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**DUONG TRUNG HIEU**

**PLANT DIVERSITY IN DONG SON - KY  
THUONG NATURE RESERVE, QUANG NINH  
PROVINCE**

**Major : Forest Resources Management**

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**DISSERTATION SUMMARY**

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- Vietnam National Library
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## LISTS OF PUBLISHED ARTICLES

1. **Duong Trung Hieu**, Can Kim Hung, Hoang Van Sam. 2019. Floristics in Dong Son – Ky Thuong Nature Reserve, Quang Ninh province. Journal of Forestry science and Technology. No 3. 76-83. Page 76-83
2. **Duong Trung Hieu**, Nguyen Thi Tuyen, Hoang Van Sam. 2019. Vegetation type in Dong Son – Ky Thuong Natural Reserve, Quang Ninh Province. Journal of Forest and Environment. No. 93+94. 59-66. Page 59-66
3. **Duong Trung Hieu**, Hoang Van Sam, Tran Trinh Phi Hung. 2019. Conservation of Gymnospermae in the Dong Son – Ky Thuong Nature Reserve, Quang Ninh province. Journal of Agricultural and Rural Development. No 11. 107-113. Page 107-113
4. **Duong Trung Hieu**, Hoang Van Sam, Tran Duy Nang. 2019. Diversity of threatened plant species in the Dong Son – Ky Thuong Nature Reserve, Quang Ninh province. Journal of Agricultural and Rural Development. No 10. 88-97. Page 88-97
5. Hoang Van Sam, Nguyen The Nha, Tran Van Chu, Nguyen Thanh Tuan, Nguyen Thi Tho, Do Thanh Tam, Le Bao Thanh, Tran Ngoc Hai, Ha Van Huan, **Duong Trung Hieu**. Claudio Cerboncini, Olarte Alexandra. 2019. Aquilaria yunnanensis S. C. Huang (Thymelaeaceae) a new record in Vietnam. Journal of Forest and Society. Vol 3 (2): 202-208. Page 202-208  
**Duong Trung Hieu**, Nguyen Thi Tuyen, Can Kim

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|---|-----------------------|
| <p>6. Hung, Hoang Van Sam. 2020. Plant biodiversity indexes study in Dong Son – Ky Thuong Nature Reserve, Quang Ninh province. Journal of Forestry science and Technology. No 3. 90-95.</p> | <p>Page<br/>90-95</p> |
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## INTRODUCTION

### 1. Problem statement

Dong Son - Ky Thuong Nature Reserve locates in the Northeast of Vietnam, is considered as a typical lowland evergreen closed forest ecosystem, with the largest concentrated natural forests and high biodiversity of rare plant and animal genetic resources. However, the forest resources here are strongly affected by the pressures of local people around the region and their livelihoods and high risk of forest encroachment. In order to maintain and protect the ecosystem, Dong Son - Ky Thuong Nature Reserve was established in 2003 according to Decision Nr. 440/QD-UB by the People's Committee of Quang Ninh province, with an area of 17,792 ha (currently 15,593.81 ha).

In order to protect and conserve the biodiversity in the NR, a number of surveys and assessments of forest resources have been conducted, initially assessing the value, potential and significance of the conservation area. However, a number of important issues have not yet been systematically implemented, such as defining criteria for classification of vegetation; systematic assessment of biodiversity in terms of plant taxonomies, diversity of flora, life form, uses and endangers of species; analyzing the factors influence plant diversity in the study area.

In order to contribute to assessing the diversity of plants in Dong Son - Ky Thuong Nature Reserve, as a scientific basis for conservation and rational use of biological resources here, the research "*Plant Diversity in Dong Son - Ky Thuong Nature Reserve, Quang Ninh Province*" was conducted.

### 2. Goal and objectives of the study

#### 2.1. Goal

To build a scientific basis and understandings for conservation and sustainable development of plant resources in Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

## **2.2. Objectives**

- To determine plant diversity characteristics and indicated index in Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

- To assess the diversity of flora in Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

- To identify the factors affecting plant diversity in Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

- To propose solutions to manage, conserve and develop plant species in Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

## **3. Research object and scopes of the study**

### **3.1. The research object**

The object of the study is vascular flora, vegetation and a number of factors affecting plant diversity in Dong Son - Ky Thuong Nature Reserve, Quang Ninh Province.

