MINISTRY OF EDUCATION AND TRAINING
MINISTRY OF AGRICULTURE AND RURAL DEVELOPMEN
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SOME SCIENTIFIC BASES FOR REHABILITATION OF NATURAL FORESTS IN BUFFER ZONE OF NAMPUI NATIONAL PARK, SAYABOURY PROVINCE, LAOS PEOPLE DEMOCRATIC REPUBLIC

MAJOR: SILVICULTURE
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SUMMARY OF PhD DISSERTATION

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Supervisor: Prof.Dr. Pham Van Dien

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LIST OF PUBLICATIONS

1. Bouaphanh Chanthavong, Nguyen Van Tu, Nguyen Thi Thu Ha. Characteristics of tree layer in secondary forests in buffer zone of Nampui National Park, Sayabury province, Lao PDR, *Journal of Forestry Science and Technology, VNUF, No.4, 2019, page 33-39.*

2. Nguyen Van Tu, Bouaphanh Chanthavong, Nguyen Thi Thu Ha. Characteristics of regeneration tree in secondary forests in buffer zone of Nampui National Park, Sayabury province, Lao PDR, *Journal of Forestry Science and Technology, VNUF, No.4, 2019, page 67-73.*

PREFACE

1. The Urgency of dissertation topic

In fact, in order to rehabilitation poor natural forests into forests that are better in terms of both quantity and quality, it is necessary to apply silvicultural technical solutions with appropriate impacts to each forest object. The impact on natural forests is not unrealistic (Pham Xuan Hoan et al., 2004). In the world and in Vietnam as well as in Laos, there have been good lessons on poor natural forest rehabilitation, but there are also places where the application is not successful. Lessons learned show that to be successful, the solutions applied must be science-based

A total 60000 ha of nature forest that classified by purpose use is production forest at buffer zone of Nampui National Park (NPNP), Lao People's Democratic Republic (Lao PDR), of which about 7000 ha are extremely poor forest and poor forest (Department of Forestry, Ministry of Agriculture and Forestry of Laos (MAF), 2018). In order to achieve the business goals and using potential, advantages of natural forests, silvicultural techniques are needed to quickly rehabilitation these extremely poor and poor natural forests. In addition to the socio-economic solutions gained in the process of rehabilitation poor forests not only such as the solution to establish and implement a system of policies, laws and financial support, but also needed silviculture technique solutions. However, because there is little knowledge, emperical about the scientific basis for silvicultural technique solutions to rehabilitation secondary forests, so that the rehabilitation of secondary forests is facing many difficulties, notably:

- The characteristic, as well as forest rehabilitation ability have not been determined.
- The forest object has not yet been classified based on characteristics reflecting its rehabilitation ability.
- Not yet proposing suitable silvicultural solutions for each forest object.

In order to contribute to solving the above-mentioned problems, we conducted the doctoral dissertation topic "***Some scientific bases for rehabilitation of natural forests in buffer zone of Nampui National Park, Sayaboury province, Laos People Democratic Republic***". This conducted is very necessary and has high theoretical and practical significance.

2. Scientific and practical significance of the dissertation

+ Scientific significance. The disertation has provided and analized data related to spatial and temporal scale of poor secondary forests in Nam Pui National Park.

+ Practical significance. The dissertation has proposed silvicultural options and established the checking - table for dividing secondary forest which are applied by specific solution of silviculture in the study sites.

3. New finding of disertation

+ The dissertation has analyzed a number of technical bases for rehabilitation poor secondary forests in the buffer zone of Nam Pui National Park.

+ The dissertation has developed the options, models and established the checking table for silvicultural solutions based – forest division in the study sites.

4. Dissertation structure

In addition to the introduction and conclusions, references, appendices, the dissertation is structured into 4 chapters.

A total of 133 pages of dissertation, of which: Introduction - 4 pages; Chapter 1: Literature review – 20 pages; Chapter 2: Contents and research methodologies - 23 pages; Chapter 3: Natural conditions of the study area - 4 pages; Chapter 4: Results and discussion - 73 pages; Conclusion, existence, recommendation 4 pages; References 8 pages. In this dissertation, there are 34 tables, 29 pictures.

CHAPTER 1: LITERATURE REVIEW

The dissertation has referred and summarized about 3 main related issues: (1). The concept of natural forest rehabilitation; (2). Achievements in forest rehabilitation research and (3). Application of research in forest rehabilitation.

1. About the concept of natural forest rehabilitation

An overview of research issues has helped to make a proper and comprehensive awareness of natural forest rehabilitation. Accordingly, the rehabilitation of natural forests is not only the rehabilitation of bare land and non-forested lands to become forests, but also the transformation of a forest of young forest or natural forest into a better forest with the standing stock higher, best possible forest quality and meeting well - off the business goals.

With the above viewpoint, forest rehabilitation is a long-term process and needs suitable impacts technical solutions to each forest object and each stage of forest rehabilitation.

2. About achievements in forest rehabilitation research

An overview of the research has helped to identify the impact of technical solutions and some achievements on natural forest rehabilitation. The outstanding achievements of this overview can be summarized as:

- Achievements in research on structure, regeneration and growth;
- Achievements in the research of dividing forest objects to impacting;
- Achievements in research and application of silvicultural technical solutions.

3. About limitation of the research

Although many achievements have been made, researches on the application of natural forest rehabilitations in the world still limited, which can summarize a number of key issues:

- The structural characteristics and regeneration as well as rehabilitative ability of the natural forest have not been identified for a specific object.
- The object of forest impact has not yet been classified, so it is impossible to propose appropriate solutions to shorten forest rehabilitative time for each specific object.
- The impact of key factors on the decision to rehabilitation natural forests in the region has not been determined. The impact of key factors on the decision to rehabilitation natural forests in the region has not been determined.

4. Identify research problems for this dissertation

With the research object of the dissertation is poor natural forests, so that dissertation chooses to rehabilitation forests from poor natural forests to become better natural forests (from poor forests to forests with volumemeeting exploitation (logging) standards, M_{log} =150m^3 ha^{-1}).

Because of from poor natural forests to better natural forests, the scientific bases for rehabilitating natural forests in the dissertation are the characteristics of forests; variation of these characteristics over space (plots) and over time (according to the survey year). The improved application of impact object division methods as a basis for proposing technical solutions is very necessary for these research.

CHAPTER 2: CONTENTS AND RESEARCH METHODOLOGIES

2.1. Research contents

2.1.1. Researching characteristics of volume and quality of trees species, shrubs, topography and soil

a) Volume
b) Distribution of plot by volume level
c) Shrubs and fresh carpets
d) Topography and soil

2.1.2. Researching variation of tree layer

a) Species composition
b) Species Improtant valune index
c) Indices of speceis divesity
d) Indices of structure and growth

2.1.3. Researching variation of regeneration layer

a) Species composition
b) Indices of speceis divesity
c) Indices of growth and quality

2.1.4. Proposing some forest rehabilitative solutions

a) Selecting group of tree species by potential, target tree species
b) Classifying forest object for rehabilitation
c) Recommended a number of silvicultural technical solutions suitable for forest rehabilitation.

2.2. Research method

2.2.1. Methodology

One of the important products of the dissertation is silvicultural technical solutions to rehabilitation poor secondary forests available in the study area. In order to propused suitable silvicultural technical solutions, it is necessary to classify forests into groups of similarities on indicators that have important and decisive influence on forest rehabilitation. Therefore, it is necessary to research the forest status characteristics as well as the variation of the factors that reflect the structure, growth and quality of the forest.

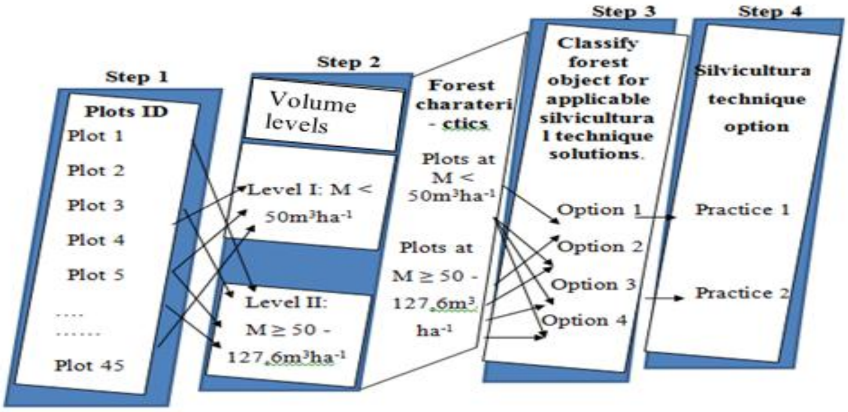


Figure 2.1. An overview of the research methodology for poor secondary forest rehabilitation

2.2.2. Field surveys

2.2.2.1. Sample plot design

The extensive field surveys were conducted with 45 typical standard forest plots of 40 m × 25 m, established in buffer zone of NPNP during the period of 2013 - 2015 (see Figure 2.2). In each the plot, there were 5 subplots with size of 5m x 5 m one subplot at the center of the plot, and the four subplots in four corners of the plot).

