnoides*	16	4.76	0.73	2.75
Thành ngạnh	*Cratoxylum maingayi*	51	1.20	2.33	1.76
Giẻ gai	*Fagus sylvatica*	24	2.20	1.10	1.65
Giẻ trắng	*Lithocarpus proboscideus*	35	1.44	1.60	1.52
Thẩu tấu	*Aporosa microcalyx*	39	0.65	1.78	1.22
Chân chim	*Schefflera arboricola*	31	0.83	1.42	1.12
Re	*Sapindus ocarpus*	17	1.24	0.78	1.01
Ngát	*Gironniera subaequalis*	21	0.90	0.96	0.93
Sến đất	*Mimusops elengi*	8	1.28	0.37	0.82
Dung giấy	*Symplocos laurina*	23	0.55	1.05	0.80
Sữa	*Alstonia scholaris*	14	0.84	0.64	0.74
Ba soi	*Macaranga denticulata*	18	0.59	0.82	0.71
Sổ	*Dillenia indica*	15	0.58	0.69	0.63
Chẹo tía	*ngelhardtia chrysolepis*	15	0.57	0.69	0.63

Ràng ràng mít	*Ormosia balansae*	19	0.38	0.87	0.63
Mã sưa	*Dalbergia tonkinensis*	13	0.54	0.59	0.57
Muồng truồng	*Zanthoxylum avicennae*	6	0.82	0.27	0.55
Lòng mang	*Pterospermum Heterophyllum*	9	0.64	0.41	0.53
Sòi tía	*Triadica cochinchinensis*	3	0.90	0.14	0.52
Chay rừng	*Artocarpus tonkinensis*	12	0.48	0.55	0.52
Máu chó	*Knema corticosa*	10	0.48	0.46	0.47
Sung	*Ficus racemosa*	11	0.39	0.50	0.44
Vạng Trứng	*Endospermum chinense*	4	0.67	0.18	0.43
Mít nài	*Artocarpus rigidus*	10	0.37	0.46	0.41
Chay rõng	*Artocarpus tonkinensis*	10	0.25	0.46	0.36
Dâu da	*Baccaurea sapida*	9	0.26	0.41	0.34
Bùi	*Llex Rotunda*	11	0.16	0.50	0.33
Hoóc quang	*Wendlandia Tinctoria*	10	0.19	0.46	0.32
Đồng tiền	*Hydrotoctyle Verticillata*	4	0.46	0.18	0.32
Muồng đen	*Senna siamea*	5	0.39	0.23	0.31
Bồ hòn	*Sapindus mukorossi*	1	0.55	0.05	0.30
Ba bét	*Mallotus floribundus*	5	0.35	0.23	0.29
Gạo	*Bombax ceiba*	4	0.37	0.18	0.28
Me Rừng	*Phyllanthus emblica linn*	3	0.42	0.14	0.28
Bồ đề	*Ficus religiosa*	6	0.25	0.27	0.26
Lộc vừng	*Barringtonia acutangula*	6	0.19	0.27	0.23
Lim xẹt	*Peltophorum pterocarpum*	5	0.23	0.23	0.23

Sấu	*Dracontomelon duperreanum*	1	0.37	0.05	0.21
Lá nến	*Typha Angustifolia*	7	0.08	0.32	0.20
Hà nu	*Ixonanthes chinensis*	3	0.20	0.14	0.17
Muồng cánh dán	*Hydnocarpus anthelminthica*	5	0.10	0.23	0.17
Trám	*Canarum sp*	3	0.19	0.14	0.16
Thừng mực	*Holarrhena pubescens*	4	0.13	0.18	0.16
Giổi	*Magnolia hypolampra*	4	0.10	0.18	0.14
Gáo	*Anthocephalus chinensis*	3	0.14	0.14	0.14
Gội gác	*Aphanamixis Grandifolia*	4	0.08	0.18	0.13
Bọt ếch	*Glochidion obliquum*	3	0.12	0.14	0.13
Cuống vàng	*Gonocaryum lobbianum*	3	0.10	0.14	0.12
Dung lông	*Symplocos racemosa*	3	0.09	0.14	0.11
Mần tang	*Litsea cubeba*	4	0.04	0.18	0.11
Xoan mộc	*Toona sureni*	1	0.15	0.05	0.10
Cứt ngựa	*Teucrium viscidum Blume*	3	0.05	0.14	0.09
Ba gạc	*Rauvolfila verticillata*	3	0.05	0.14	0.09
Xoan đào	*Pygeum arboreum*	2	0.08	0.09	0.09
Trường vải	*Amesiodendron chinense*	3	0.04	0.14	0.09
Mán đỉa	*Archidendron Clypearia*	3	0.03	0.14	0.09
Sp4		1	0.11	0.05	0.08
Vắp	*Mesua Ferrea*	1	0.10	0.05	0.07
Trám trắng	*Canarum album*	2	0.05	0.09	0.07

Sồi phảng	*Lithocarpus fissus*	1	0.09	0.05	0.07
Trâm trắng	*Syzygium wightianum*	2	0.04	0.09	0.07
Hu đay	*Trema orientalis*	1	0.07	0.05	0.06
Sp5		1	0.07	0.05	0.06
Bồ kết	*Fructus Gleditschiae*	2	0.02	0.09	0.06
Xoan nhừ	*Choerospondias axillaris*	1	0.07	0.05	0.06
Thanh thất	*Ailanthus triphysa*	1	0.06	0.05	0.05
Gội nếp	*Aglaia spectabilis*	1	0.05	0.05	0.05
Núc nác	*Oroxylum indicum*	1	0.04	0.05	0.04
Ké	*Xanthium strumarium*	1	0.03	0.05	0.04
Bứa	*Garcinia oblongifolia*	1	0.02	0.05	0.03
Vả	*Ficus auriculata*	1	0.02	0.05	0.03
Hoắc quang	Wendlandia Tinctoria	1	0.02	0.05	0.03
Gòn	*Ceiba pentandra*	1	0.01	0.05	0.03
Lá		1	0.01	0.05	0.03
Nhọ nồi	*Eclipta prostrata*	1	0.01	0.05	0.03