### **3.2. The scope of the study**

Dong Son - Ky Thuong Nature Reserve, Quang Ninh Province.

The study focuses on natural forest and plantation tree species.

The study conducting duration: August 2015 to December 2019

## **4. Significance of the study**

### **4.1. Scientific significance**

Providing scientific information and data on the diversity of vegetation and flora in Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

### **4.2. Practical significance**

The results of the study are the scientific basis for developing a strategy for sustainable management, conservation and development of

plant resources in Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

## **5. New contribution of the disertation**

Assessment of the diversity, biodiversity indexes and characteristics of flora and vegetation in Dong Son - Ky Thuong Nature Reserve.

Providing a list of vascular plants at Dong Son - Ky Thuong Nature Reserve with 1,246 species of 688 genera and 180 families of 5 vascular plants.

Providing a new record for the Vietnamese flora, *Aquilaria yunnanensis* S. C. Huang, of Thymelaeaceae; newly added 218 species, 71 genera, 12 families to the flora system of Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

## **6. The structure of the disertation**

The disertation contains 143 pages is structured in five sections: Introduction, Chapters 1: Literature Review, Chapter 2: Research Content and Methods, Chapter 3: Results and Discussion, Chapter 4: Conclusion and Recommendation. The disertation has 27 tables, 06 figures, and uses 115 references (85 in Vietnamese and 30 English references).

## **Chapter 1**

### **LITERATURE REVIEW**

#### **1.1. Overview of related researches in the world**

1.1.1. Characteristics of vegetation and plant diversity

1.1.2. Flora and its characteristics

1.1.3. Factors influencing plant diversity

#### **1.2. Overview of related researches in Vietnam**

1.2.1. Characteristics of vegetation and

1.2.2. Plant diversity

1.2.3. Factors influencing plant diversity

1.2.4. Overview of related researchs in Dong Son - Ky Thuong Nature Reserve

1.2.5. Orientation of research in Dong Son - Ky Thuong Nature Reserve

### **1.3. Socio-economics and natural conditions in the study area**

## **Chapter 2**

### **RESEARCH CONTENT AND METHODS**

#### **2.1. Research contents**

- Diversity of vegetation in Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

- Plant diversity and conservation value in Dong Son - Ky Thuong natural reserve, Quang Ninh province.

- Factors influencing plant diversity of Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

- Solutions to sustainably manage and conserve plant resources in Dong Son - Ky Thuong Nature Reserve, Quang Ninh province.

#### **2.2. Research methods**

##### ***2.2.1. Methodology***

The study of vegetation and flora is the basis for assessing the current status of plant resources in the study area, in order to propose selecting plant conservation measures, especially for endangered, rare and native species of the area.

##### ***2.2.2. Secondary data collection***

The study using secondary data in natural conditions, socio-economics characteristics of the study area and other relevant documents related to the topics.

##### ***2.2.3. Field investigation of vegetation and flora methods***



The study using methods of plant diversity (Nguyen Nghia Thin, 1997, 2004, 2008; Hoang et al, 2009; Hoang et al, 2011).

#### *2.2.3.1. Investigation on transects*

A total of 14 transects were conducted: On the transect, we recorded characteristics of vegetation types, habitats, statistics of the plants encountered and the natural or human impacts on the vegetation .... all the results are marked on the map.

#### *2.2.3.2. Investigation on the sample plots*

83 representative sample plot (OTC) typically for elevations and forest status (size 40x25m), including tropical belt (elevation <700m with 68 OTC); subtropical belt (elevation of 700-1,096m with 15 OTC).

- Data collected in the OTC: investigating the composition of plant species in the tree layer. For trees, determine the diameter of the trunk at 1.3m from the ground (D1.3), the height soaring (Hvn), the canopy diameter (Dt) of all trees with D1.3 larger than 6cm and plant specimens were collected.