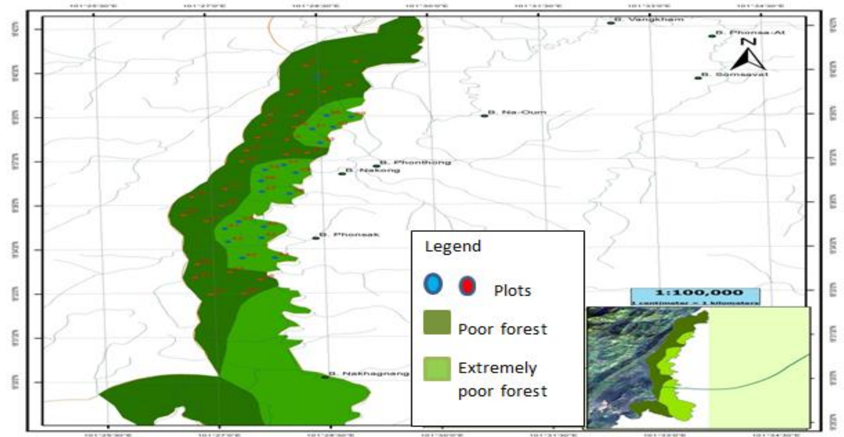


Figure 2.2. The map of sample plots at buffer zone of the research sites

2.2.2.2. Data collection

Tree layer

In the sampling plot, the information about the trees, woody and herbaceous climbers were collected with tree name (Laos name, scientific name and Vietnamses name); diameter at breast height ($D_{1.3}$ cm); top height (H_{vn} m), low branch height (H_{dc} m) and canopy diameter (D_t m) for all trees with DBH from ($D_{1.3}$) ≥ 6 cm in the plots.

- Assessing the quality of plants through morphological indicators according to 3 levels: well - off (A); medium (B), moderate (C).

Regeneration layer (sapling and seedling)

In the subplot 5m × 5 m was used to collect the information on regenerations, shrubs, with species name (Vietnamese name, Laos name, scientific name) and top height for the regeneration of $D_{1.3}$ < 5 (the top height not more than 5 m)

Data collections of the field survey are recorded according to table

2.2.3.Time span of field survey

Field survey is conducted at 2 times, each time is separated by 2 years.

The first time: from December 2013 to March 2014 (hereby 2013)

The second time: December 12, 2015 January 2016 (hereby 2015)

2.2.4. Data treatment

Data analysis was carried out following equations:

(i). Similarity of species between study plots was determined by using Ward Linkage Method.

(ii). Species Important Value Index (%) by the following equation:

$$IV_i\% = \frac{N_i\% + G_i\%}{2} \quad (2.1)$$

$$Gi\% = \frac{G_i}{G}100\ (m^2) \quad (2.2)$$

$$Ni\% = \frac{N_i}{N}100 \quad (2.3)$$

Measure of species diversity was measured by the following indices of species diversity: Menhinick Species Richness Index: Shannon-Weiner Species Diversity Index (H'):

All where, S = ΣNo. of species

N = Σ No. of trees

N_i = the number of trees of the species i^{th}

H = Mean height of forest type

$D_{1.3}$ = Diameter at breast height

(vii). Sorensen's similarity index (between tree species at canopy layer and sampling layer)

$$SI = 2C*100/(A+B) \quad (2.4)$$

Where, A: Total number of tree species

B: Total number of sapling species

C: Number of species which occuring at both tree layer and regeneration layer).

- Tree density per hectare (ha). $N/ha = \frac{N}{S}.10000$(trees/ha) (2.5)

Where, N_{ha-1} = the number of trees per ha.

N_{plot} = the number of trees in a plot.

S_{plot} = the area of each plot in m^2 ($2000m^2$).

- Regeneration density per hectare (ha): $N/ha = \frac{\sum Ni*10^4}{\sum s_i}$ (tree/ha) (2.6)

Where, N_{ha-1} = the number of regeneration per ha.

ΣN_i = the number of regeneration in 5 subplot.

ΣS_{ti} = the area of 5 subplots in m^2 ($125m^2$).

The division of impact subjects is done under 4 options. The difference of 4 options are the composition, the number of variation (from 1 to 15 variations)

Option 1: Base on densities of potential, target tree species in tree layer - $N_{cmđ}$ *(Circular No 29/2018/TT - BNNPTNT):*

+ If densities of potential, target tree species > 500 individual ha^{-1}, applicated Natural forest maintenance.

+ If densities of potential, target tree species < 500 individual ha^{-1}, applicated Enrichment of natural forest.

Option 2: Base on densities of potential, target tree species in regeneration layer - $N_{tsmđ}$ *(Circular No 29/2018/TT - BNNPTNT):*

+ If densities of potential, target tree species in regeneration > 1000 individual ha^{-1}, applicated Natural forest maintenance.

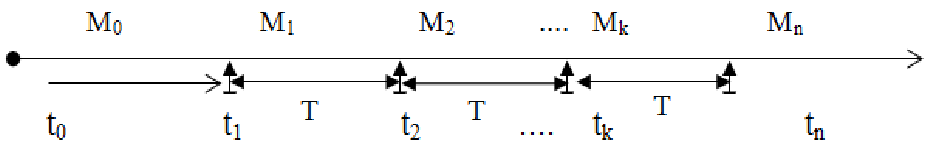
+ If densities of potential, target tree species in regeneration < 1000 individual ha^{-1}, applicated Enrichment of natural forest.

Option 3: Base on both $N_{ccmđ}$ and $N_{tsmđ}$, *applicated:* NNatural forest maintenance or Enrichment of natural forest.

Option 4: Base on variation (3 suboption); 15; 7 and 5 variations*):* topographyy, soil, vegetation: 1. Elevation (m); 2 Soil layer (m); 3. Gradient; 4. Number of potential, target tree species in tree layer ; 5. Diameter at the beast heigh D (cm); 6. H (m); 7. Densities ha^{-1}; 8. Densities of potential, target tree species; 9. Basal area; 10. Grant volume; 11. Grant volume fo good quality tree layer; 12. Grant volume fo bad quality tree layer; 13. Canopy; 14. Number of potential, target tree species in regeneration; 15. Densities of potential, target tree species in regeneration. Statistical quantitative methods for calculating and processing option were computed with the support of R

- Calculating and processing option applicated Natural forest maintenance

Processing of natural maintenance showed in fig 2.3



(Source: Pham Van Dien and Pham Xuan Hoan, 2011)

- Mean increament of volume in periods M_0 and M_n is P_{M0} (%/year):

$$P_{MO}(\%) = \frac{(M_n - M_o)x200}{(M_n + M_o)t_n} \quad (2.7)$$

$$t_n > (K-1)T = T/2 \quad (2.8)$$

$$A'_n \leq A_n \leq 100\% \quad (2.9)$$

$$t' = log(1 + p_{M_o})\left(\frac{100^{K+1}}{(100-1)(100-1)^{K}(1+P_{M_1})^{KT}}\right) + KT \quad (2.10)$$

$$a_o(\%) = \frac{M_{ot}}{M_o}100 \tag{2.11}$$

$$a_k(\%) = \frac{100^k x\, a_0}{(100-1)^k} \tag{2.12}$$

$M_{cnd(1-k)} = M_{cnd(1)} + M_{cnd(2)} + .. + M_{cnd(k)}$

$$= \frac{1xM_o(1+P_{Mo})^{t1}}{100} \text{x}(0+1+(1+P_{M1})^T+.+(1+P_{M1})^{(K-1)T}) \tag{2.13}$$

(Source: Pham Van Dien and Pham Xuan Hoan, 2011)

Where all:

M_0 = Grand total volumetrees at time survey ha^{-1}
a_0 = The percentage of good volume trees at time survey ha^{-1}
I = Intensity of salvage logged volume trees (% ha^{-1})
K = Grand total number of salvage logged (1, 2, 3,...)
T = Time spanning between two salvage logged (year)
tn = Grand year total from the first point M_0 to $M_{qđ}$ (year)
An = The percentage of grand total good volume trees (100%ha^{-1})
$M_{QĐ}$ = Grand total good volume trees at this point t_n (150m^3 ha^{-1})

CHAPTER 3: NATURAL CONDITIONS OF THE STUDY AREA

3.1. Nampui National Park

The park is located in the Northeastern region of Sayaboury province, (Figure 3.1). The park is distributed over seven different communes in three districts: Phieng, Pak Lai and Thoong Mi Say. The geographic coordinates of the park are from 18°13' to 19°2' North latitude and between 101°05' and 101°31' East longitude. The Northern borders of NPNP adjoin Thailand. Regarding the buffer zone area, the total natural area is 60000 hectares.