#### *2.2.3.3. Collecting and processing of plant specimens*

Each plant species were collected a representative from 3-5 samples to identify, according to method of collecting and processing samples of Nguyen Nghia Thin (1997).

#### *2.2.3.4. Participatory Rural Appraisal (PRA)*

- Interview local people and officials of Dong Son Ky Thuong Nature Reserve to identify factors affecting forest resources and management, as well as indigenous knowledge in the use and conservation of plant species in the study area.

#### **2.2.4. Expert consultation**

Expert consultation were used for plant classification.

#### **2.2.5. Data processing and analysing methods**

##### *2.2.5.1. Assessment method of vegetation structure*

The study applies the classification system of vegetation units from the perspective of Thai Van Trung (1978, 1999) when evaluating Vietnamese vegetation units.

- *Describing the structure of the 5-storey layers:* The tree layers (including the canopy layer; the ecological-dominant layer, the under-canopy); The shrub floor and the grass floor In addition, the study also conducts extra-terrestrial plants descriptions.

- *Drawing the graph of representative sample plots:*

- *Determining dominion species based on Importance Value - IV% (Daniel Marmillod)*

- *Building the map of vegetation types by using Mapinfo 15.*

#### 2.2.5.2. *Determining the biodiversity index of the tree layer*

Identifying indicators: Simpson's diversity index (Cd); Shannon-Wiener coefficient (H'); Similarity index (SI); The entropy of the Ryenyi (H $\alpha$ )

#### 2.2.5.3. *Flora diversity assessment methods*

- *Plant specimen identification:* The botanical books in Viet Nam and other countries were used to identify the specimens. In addition, some of the specimens collected in the study area were classified based on comparisons with those found in a number of domestic and foreign plant museums and were directly identified by a number of plant experts.

- *Plant checklist building:* Plant checklists were developed according to the classification system of Brummitt R. K. (1992) in combination with International Nomenclature Law, Tokyo (1994).

#### 2.2.5.4. *Plant diversity assessment of taxon*

- *Diversity of taxon:*

- *Diversity of species assessment of generas and families:* Assess the ten families and ten generas with the highest diversity of species; Define genera (average number of species of a genus), family index and

genus/family index (average genus of a family).

#### *2.2.5.5. Assessment of new species added to the plant checklist*

New species added to the regional plant checklist were compared with the most recently published checklist and several published plant studies in the region.

#### *2.2.5.6. Assessment of diversity of plant life form*

Determining the life forms of species and the spectrum of biology based on the classification of Raunkiaer (1934) and applied to the specific conditions of Vietnam of Nguyen Nghia Thin (1997, 2008).

#### *2.2.5.7. Assessment of usage value diversity of plants species*

The determination of plants' usage value was mainly based on the published documents and actual use of local people.

#### *2.2.5.8. Assessment of plant conservation value*

- Assess the diversity of rare and precious species: The conservation status of species is assessed according to the Vietnam Red Book - part II - Plants (2007), Decree 06/2019/ND-CP of the Government of Vietnam ( 2019), World Red List 2020 (IUCN Red List of Threatened Plant Species, 2020) and CITES (2017).

- Develop distribution maps of tree species: Use GIS software to build distribution maps of rare and precious tree species and gymnosperm according to the ratio: 1/25,000

#### *2.2.5.9. Propose solutions to manage and conserve plant diversity in the study area*

Based on the results of the study, analyzed the advantages, shortcomings, actual conditions of the area and current legal documents to propose solutions for plant resources management and conservation in Dong Son Ky Thuong nature reserve.

## Chapter 3

### RESULTS AND DISCUSSION

#### 3.1. Vegetation diversity in Dong Son - Ky Thuong Nature Reserve

According to the vegetation classification of Thai Van Trung (1978, 1999), Dong Son - Ky Thuong Nature Reserve is divided into 2 elevation belts. Each belt is divided into different vegetation units, including:

- ***Tropical evergreen closed rainforest (Rkx) (<700m), including 06 sub-types as following:***

- + Tropical evergreen closed rainforest has experienced impacts
- + Tropical evergreen closed rainforest after exploitation
- + Tropical secondary bamboo rainforest
- + Tropical secondary rain shrubs
- + Tropical secondary rain grassland
- + Reforestation

- ***Sub-tropical evergreen closed rainforest on lowland (Rka) (>=700m), including 04 sub-types as following:***

- + Sub-tropical evergreen closed rainforest on lowland has experienced impacts
- + Sub-tropical evergreen closed broadleaf rainforest after exploitation
- + Sub-tropical rain shrubs
- + Sub-tropical rain grassland

##### 3.1.1. ***Tropical evergreen closed rainforest (Rkx)***

Tropical evergreen closed rainforest distributed at elevations below 700m with an area of 14,571.12 ha, accounting for 93.44% of the total area of Dong Son - Ky Thuong Nature Reserve.

The tropical evergreen closed rainforest has been exploited for a long time so the forest area has been affected more or less on the

structure and composition of plant species.

### ***3.1.2. Sub-tropical evergreen closed rainforest on lowland (Rka)***

This type of forest is distributed at elevations from 700m to 1096m, occupying a small area. Most of the area of this forest type is sub-tropical evergreen closed rain forest.

### ***3.1.3. Species diversity of tree layer in Dong Son - Ky Thuong Nature Reserve***

#### ***3.1.3.1. Differences of species diversity among vegetation types***

The study has selected a number of indicators to evaluate the richness of woody plants.

The Shannon - Wiener ( $H'$ ) coefficient is used to assess the species diversity of a tree community, the greater the  $H'$  value, the higher the species diversity. In the study area,  $H'$  index fluctuated not much among vegetation types (from 2.97 to 3.70). The impacted tropical evergreen closed rainforest has the highest diversity index (3.70) and the lowest is the sub-tropical evergreen closed broadleaf rainforest after exploitation (2.97).

The dominance index ( $Cd$ ) is valid and opposite to  $H'$ , the higher the  $Cd$  value, the lower the species diversity. The results show that the  $Cd$  index of different forest types is relatively uniform, ranging from 0.039 to 0.064. The highest  $Cd$  index is in sub-tropical evergreen closed broadleaf rainforest after exploitation (0.039) and lowest in the tropical evergreen closed rainforest has experienced impacts (0.064). That means the impacted tropical evergreen closed rainforest has the highest species diversity.

The Similarity Index ( $SI$ ) between impacted tropical evergreen closed rainforest and tropical evergreen closed rainforest after exploitation was highest ( $SI = 0.56$ ) compare to the  $SI$  among forest types. The lowest  $SI$  is between the impacted sub-tropical evergreen closed rainforest on lowland and the tropical evergreen closed rainforest

after exploitation (SI = 0.22).

There is not much difference in species composition between impacted tropical evergreen closed rainforest and tropical evergreen closed rainforest after exploitation. However, there is a relative difference in species composition between impacted sub-tropical evergreen closed rainforest on lowland and tropical evergreen closed rainforests after harvesting, or between sub-tropical evergreen closed broadleaf rainforest after exploitation with 2 types of forests (impacted tropical evergreen rainforest and tropical evergreen closed rainforest after exploitation).

The Ryenyi entropy ( $H\alpha$ ) is a convenient tool to describe the variation in species diversity in the vegetation types, showing the scale of the multiple indices. The calculation results of  $H\alpha$  strip show that, the tropical evergreen closed rainforest is more richness of species than the other types of forests.

The analysis of diversity indicators shows that, the tropical evergreen closed rainforest has the highest biodiversity, and the lowest is the sub-tropical evergreen closed broadleaf rainforest after exploitation.

### 3.1.3.2. *Species diversity index by elevations*

The analysis results of the tree diversity index of the two elevations show that the higher the elevation, the lower the number of tree species. The diversity index  $H'$  for elevations below 700m ( $H' = 3.68$ ) is greater than that for elevations above 700m ( $H' = 3.48$ ), showing that elevation below 700m have a greater degree of species diversity than the elevation above 700m. However, the dominance index ( $Cd$ ) of the these two elevations does not differ, showing that the two elevations have the same level of uniformity.