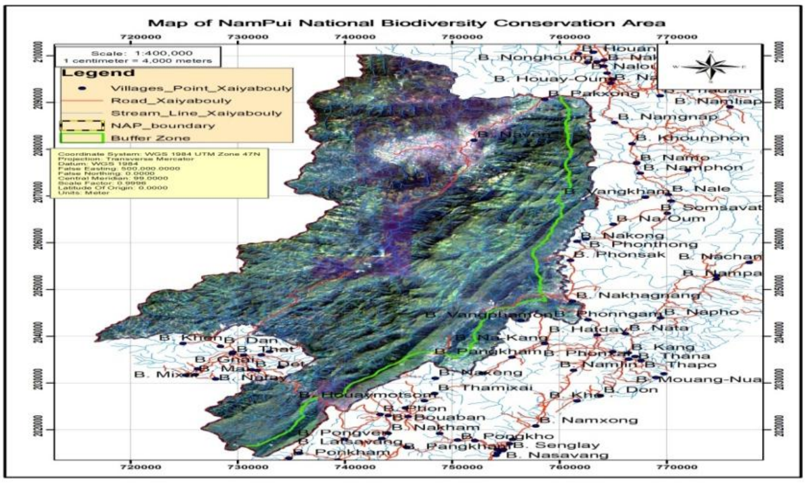


Figure 3.1. Geographic location, boundaries and area of Nampui national park

Annual mean temperature ranges from 22°C to 25°C. The total mean rainfall ranges from 124,5mm $month^{-1}$. Rainfall is concentrated from May to November, accounting for 70 -75% of annual rainfall.

The Park has two main stream systems. They are headwaters of two rivers in the area: Pui River, Phun River and Loop River, Nham River. There are many small streams, relatively high density, distributed evenly over the area of the national park. The stream flow is often greater in the rainy season, and during the dry season they are not dry but have low water flow.

The geological background of Nampui national park is formed from the following four rock groups: acid magma rock group, mainly granite rocks; neutral alkaline magma group, mostly basalt; shale group, mainly clay schist, mica schist and accreting matter group along streams, mostly new alluvium.

Brown-red feralit soil developed on neutral alkaline magma rock: About 16.0% of the total areas are these soils. They often appear at Eastern slopes of NPNP range. The soil layer is thick (> 100 cm), slightly acid with PHkcl

3.2. Buffer zone of Nampui National Park

The bufer zone located in the East – South of the Nampui national park

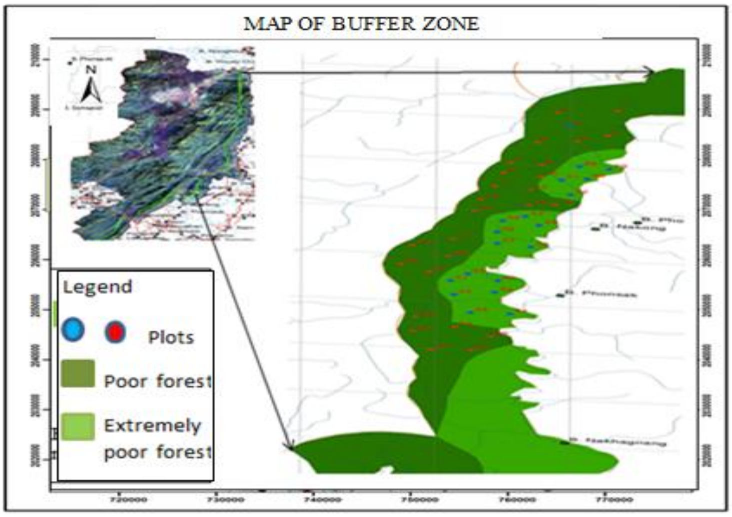


Figure 3.2. Map of buffer zone in Nampui national park

- The East borders with Phieng district, including villages: Naven, Nam Xong and Pak Lai district, including: Ban Nhai and Vang Pha Mon village.
- Southeast borders with Thong Mi Say district's Kham village.
- The West is adjacent to Nampui National Park.
- The North borders Phieng district
- Relative elevation: less than 700m above sea level.
- Slope: less than 35 degrees, most with a slope of 15 to 30 degrees.
- Soil is less acidic. Soil texture is light and medium. Humus horizon is also thin. These soils are also appropriate for forest tree species.
- Forest vegetation: from extremely poor to medium volume. Main tree species: *Chukrasia tabularis*, *Erythrophleum fordii*, *Liquidambar formosana*, *Canarium tramdenum*, *Schima wallichii* (DC.) Korth, *Dillenia heterosepala* Finet et Gagnep, v.v.

CHAPTER 4: RESULTS AND DISCUSSION

4.1. Characteristics of volume and quality of trees species, shrubs, and topography and soil

4.1.1. Characteristics of volume

Volume and quality parameters of forest in the study site are showed in the table 4.1. There was a significant difference among the year

Table 4.1. Characteristics of volume

Years	Characteristics of growth		Characteristics of tree quality	
	Mean volume ha^{-1} (M^3/ha)	Mean growth year Pm (%)	Good quality volume (%)	Under moderate (%)
2013	61,86	-	84,2	15,8
2015	64,99	2,6	86,4	13,6

Volume of studied forests ranges from 7,66 to 127,62 m^3ha^{-1}which belong the poor and medium forest statuses**.** The mean proportion of trees in good quality volume is 85% showing that the rehabilitation potential of these forests is rather good. Mean increament of volume in all forest compartments (in both volume class) is 2.6%.

4.1.2. Similarity of volune among plots

To divide the volume of plots into homogeneous formation, all the 45 plots were subjected to similarity analysis using clustered dendrogram. This analysis divided the volume in to 2 cluster groups (CGS) at 50% similarity level (see Fig. 4.1)

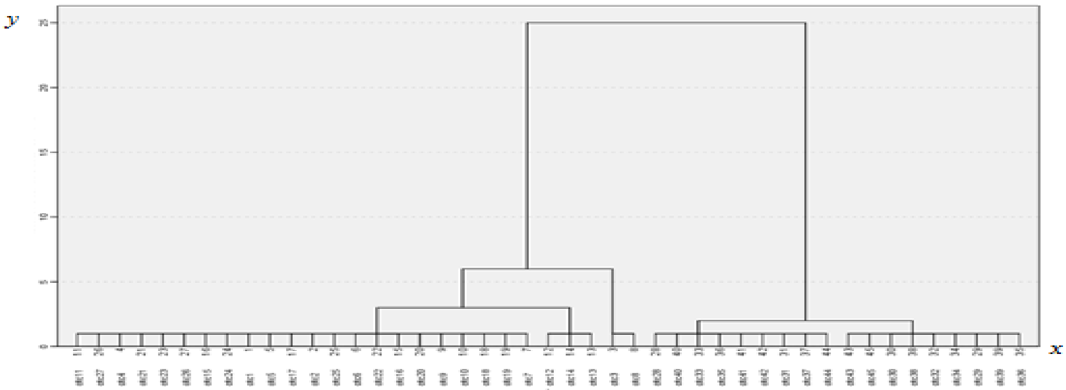


Figure 4.1. Dendrogram index of similarity between plots

Abbreviation at the figure are: OTC1: Plot1; OTC2: Plot2 v.v.

Figure 4.1 showed that CG1(Extremely poor forest: ($M \leq 50m^3ha^{-1}$) comprised of 18 plots (plots ID: 28; 40; 33; 36; 41; 42; 31; 37; 44; 43; 45; 30; 38; 32; 34; 29; 39 và 35). CG2 (Poor forest: $50 < M \leq 127{,}62\ m^3ha^{-1}$) comprised of 27plots (plots ID: 11; 26; 4; 21; 23; 27; 16; 24; 1; 5; 17; 2; 25; 6; 22; 15; 20; 9; 10; 18; 19; 7; 12; 14’ 13; 3 và 8)

It presents that area propotion of the CG1 and CG2 in the forets (see figure 4.2).