In the two elevations, the number of the same tree species is not many, the close index between elevation below 700m and above 700m

is 0.32, the similarity in species composition between these two elevations is not high. This result is also consistent with the point of view of Thai Van Trung (1999) about the difference in species composition between elevations.

### 3.2. Floristics in Dong Son - Ky Thuong Nature Reserve

#### 3.2.1. The diversity of taxa of plant division

##### 3.2.1.1. Diversity of taxa

From the results of this study, the author has built a List of plants in Dong Son - Ky Thuong Nature Reserve, including 180 families, 688 genera and 1,246 vascular plant species of 5 plant divisions. The distribution of taxons of all plant divisions is shown in Table 3.12.

**Table 3.12: The vascular plant divisions in Dong Son - Ky Thuong Nature Reserve**

Nr	Taxa	Family		Genera		Species	
		Nr.	%	Nr.	%	Nr.	%
1	Lycopodiophyta	2	1,11	3	0,44	10	0,80
2	Equisetophyta	1	0,56	1	0,14	1	0,08
3	Polypodiophyta	27	15,00	59	8,57	110	8,82
4	Pinophyta	5	2,78	7	1,02	10	0,80
5	Magnoliophyta	145	80,56	618	89,83	1117	89,65
5.1	<i>Magnoliopsida</i>	119	66,11	484	70,35	889	71,35
5.2	<i>Liliopsida</i>	26	14,45	134	19,48	228	18,30
	<b>Total</b>	<b>180</b>	<b>100</b>	<b>688</b>	<b>100</b>	<b>1,246</b>	<b>100</b>

The table shows that Magnoliophyta species have absolute advantage over others in terms of number of families, genera and

species; Polypodiophyta ranks second; Pinophyta and Lycopodiophyta have very low number of taxons, 5 and 2 families, 7 and 3 genera respectively. Equisetophyta has the lowest number of taxons, only 1 family, 1 genus and 1 species.

### *3.2.1.2. Diversity index of taxa under division*

The results of diversity index show that, there is a big difference with the index ranges from 1.0 to 7.7 among plant divisions. The difference is lower when it ranges from 1.0 to 3.3, the same number of genera/family varies from 1.0 to 4.2. This shows a high level of diversity in genera and family numbers of divisions in the region. Overall in the region, each family has average 6.9 species. The diversity index is 1.8 corresponding to the average of each genus has nearly 2 species. The average number of genera per family is 3.8.

### *3.2.1.3. Diversity of families*

The results show that there are 10 richest families, although only accounting for 5.56% of the total families of the whole system, but have 441 species, accounting for 35.39% of the total species.

### *3.2.1.4. Diversity of genera*

Dong Son - Ky Thuong Nature Reserve has 688 plant genus with the number of species in each genus ranging from 1 species (Achitea, Dichroa, Abroma ...) to 26 species (Ficus). The results show that the 10 most diverse genera have 113 species, accounting for 9.07% of the total species of the whole system. In addition, the identification of single genera and family is very important for conservation, because they are vulnerable to extinction. Dong Son - Ky Thuong Nature Reserve has recorded up to 433 single genera, accounting for 63.3% of the total genera. Meanwhile, the number of single-family is reached 48 families, accounting for 26.7% of the total number of families.

## ***3.2.2. New taxon records for flora in Dong Son – Ky Thuong Nature Reserve***



Compared with the previous survey results, the study has added 218 species, 71 genera and 12 families to the flora system of Dong Son - Ky Thuong Nature Reserve (Appendix 06). In particular, the study results added a new plant species to the Vietnamese flora, the Do Yunnan (*Aquilaria yunnanensis* S. C. Huang) of the Frankincense family (Thymelaeaceae).