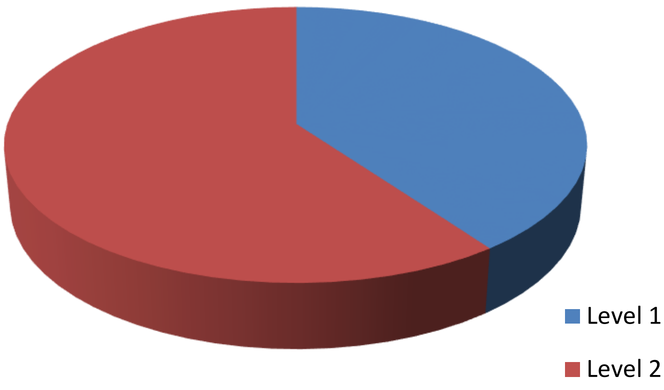


Figure 4.2. Area propotion of CG1 (level 1) and CG2 (level 2)

Level 1 ($M \leq 50m^3ha^{-1}$); level 2 ($50 < M \leq 127{,}62\ m^3ha^{-1}$)

4.1.3. Shrub, canopy closed and openness (%)

Shrub species and canopy was calculated for the 2 years separately and showed in table 4.2.

Table 4.2. Shrub indices for 2 forest volume level

Volume Level	Year 2015			Year 2013			Fluctuarion	
	$\overline{H}_{cb,tt}$ (m)	Canopy closed (%)	Canopy opennes (%)	$\overline{H}_{cb,tt}$ (m)	Canopy closed (%)	Canopy openness (%)	$\Delta H_{cb,tt}$ (m)	ΔCanopy (%)
I	0,89	67,71	32,29	0,68	42,41	57,59	0,21	25,3
II	0,81	63,89	36,11	0,72	38,74	61,26	0,09	25,15

Where: $H_{cb,tt}$: *mean height of shrub (m)*

$\Delta H_{cb,tt}$: *mean variation of shrubi (m)*

Δcanopy: *mean variation of canopy closed (%)*

The coverage of shrub and grass is medium (38,74 - 67,71%) and mean height of shrubs ranges from 0.68 to 0.89m.

The results revealed that, shrub parameters of each volume level (forest type) decreased from the level I to the level II

The shrub dominations are Lomariopsidaceae, Cannaceae, Apocynaceae, Solanaceae, Zingiberaceae.

4.1.4. Topography and soil

Topographic - soil characteristics of the study site include:

- According to gradient level: (i). Under 10 degree there are 2 plots; (ii) From 10 to 20 degree with 20 plots; (iii). From 20 to 30 degree there are 14 plots; and (vi) 9 plots greater 30 degree.

- According to elevation level: (i). Elevation < 300m above sea level, there are 22 plots; (ii) elevation from 300 to 500m has 8 plots and (iii). elevation from 500 - 900 m has 15 plots

4.2. Variation of tree layers

4.2.1. Forest Composition

4.2.1.1. Volume level I

The compositions were studied at level I for tree layer. The details of tree layers at this level is shown in Table 4.3.

Table 4.3. Composition of tree layer at level I

No	Year 2013				Year 2015			
	Species / Scientific name	Ni (%)	Gi (%)	IV (%)	Species / Scientific name	Ni (%)	Gi (%)	IV (%)
I	**5 species**	**40,54**	**52,17**	**46,35**	**5 species**	**41,6**	**50,83**	**46,2**
1	*Schima wallIhii*	14,92	17,01	15,16	*Schima wallIhii*	16,29	17,51	16,2
2	*Trema orientalis*	7,57	13,37	10,47	*Trema orientalis*	6,76	12,34	9,35
3	*Ormosia pinnata*	4,9	10,11	7,51	*Ormosia pinnata*	6,24	9,97	8,1
4	*Castanea satvia*	7,8	6,86	7,33	*Castanea satvia*	7,8	6,97	7,38
5	*Liquidambar formosana*	5,35	4,82	5,88	*Liquidambar formosana*	4,51	4,04	5,17
II	**62 other species**	**59,46**	**47,83**	**53,65**	**66 other species**	**58,4**	**49,17**	**53,8**
I+II	**67 species**	**100**	**100**	**100**	**71 species**	**100**	**100**	**100**

Where: N_i%: The number of trees of the species i ha^{-1}.
IV %: The Important Value of species i ha^{-1} (%) .
LK: other species.

In the level I, on the year 2015, 71 species were recorded, on the year 2013 67 species were recorded, these species belonging to 32 families such as: Fabaceae, Fabaceae, Dipterocarpaceae, Euphorbiaceae, Anacardiaceae, Podocarpaceae, and so on. Out of 71 tree species, only 5 species showed a significant preference to this forest volume level (see table 4.3).

4.2.1.1. Volume level II

The compositions were studied at level II for tree layer. The details of tree layers at this level is shown in Table 4.4.

Table 4.4. Composition of tree layer at level II

No	Year 2013				Year 2015			
	Species / Scientific name	Ni (%)	Gi (%)	IV (%)	Species / Scientific name	Ni (%)	Gi (%)	IV (%)
I	**6 species**	**39,54**	**42,02**	**42,78**	**6species**	**40,04**	**40,83**	**42,48**
1	Castanea satvia	10,93	10,74	10,84	Castanea satvia	10,9	10,8	10,85
2	Liquidambar formosana	9,87	9,27	9,57	Liquidambar formosana	9,5	9,18	9,34

No	Year 2013				Year 2015			
	Species / Scientific name	Ni (%)	Gi (%)	IV (%)	Species / Scientific name	Ni (%)	Gi (%)	IV (%)
3	Schimaw allihii	6,43	6,41	6,42	Schimaw allihii	6,24	6,39	6,31
4	Erythrophleum fordii	4,31	5,76	5,73	Erythrophleum fordii	4,31	5,74	5,67
5	Engelhardtiac hrysolepis	3,94	5,38	5,16	Engelhardtiac hrysolepis	3,73	5,26	5,2
6	Machilus bonii	4,06	4,46	5,06	Syzygium cumini	5,36	3,46	5,11
II	**37 other species**	**60,46**	**57,98**	**57,22**	**37 other species**	**59,96**	**59,17**	**57,52**
I+II	**43 spescies**	**100**	**100**	**100**	**43 species**	**100**	**100**	**100**

Where: N_i%: The number of trees of the species i ha^{-1}.

IV %: The Important Value of species i ha^{-1} (%) .

LK: other species.

In the level II, on the year 2015 and 2013, 43 species were recorded belonging to 27 families such as: Fabaceae, Fabaceae, Dipterocarpaceae, Euphorbiaceae, Anacardiaceae, Podocarpaceae, and so on. Out of 43 tree species, only 6 species showed a significant preference to this forest volume level (see table 4.4).

4.2.1.2. Similarity between volume level I and level II in terms of species composition

The Sorensen's index was calcualted to compare the similarity between the level I and level II is shown in table 4.5 (see Table 4.5).

Table 4.5. Percent of similarity stem between level I and level II

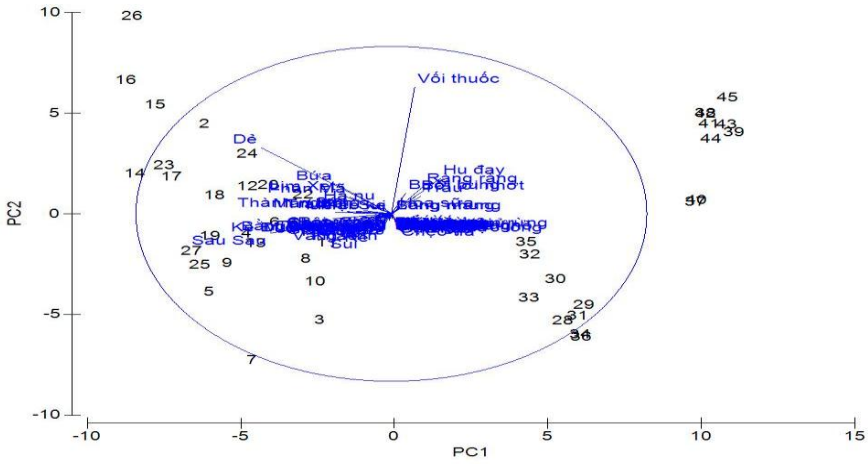
Year	Volume level	Sorensen's index			
		Level/2013		level/2015	
		I	II	I	II
2013	I	100			
	II	60,00	100		
2015	I	97,10	63,15	100	
	II	60,55	98,82	61,95	100

Where: Lelve I: ($M < 50$ m^3/ha^{-1})

Level II: ($M \geq 50$ - 127,62 m^3/ha^{-1})

Comparing the similarity index between tree species at 2 level showed that, the mean forest has the highest percentage of species common (98,82%). The lowest percentages of species common was at the level (60,00%).