### **3.2.3. *The diversity of life form***

The study discovered the Spectrum of Biology (SB) for the flora of Dong Son - Ky Thuong Nature Reserve as following:

$$\mathbf{SB = 73,84Ph + 7,54Ch + 2,81Hm + 11,72Cr + 4,09Th}$$

Looking at the life form spectrum in the area, the plants here are mainly the upper bud (Ph) accounting for a large proportion, up to 73.84%. Among the 6 life forms in this group, the upper bud group is woody (MM), accounting for the highest proportion (37.24%). Other groups in the formula of life form such as closed to the soil bud (Ch), hidden bud (Cr), yearly bud (Th) have almost the same ratio with not much difference, from 4.09% to 11.72 %. The lowest group is the semi-hidden bud (Hm) which accounts for only 2.81% of the total species.

### **3.2.4. *Usage value diversity of flora***

With total of 1,246 plant species in Dong Son - Ky Thuong Nature Reserve, there are 1,899 uses (use factor is 1.52), many species have multiple uses (from 2 to 4 different uses). The number of tree species used as medicine is the most with 456 species, accounting for 24.01% of the total species of the whole system. Next is the group of timber trees with 454 species, accounting for 23.91%; 404 species are used as ornamental plants and shade, accounting for 21.27%. The group of common materials, although accounting for a low proportion, has only 125 species but play an important role in the life of the local people when 100% of the households depend on fuel, lanyards, taking materials for knitting and dyeing.

### **3.2.5. Current status of rare plant species**

#### *3.2.5.1. Species composition and conservation status of rare plant species*

The flora in Dong Son - Ky Thuong Nature Reserve is not only diverse in species composition, but also has high conservation value. Dong Son - Ky Thuong Nature Reserve has 115 species of rare plants (accounting for 9.23% of the total species of the whole system), belonging to 49 families (Appendix 08).

**Rare species according to Vietnam Red Book, 2007:** Dong Son - Ky Thuong Nature Reserve has 53 species in Vietnam Red Book (2007) accounting for 46.09% of rare and 4.25% of total species in the area. Among them, there is 01 species is critically endangered (CR); 17 species is endangered (EN); and 35 species are vulnerable (VU).

**Rare species according to IUCN Red List (2020):** there are 47 species, accounting for 3.77% of the total species of the whole flora and accounting for 40.87% of the total number of rare species. There are 3 species are critically endangered (CR); 7 species are endangered (EN); 7 species are vulnerable (VU); 3 species are near threatened (NT); 22 species are least concern (LC) and 3 species are data deficient (DD).

**Rare species according to Decree 06/2019/ND-CP (2019) of the Government of the Socialist Republic of Vietnam:** there are 54 species accounting for 46.96% of rare species and accounting for 4.33% of the total species of the whole flora, including 1 species in group IA (Prohibition of exploitation and use) and 53 species in group IIA (Limit on exploitation and use).

**Rare species according to the CITES (2017):** there are 40 species of plants on the list of wild plant species listed in the CITES list, accounting for 34.78% of rare species and 3.21% of total species. There are 38 species included in Appendix II and 2 species of appendix III.

Therefore, it can be seen that the rare plant species in Dong Son

- Ky Thuong Nature Reserve have high conservation value not only in the country but also in the world.

### 3.2.5.2. Distribution status of some rare plant species

#### a) *Erythrophleum fordii* Oliv.

- Conservation status: EN (IUCN 2020); IIA (Decree 06/2019/ND-CP)

- Distribution and regeneration characteristics: *Erythrophleum fordii* Oliv is distributed mainly at the elevation of 170m - 300m above sea level. According to the survey results, there are 58 mature trees with a diameter of 7cm - 55cm. *Erythrophleum fordii* Oliv has good regeneration potential.

#### b) *Hopea mollisima* C. Y. Wu

- Conservation status: EN (IUCN 2020); VU (Vietnam Red Book 2007)

- Characteristics of distribution and regeneration: *Hopea mollisima* C. Y. Wu is distributed mainly at an altitude of less than 700m above sea level. On the investigation transects, 35 mature trees were found with a diameter of 9cm - 44cm. *Hopea mollisima* C. Y. Wu naturally regenerated relatively well.