Redundancy analysis species common of 45 plots relation level I and level II see Figure 4.3.



Figurre 4.3. Redundancy species analysis of 45 plots

The relationships between tree species and 2 volume forest level (see fig.4.3): the first and second axes accounted for 18,00 and of tatal species respectivey and the species divide in four groups.

- Group 1: species domination: *Garcinia oblongifolia* Champ. ex Benth, *Millettia ichthyochtona, v.v.*

- Group: species domination, *Lagerstroemia speciosa*, *Saraca dives*

- Group 3: species domination, *Trema orientalis*, *Ormosia pinnata. v.v.*

- Gruop 4: species domination, *Vatica odorata, Prunus arborea, v.v.*

4.2.2. Species diversity indices and important value

Tree species diversity indices were calculated for the 2 volume levels showed in table 4.6

Table 4.6. Species diversity indices

Volume levels	**Species diversity indices**									
	Year 2013					**Year 2015**				
	∑ ni	**∑N**	**R**	Δ_{si}	$\mathbf{\Delta_{sh}}$	**∑ ni**	**∑N**	**R**	Δ_{si}	$\mathbf{\Delta_{sh}}$
I	449	67	3,16	0,95	1,53	577	71	2,95	0,95	1,52
II	1601	43	1,07	0,95	1,43	1715	43	1,01	0,95	1,40

- Important value:

Volume level I

Base with an IV% value of their species (see table 4.3), the species composition equation for the level I is:

+ For year 2015: 16,20Scwa + 9,35Tror + 8,10Orpi + 7,38Casa + 5,17Lifo + 53,80others

+ For year 2013*:* 15,16Scwa + 10,47Tror + 7,51Orpi + 7,33Casa + 5,88Lifo + 53,65others

Where: Scwa: Schima wallihii; Tror:Trema orientalis;Orpi:Ormosia pinnat; Casa:Castanea satvia; Lifo: Liquidambar formosana

Volume level II

Base with an IV% value of their species (see table 4.4), the species composition equation for the level II is:

+ For year 2015: 10,8Casa + 9,34Lifo + 6,31Scal + 5,67Erfo + 5,20Enhr + 5,11Mabo + 57,52 others

+ For year 2013: 10,84Casa + 9,57Lifo + 6,42Scal + 5,73Erfo + 5,16Enh + 5,06Sycu + 57,22others

Where: Casa: Castanea satvia; Lifo: Liquidambar formosana; Erfo: Erythrophleum fordii; Scal:Schimaw allihii; Enhr: Engelhardtiac hrysolepis; Sycu: Syzygium cumini

- Species diversity indice:

The Menhinick Richness index varies from 1,07 at the level II to 3,16 at level I . This index were likely gradually increasing with decreasing the volumeof trees. For two other indexes, there are a trend of slight increasing from the extremely poor to poor forests, but not significant difference. For example, The Simpson index ranged from 1,43 to 1,53, and the Shannon index ranged from 0.95 to 0.95. It means that there is only slightly different in terms of species diversity among these forest types; and the foor forest likely has the highest level of species diversity.

4.2.3. Growth and structural parameters

Growth and structural parameters of the year are showed in the Table 4.7, there was a significant difference among the year.

Table 4.7. ***Growth and structural parameters variation***

Volume levels	Year 2013				Year 2015				Mean variation				
	$D_{1.3}$ (cm)	Hvn (m)	G (m^2/ha)	M (m^3/ha)	$D_{1.3}$ (cm)	Hvn (m)	G (m^2/ha)	M (m^3/ha)	$\Delta D_{1.3}$ (cm)	ΔHvn (m)	ΔG (m^2/ha)	ΔM (m^3/ha)	PM %
I	15,07	12,68	9,4	40,5	14,03	11,77	10,50	42,86	-0,52	-0,45	0,55	1,18	2,91
II	16,29	10,56	12,4	76,1	16,47	11,49	13,1	79,75	0,09	0,46	0,35	1,825	2,40
Bình quân	**15,80**	**11,41**	**11,20**	**61,86**	**15,49**	**11,60**	**12,06**	**64,99**	**-0,15**	**0,10**	**0,43**	**1,57**	**2,60**

Where, G: Mean basal area ha^{-1} (m^2/ha^{-1}); M: Mean stand volume ha^{-1}(m^3/ha^{-1}).

$\Delta D_{1..3}$: Mean variation of diameter at breat height per year (cm/$year^{-1}$); ΔHvn: Mean variation of height per year (m/$year^{-1}$);ΔG: Mean variation of basal area per year (m^2/$year^{-1}$ha). ΔM: Mean variation of stand volume per year ($m^3/ha^{-1}/year^{-1}$).

- Stand volume level I: (i) Mean diameter at breat height ($D_{1.3}$) at the year 2013 = 15,07 cm, year 2015 = 14,03 cm, $\Delta D_{1.3}$ = - 0,52cm. (ii) Mean height at the year 2013 = 12,68m, year 2015 = 11,77, ΔHvn = - 0,45m. (iii) Mean stand volume at the year 2013 = 40,5, year 2015 = 42,86, mean variation fo vulume: ΔM = 1,18m^3/$year^{-1}$/ha^{-1}. Growth rate: PM% = 2,91%/$year^{-1}$.
- Stand volume level II: ((i) Mean diameter at breat height ($D_{1.3}$) at the year 2013 = 16,29 cm, year 2015 = 16,47 cm, $\Delta D_{1.3}$ = 0,09cm. (ii) Mean height at the year 2013 = 10,56m, year 2015 = 11,49, ΔHvn =0,46m. (iii) Mean stand volume at the year 2013 = 76,1, year 2015 = 79,57, mean variation fo vulume: ΔM = 1,82m^3/$year^{-1}$/ha^{-1}. Growth rate: PM% = 2,4%/$year^{-1}$

4.3. Variation of regeneration

4.3.1. Species composition

4.3.1.1. Volume level I

The compositions were studied at level I for regeneration layer. The details of regeneration layers at this level is shown in Table 4.8.

Table 4.8. Composition of regeneration layer at level I

No	Year 2013			Year 2015		
	Species/scientific name	**n_i**	**K_i (%)**	**Species/scientific name**	**n_i**	**K_i (%)**
I	**6 species**	250	49,7	**6 species**	268	40,13
1	*Vatia odorata*	55	11,8	*Vatia odorata*	58	8,68
2	*Castanea satvia*	43	8,64	*Castanea satvia*	46	6,89
3	*Cinnamomum parthenoxylon*	42	8,37	*Cinnamomum arthenoxylon*	45	6,74
4	*Canarium tramdenum*	41	8,11	*Canarium ramdenum*	44	6,59
5	*Syzygium cumini*	37	7,05	*Syzygium cumini*	40	5,99
6	*Cinnamomum arthenoxylon*	32	5,73	*Cinnamomum arthenoxylon*	35	5,24
II	**56 others**	269	50,3	**62 others**	400	59,87
I+II	**62**	**519**	**100**	**68 loài**	**668**	**100**

Where: N_i%: The number of trees of the species i ha^{-1}.

LK: other species.

In the level I, on the year 2015, 68 species were recorded, on the year 2013, 62 species were recorded, these species belonging to 29 families such as: Fabaceae, Fabaceae, Dipterocarpaceae, Euphorbiaceae, Anacardiaceae, Podocarpaceae, and so on. Out of 68 tree species, only 6 species showed a significant preference to this forest volume level (see table 4.3).

4.3.1.2. Volume level II

The compositions were studied at level II for regeneration layer. The details of regeneration layers at this level is shown in Table 4.9.

Table 4.9. Composition of regeneration layer at level II

No	Year 2015			Year 2013		
	Species/scientific name	**n_i**	**K_i (%)**	**Species/scientific name**	**n_i**	**K_i (%)**
I	5 species	355	33,93	7 species	443	47,38
1	*Castanea satvia*	95	9,08	*Castanea satvia*	93	9,95
2	*Syzygium cumini*	87	8,32	*Syzygium cumini*	85	9,09
3	*Canarium tramdenum*	63	6,02	*Canarium tramdenum*	61	6,52
4	*Elaeocarpus griffithii*	56	5,35	*Elaeocarpus griffithii*	54	5,78
5	*Garcinia oblongifolia*	54	5,16	*Garcinia oblongifolia*	52	5,56
6				*Archidendron clypearia*	50	5,35
7				*Cinnamomum arthenoxylon*	48	5,13
II	67 others	691	66,07	59 others	492	52,62
I+II	72 species			66 species	935	100

Where: N_i%: The number of trees of the species i ha^{-1}.