#### c) *Cinnamomum balansae* Lecomte

- Conservation status: EN (IUCN 2020); VU (Vietnam Red Book 2007); IIA (Decree 06/2019/ND-CP)

- Characteristics of distribution and regeneration: *Cinnamomum balansae* Lecomte scatteredly distributed at elevation of 200m - 700m above sea level, encountered on 04 investigation transects with 19 mature trees. *Cinnamomum balansae* Lecomte has good regeneration in the height of less than 50 cm. Both mature mother and the regenerated trees of *Cinnamomum balansae* Lecomte are lower than other rare broadleaf species surveyed in the study area.

#### d) *Chukrasia tabularis* Juss.

- Conservation status: LC (IUCN 2020); VU (Vietnam Red Book 2007)

- Characteristics of distribution and regeneration: *Chukrasia tabularis* Juss distributed at elevations below 700m above sea level, *Chukrasia tabularis* Juss are found on 5 transects, 22 mature trees with a diameter of 25-42cm. *Chukrasia tabularis* Juss have a good ability to regenerate in the seedling stage, but poorly capable of regenerating shoots.

**e) *Madhuca pasquieri* (Dubard) H. J. Lam**

- Conservation status: VU (IUCN 2020); EN (Vietnam Red Book 2007)

- Characteristics of distribution and regeneration: In the study area, *Madhuca pasquieri* (Dubard) H. J. Lam are widely distributed on the elevations from 350-1096m above sea level, finding in 07 transects with 51 mature trees. *Madhuca pasquieri* (Dubard) H. J. Lam have the ability to regenerate well.

**f) *Dacrycarpus imbricatus* (Blume) de Laub**

- Conservation status: LC (IUCN 2020)

- Characteristics of distribution and regeneration: *Dacrycarpus imbricatus* (Blume) de Laub relatively narrow distribution, encountered on 03 transects, at elevations from 700 - 1096m above sea level, with 5 mature individuals. *Dacrycarpus imbricatus* (Blume) de Laub naturally regenerated relatively few with 7 individuals encountered, the trees regenerated mainly in the seedling stage, growing at a moderate level and were all derived from seeds.

**g) *Nageia fleuryi* (Hickel) de Laub**

- Conservation status: NT (IUCN 2020)

- Characteristics of distribution and regeneration: *Nageia fleuryi* (Hickel) de Laub are distributed on the slopes of the mountain where less affected, scattered at an altitude of 750-1020m, with 09 mature trees

found. Results of the regeneration tree survey found 4 individuals on 2 transects and all were in the seedling stage, growing relatively well, originating from seeds. *Nageia fleuryi* (Hickel) de Laub has good natural regeneration ability, but because the mother tree has been exploited, the quantity of seedlings is still very limited. The seedlings are in good shape, so local people often exploit it for ornamental purposes.

**h) *Podocarpus neriifolius* D. Don**

- Conservation status: LC (IUCN 2020); PL III (CITES 2017)
- Characteristics of distribution and regeneration: *Podocarpus neriifolius* D. Don are scattered around the top of Thien Son. Through investigation, 07 individuals were discovered on 03 transects. Compared with other species of gymnosperm investigated in the area, *Podocarpus neriifolius* D. Don have good natural regeneration, mainly from seeds.

**i) *Amentotaxus yunnanensis* H.L.Li**

- Conservation status: VU (IUCN 2020)
- Characteristics of distribution and regeneration: *Amentotaxus yunnanensis* H.L.Li scatteredly distributed at elevations of 700 - 1096m in the study area, encountered 07 mature individuals. *Amentotaxus yunnanensis* H.L.Li naturally regenerates relatively little. Regeneration plants are mainly in the height stage from 50-100cm, the individuals found are regenerated from seeds.

**j) *Podocarpus pilgeri* Foxw**

- Conservation status: LC (IUCN 2020); IIA (NĐ 06/2019)
- Characteristics of distribution and regeneration: The results of the survey found 09 individuals of *Podocarpus pilgeri* Foxw on 03 survey transects, scatteredly distributed at elevation of 730-1050m. *Podocarpus pilgeri* Foxw are naturally regenerated relatively well, mainly from seeds.