LK: other species.

In the level II, on the year 2015, 72 species were recorded. Out of 72 tree species, only 5 species showed a significant preference to this forest volume level.

Year 2013, 66 species were recorded belonging to 31 families such as: Fabaceae, Fabaceae, Dipterocarpaceae, Euphorbiaceae, Anacardiaceae, Podocarpaceae, and so on. Out of 43 tree species, only 7 species showed a significant preference to this forest volume level (see table 4.8).

4.3.1.3. Similarity regeneration layer between volume level I and level II in terms of species composition

The Sorensen's index was calcualted to compare the similarity between the level I and level II is shown in table 4.10.

Table 4.10. Percent of similarity stem between level I and level II

Year	**Volume levels**	**Volume levels**	
		I	II
2013	I	100,00	70,31
	II	70,31	100,00
2015	I	100,00	66,16
	II	66,16	100,00

Where: Lelve I: (M < 50 m^3/ha^{-1})

Level II: (M ≥ 50 - 127,62 m^3/ha^{-1})

Comparing the similarity index between tree species at 2 level showed that, the mean forest has the highest percentage of species common (70,31%). The lowest percentages of species common was at the level (66,16%).

4.3.2. Species diversity indices and important value

Regeneration species diversity indices were calculated for the 2 volume levels showed in table 4.11

Table 4.11. Species diversity indices

Volume levels	**Species diversity indices**									
	Year 2013					**Year 2015**				
	∑ ni	**∑N**	**R**	Δ_{si}	Δ_{sh}	**∑ ni**	**∑N**	**R**	Δ_{si}	Δ_{sh}
I	519	62	2,16	0,94	1,87	668	68	2,63	0,96	1,61
II	935	66	2,15	0,95	1,65	1046	72	2,23	0,92	1,54

- Important value:

Volume level I

Base with an Ki% value of their species (see table 4.7), the species composition equation for the level I is:

+ For year 2015: 8,68Vaod + 6,89Casa + 6,74Cipo +6,59Sycu + 5,99 Catr+5,24Cipa + 59,87other

+ For year 2013: 11,8Vaod + 8,64Casa + 8,37Cipo +8,11Sycu + 7,05Catr + 5,73Cipa + 50,30 other

Where : Vaod: Vatia odorata; Casa: Castanea satvia ; Cipo: Cinnamomum porthe ; Sycu : Syzygium cumini; Catr : Canarium tramdenum; Cipa: Cinnamomum parthenoxylon

Volume level II

Base with an Ki % value of their species (see table 4.8), the species composition equation for the level II is:

+ For year 2015: 9,08Casa + 8,32Sycu + 6,02Catr + 5,35Elgr + 5,16Gaob + 66,07others

+ For year 2013: 9,95Casa + 9,09Sycu + 6,52Catr + 5,78Elgr+5,56Gaob+ 5,35Arcl+ 5,13Cipa+ 52,71others

Where: Casa: Castanea satvia; Sycu: Syzygium cumini; Catr: Canarium tramdenum; Elgr:Elaeocarpus griffithii; Gaob: Garcinia oblongifolia; Arcl: Archidendron clypearia; Cipa: Cinnamomum parthenoxylon

- Species diversity indice:

The Menhinick Richness index varies from 2,15at the level II to 2,16 at level I . This index were likely gradually increasing with decreasing the volumeof trees. For two other indexes, there are a trend of slight increasing from the extremely poor to poor forests, but not significant difference. For example, The Simpson index ranged from 1,54 to 1,87, and the Shannon index ranged from 0.92 to 0.96. It means that there is only slightly different in terms of species diversity among these forest types; and the foor forest likely has the highest level of species diversity.

4.3.3. Growth indices, qualities and parents of regeneratinon layer

4.3.3.1. Voluume level I

- *Regeneration structural characteristics by the height*

Mean growth height at year 2013 and 2015 is presented in figure 4.4

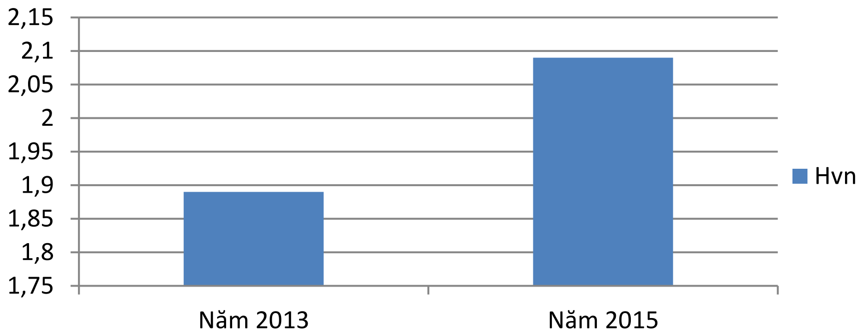


Figure 4.4. *Mean growth height of regeneration*

Mean growth height at 2013, 1015 is 1,89m, 2,09m. Respectively. Growth mean of height is 10cm year^{-1} (see Fig. 4.4)

- The total percent of regeneration per hectare by height classes of regeneration layer is presented in figure 4.5.

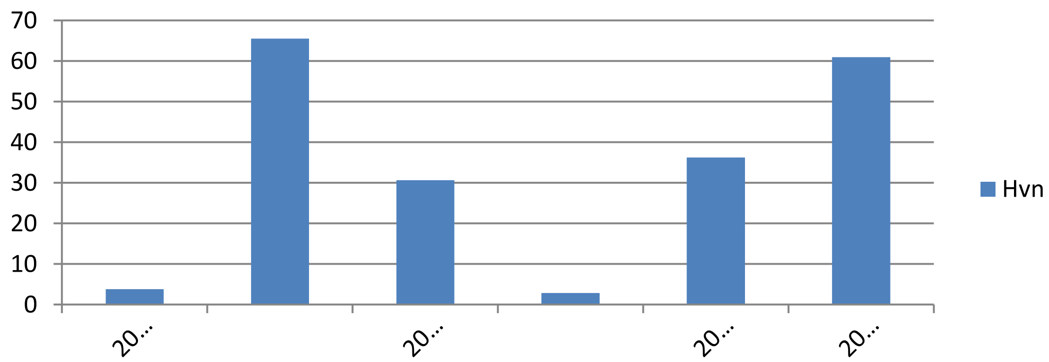


Figure 4.5. The tendency of No.of height regeneration stems classes

The figure 4.5 shows the trend of regeneration structure by their height along 2 years. This analysis shows that, level I have the greatest percentages of regeneration height in the 1,5m - 2m range, they account for from 32% to 42%. The lowest percentages of regeneration height in the 1 -2,5m range, only from 5 -8%).

Regeneration density was found to be maximum in the year 2015 (1549 seedlings ha^{-1}) and minimum (674 seedlings ha^{-1}).

- Quality

- The total percent of regeneration per hectare by quality of regeneration layer is presented in figure 4.6.

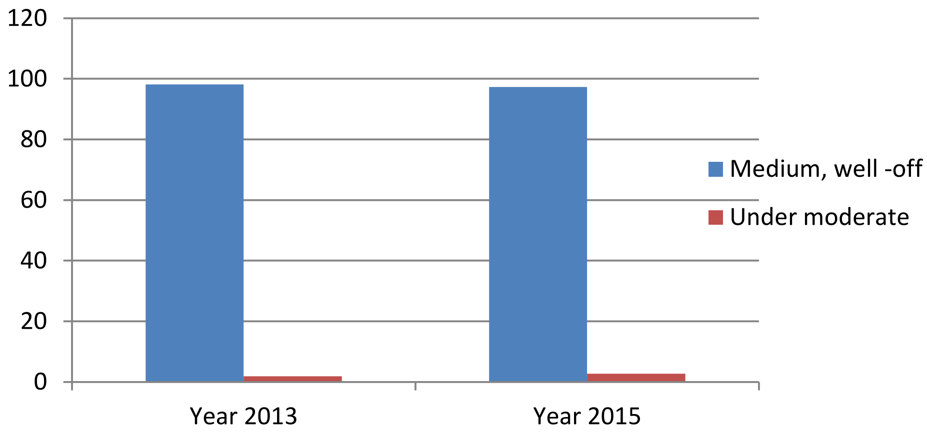


Figure 4.6. The percent of regeneration per hectare by quality

The figure 4.6 shows the trend of regeneration structure by their quality along 2 years. This analysis shows that, level I have the greatest percentages of regeneration quality in the medium, well off, they account for from 96% to 98%. The lowest percentages of regeneration quality in the under moderate, only from 4% -2% respectively.

4.3.3.2. Volume level II

- *Regeneration structural characteristics by the height*

Mean growth height at year 2013 and 2015 is presented in figure 4.7

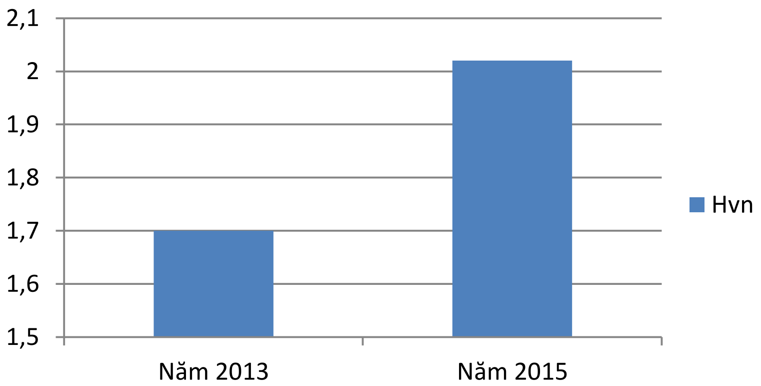


Figure 4.7. Mean growth height of regeneration

Mean growth height at 2013, 1015 is 1,89m, 2,09m. Respectively. Growth mean of height is 10cm $year^{-1}$ (see Fig. 4.7)

- The total percent of regeneration per hectare by height classes of regeneration layer is presented in figure 4.8.

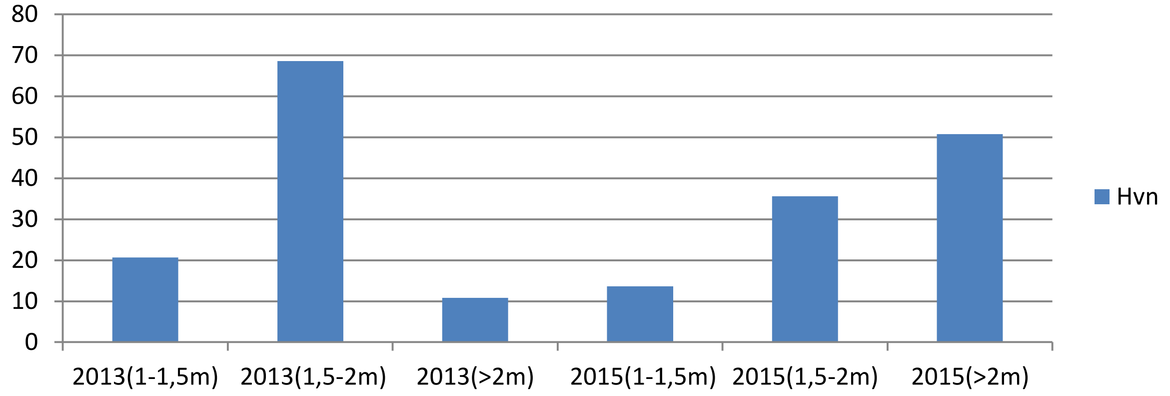


Figure 4.8. The tendency of No.of height regeneration stems classes

The figure 4.8 shows the trend of regeneration structure by their height along 2 years. This analysis shows that, level I have the greatest percentages of regeneration height in the 1,5m - 2m range, they account for from 42% to 64%. The lowest percentages of regeneration height in the 1 -2,5m range, only from 5 -8%).

Regeneration density was found to be maximum in the year 2015 (1549 seedlings ha^{-1}) and minimum (674 seedlings ha^{-1}).

- Quality

- The total percent of regeneration per hectare by quality of regeneration layer is presented in figure 4.9.

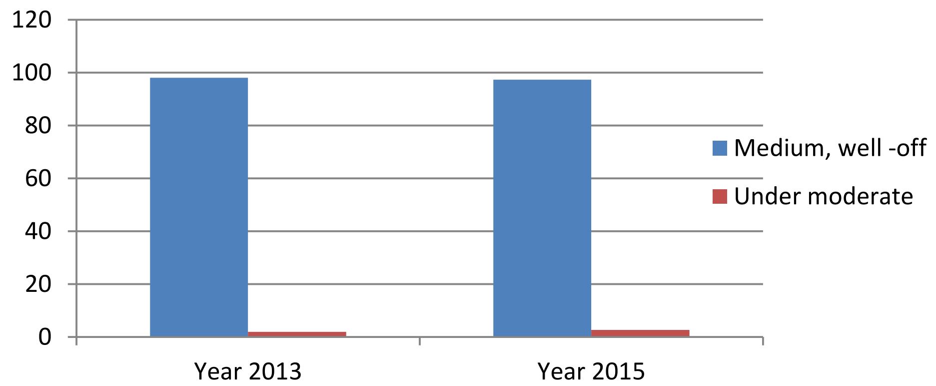


Figure 4.9. The percent of regeneration per hectare by quality

The figure 4.9 shows the trend of regeneration structure by their quality along 2 years. This analysis shows that, level I have the greatest percentages of regeneration quality in the medium, well off, they account for from 97% to 99%. The lowest percentages of regeneration quality in the under moderate, only from 3% -1% respectively.

4.4. Forest rehabilitative solutions

4.4.1. Selected purpose plant species for forest restoratio

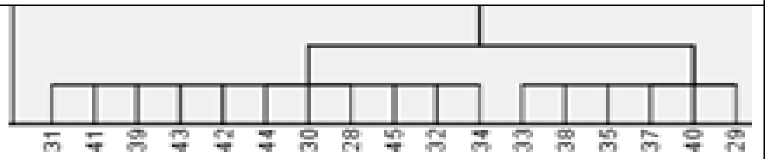
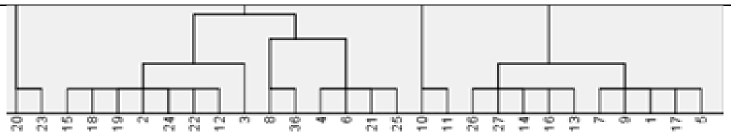
The disertation has identified 33 species of plant (tree and regeneration layer) for rehabilitation (business) purposes based on 8 selection criteria for the research subjects. Out of 33 target tree species, the number of target plant species in groups VI and VII is mainly, timber groups I to III have very few plant species..

4.4.2. Classify forest object for applicable silvicultural technique solutions

Similarity of applicable silvicultural technique solutions between plots

To divide the plots into homogeneous formations by 5 variables, all the 45 plots were subjected to similarity analysis using clustered dendrogram. This analysis divided the plot in to 2cluster groups at 50% similarity level and shown in table 4.12.

Table 4.12. The number plots of 2 groups of Similarity of applicable silvicultural technique solutions (5 variables)

No	Silvicultural technique action	Number plot	Plot ID
1	Enrichment of natural forest	17	
2	Nurtural of natural forest	28	

Out of 45 plots, 17 plots for applicable enrichment and 28 plots for Nurture

4.4.4. Forest rehabilitative solutions

4.4.4.1. Enrichment of natural forest

a) Species for enrichment:

Out of 33 speceis for rehabilitative forest purpose, 5 species were selected. The details of species enrichment are shown in Table 4.13.

Table 4.13. Species for enrichment

TT	Species			C_j	Order	Timber group
	Vietnamses name	Scientific name	Laoses name			
1	Giổi xanh	*Mihelia mediocris* Dandy	Ham xai	0.977	1	IV
2	Vàng tâm	*Manglietia conifera*	Can leung	0.955	2	IV
3	Lim xanh	*Erythrophleum fordii*	Ca cha	0,942	3	II
4	Táu mật	*VatIa odorata*	Xi dông	0,932	4	II
5	Re hương	*Cinnamomum parthenoxylon*	Khe hom	0,911	5	II

b) Criteria for planting: Planting with seedlings sowing from seeds, being pregnant, seedlings height of 1 m or more, seedlings nurtured and cared for at least 1 year in the nursery;

c) Creating land areas for planting trees (chopping tape): to perform in gaps with an area of less than 1,000 m2 or where forest trees are unevenly distributed;

Arrange planting strips along contour lines in areas with steep slopes above 25°; land area with steep slope below 25 ° to arrange strip in aspect east-west

d) Time span Planting: in the spring or summer-autumn

e) Planting density: 500 trees ha^{-1}, each strip planting 2 lines of same trees species.

g) Tree planting distance: Line to line 4m x 4m. Tree to tree: 2m x 2m

h) Dig hole size: 30cm x 30cm x30cm

i) Take care of tree planted enrichment: take care in the first 3 years after planting, at least 2 times per year.

4.4.4.2. Natural forest maintenance

The exploration of the optimal plan for each forest volume level are summarized in the table 4.14.

Table 4.14. The optimal plan for salvage logging nurtural natural forest

M_o (m^3ha^{-1})	a_o (%)	I (%)	K (lần)	T (năm)	tn (năm)	An (%)	$M_{QĐ}$ (m^3/ha)
30	40	20	5	8	117,9	100	150
	50	15	5	8	102,6	100	150
	60	15	4	8	98,3	100	150
	70	15	3	8	94,1	100	150
	80	20	1	16	84,7	100	150
	90	10	1	16	78,7	100	150
40	40	25	4	12	101,2	100	150
	50	15	5	8	88,1	100	150
	60	20	3	12	82,8	100	150
	70	20	2	16	73,5	100	150
	80	20	1	16	70,1	100	150
	90	10	1	16	64,2	100	150
50	40	25	4	12	89,9	100	150
	50	15	5	8	76,8	100	150
	60	25	2	16	68,8	100	150
	70	20	2	12	66,2	100	150
	80	20	1	16	58,9	100	150
	90	10	1	16	52,9	100	150
60	40	25	4	12	80,7	100	150
	50	15	5	8	67,6	100	150
	60	25	2	16	59,6	100	150
	70	20	2	16	53,0	100	150
	80	20	1	16	49,7	100	150
	90	10	1	16	43,7	100	150
70	40	25	4	12	72,9	100	150
	50	15	5	8	59,8	100	150
	60	25	2	16	51,8	100	150
	70	20	2	16	45,3	100	150

M_o (m^3ha^{-1})	a_o (%)	I (%)	K (lần)	T (năm)	tn (năm)	An (%)	$M_{QĐ}$ (m^3/ha)
	80	20	1	16	41,9	100	150
	90	10	1	16	35,9	100	150
80	40	25	4	12	66,2	100	150
	50	15	5	8	53,1	100	150
	60	25	2	16	45,0	100	150
	70	15	1	8	36,0	100	150
	80	20	1	16	35,1	100	150
	90	10	1	16	29,2	100	150
90	40	20	5	8	62,4	100	150
	50	15	5	8	47,1	100	150
	60	25	2	16	39,1	100	150
	70	20	2	16	32,6	100	150
	80	10	3	8	29,9	100	150
	90	10	1	16	23,2	100	150

Compared to the optimal salvage logged option for each specific plot, under the same conditions of current volume, good quality tree ratio and annual growth rate, the optimal salvage logged brings very well practical.

Table 4.15. Forest rehabilitation time comparison

Year	**Non salvage logged (I = 0, K = 0, T = 0)**	**Optinal salvage logged**	**Year shortened (năm)**
The number of years needed to bring volume from M_o to $M_{QĐ}$ (years)	55,80	39,30	16,50

Abbreviation in the table are:

M_0 = Grand total volumetrees at time survey ha^{-1}

a_0 = The percentage of good volumetrees at time survey ha^{-1}

I = Intensity of salvage logged volumetrees (% ha^{-1})

K = Grand total number of salvage logged (1, 2, 3,...)

T = Time spanning between two salvage logged (year)

tn = Grand year total from the first point M_0 to $M_{qđ}$ (year)

An = The percentage of grand total good volumetrees (100%ha^{-1})

$M_{QĐ}$ = Grand total good volumetrees at this point t_n (150m^3 ha^{-1})

- Non salvage logged, 55,8 years needed to bring volume from M_0 to $M_{QĐ}$ = *150m^3 ha^{-1}.*

- Optinal salvage logged, 39,3 years needed to bring volume from M_0 to $M_{QĐ}$ = *150m^3 ha^{-1}. Resulted, 17 years* shortened

CONCLUSIONS - LIMITATION - SUGGESSTIONS

1. Characteristics of volumeand quality of trees species, shrubs, and topography and soil

a) Volumetrees

- The natural forests were selected for our research are extremely poor, poor and medium secondary forests with volumetree ranging from 7.66 to 127.62 m^3 ha^{-1}. However, the proportion of good quality volume at an mean of 85% is a favorable condition for forest rehabilitation in the study area.

- Based on the level of differentiation of forest volumehas divided the 45 plots into 2 groups to assess the characteristics of forests (group 1, M <50 m^3 and group 2, M = 50.00 -127.62 m^3ha^{-1}). .

b) Shrubs and fresh carpets, Topography and soil

- Shrub, fresh carpet have medium canopy coverage (38.74 - 42.41% in 2013 and 63.89 - 67.71% in 2015). The mean height of shrubs from (0.68 - 0.72 m in 2013 and 0.81 - 0.89 m in 2015). Based on this has determined the mean of prospective regenerated trees is 1m or more.

The 7 variation of terrain – soil have described. The plots researched at different topographic - soil conditions. These factors are also considered in the classification of impact subjects. However, because the "5 indicators" option is the most appropriate, topographic - soil factors do not participate in the most appropriate plan above.

2. About variation of tree layers

- The indicators of increasing variation are: density, number of individual species and standing stock.

- The reduction indicators are: mean diameter, mean height of 2 volumelevel.

- Species composition at level I (M <50 m^3ha^{-1}) has increased, from 67 species in 2013, reaching 71 species in 2015. At the level II (M = 50 - 127.6 m^3ha^{-1}), species composition did not change between the two time surveys. Species composition varies significantly between plots, shown at approximately 12% of species composition. Species with high importance index (IV $\geq$ 10.85%). Based on the diverse indices, the forest flora community in the study area reached an mean level.

The mean index of the tree layer is high, the density and volumeincrease over time in all plots. The increase was higher at level I (volumegrowth rate reached 2.91%), lower than at level II (growth rates reached 2,4%).

3. About variation of regeneration

- The indicators of increasing variation are: height, number of individual species.

- The composition of regeneration laye at the level I has increased, from 62 species in 2013, to 68 species in 2015. At the level II, the composition also changed. changed between the two time surveys, from 66 species in 2013, to 72 species in 2015. The species composition has a large variation between the plots, is shown at the level of similarity in species composition approximately 18% . Species with high importance index (IV $\geq$ 10.60%). Based on the various indices, the forest flora community in the study area is at medium level

- Density of purpose regeneration layer with higher 1m in height of these plots varies quite high from 800 - 2,900 trees ha^{-1}

4. About silvicultural technique rehabilitative solutions

a) The disertation has identified 33 species of plant (tree and regeneration layer) for rehabilitation (business) purposes based on 8 criteria for the research subjects.

b) Regarding the division of impact subjects: the division of impact subjects is based on the forest rehabilitation capacity of each plots. This ability is assessed through factors that affect the time it takes for the forest to reach the volumeharvest standard (the volumeof the good quality manure is 150 m^3ha^{-1}). which has analyzed 4 options for dividing the impact objects and selected the fourth option (based on 5 indicators) as the basis for technical solutions for forest rehabilitation.

c) About forest rehabilitation: has determined 2 groups of forest rehabilitation solutions: Forest enrichment and Forest nourishment

+ Group 1: Enrichment of natural forest, Out of 33 speceis for rehabilitative forest purpose, 5 species were selected.

+ Group 2: Natural forest maintenance , has clearly determined the technical criteria for nurturing forest plots and has identified the most suitable salvage logged plan for a specific forest plot. Compared to the no-interventive nurturing plan, the most suitable intervention plan has shortened the time of forest rehabilitation from 56 years to 39 years, the mean for the forest plots is 16.50 years.

The disertation has also developed a table of options for salvage logged nourishment to apply to any forest plot in the study area.

The disertation has provided and analized data related to spatial and temporal scale of poor secondary forests in Nam Pui National Park.

The dissertation has proposed silvicultural options and established the checking

- Table for dividing secondary forest which are applied by specific solution of silviculture in the study sites.

The findamental points of the dissertation are: (i) Current status and variation tendency of target tree species groups in the canopy and regeneration layers have been used in order to classify forest rehabilitation objects. Classification of the forest rehabilitation objects in a basic undestanding is division based on rehabilitation ability of each forest status; (ii) Rehabilitation options and lookup table using for identifying suitable forest rehabilitation can be well applied in forest management and development practices in the study area.

SUGGESTIONS

- It is possible to apply the solutions of forest rehabilitation proposed by the thesis to the activities of rrehabilitating natural forests in the buffer zone of Nam Pui National Park, Lao PDR.

- There should be a pilot model for application of silvicultural salvage logged techniques for forest nurturing established by the disertation as a basis for summarizing, assessing and replicating the model into forest rehabilitation practices in the study area.