### **3.3. Factors influencing plant diversity in Dong Son - Ky Thuong Nature Reserve**

#### **3.3.1. Direct cause**

##### **a) Illegal logging and firewood**

In 4 years (2015-2018), the total number of violations cases of the Forest Protection and Development Law was 55, of which the principal handling was confiscation of material evidences and administrative handling, in 2016 and 2017 there were 2 cases of criminal handling. The main violations are the exploitation and transportation of forest products. The violations in the field of forest management and protection tend to increase, these are the main causes that directly harm the forest resources and seriously reduce the diversity of the flora.

##### **b) Expanding of agricultural land**

Residents in the region belong to the four main ethnic groups, namely Dao, Kinh, Chinese and San Chi, of which Dao account for 79.7%. Production activities of the local people account for over 95% are agricultural production. Deforestation for upland cultivation not only causes deforestation but also indirectly reduces or narrows the habitats of many plants and animals. Activities of clearing forest land for cultivation of minority ethnic groups in the reserve areas are very common.

##### **c) Non-timber forest products (NTFPs) extraction**

The exploitation of NTFPs is also very complicated, because local people are lived in villages located in or near forests. These activities are mainly taking bamboo shoots, medicinal plants, vegetables, orchids ... which are being illegally exploited by local people.

##### **d) Infrastructure and road constructions**

During the field survey we recorded a number of roads are under construction near the edge of the forest in Dong Son commune. In

the Nature Reserve, there are many roads opened by local people to enter the forest to harvest timber and non-timber forest products, causing habitat fragmentation to affect the biodiversity of the reserve.

**e) Cattle grazing activities**

Most households in the area have a free grazing practice without grazing areas. Cattle and buffaloes trampled on trees, went everywhere to destroy the land, made the land eroded, hardened. They also spread diseases to wild animals and affect the ability to regenerate of the seedling layer.

**f) Forest fire**

The risk of forest fire is mainly due to human activities, greatly affecting forest plant resources. In particular, forest fire influence on the growth and development of the upper tree layer, the existence and development of the regenerated tree layer and the role of moisturizing, protecting and limiting soil erosion, drifting soil of scrub.

**g) Illegal coal mining**

Located in an area with large coal resources of Quang Ninh province, the phenomenon of illegal coal mining in the Nature Reserve is still frequent. Coal mining activities greatly affect the area, forest structure, integrity and biodiversity of the Nature Reserve.

**3.3.2. Indirect cause**

**a) Poverty**

The underlying cause of poverty in the communities living in Dong Son - Ky Thuong Nature Reserve is not only because of lack of cultivation land, but also because of poor soil conditions and soil degradation. The majority of minority ethnic groups have no experience in applying advanced scientific and technological achievements in agricultural production, leads to low productivity and rapidly depleted of nutrition.

**b) Population growth**

The average natural population growth rate of the region is high, lead to increasing demand for food, agricultural land, timber for housing and other purposes creates a great pressure on the Nature Reserve.

**c) Awareness of the community is limited**

The capacity and awareness of local people in the core and adjacent areas of the Nature Reserve are relatively low. Therefore, people are not fully aware of the laws and importance of forests.

**d) Management and law enforcement capacity is limited**

Local authorities in some communes in the Nature Reserve are not really involved. The management board of the Nature Reserve is assigned to manage a large area of forest but has insufficient capacity. The propaganda and education activities to the local people about protecting forest resources is not effective. The forest protection contract has been signed but not fully implemented.

**e) Influence of market economy**

The market economy has led to a strong social division, the increasing need for material to encourage people to go to the forest to harvest more forest products.

**3.4. Proposed solutions to conserve plant resources in Dong Son - Ky Thuong Nature Reserve**

***3.4.1. Strengthening forest management and protection***

Strengthening the leadership of authorities at different levels in forest protection and improving the qualified and capable staff for the Management Board; increasing investment in safety equipment and means; building signs and banned signs in places where many people live and pass.

***3.4.2. Socio-economic development***

Early fulfillment of forest protection contracts, payment of forest environmental services to forest owners; develop a number of



crops with high yield, good commercial value, potential, short harvest time, feasible planting on the land of the region and in accordance with the customs of minority ethnic communities; building a number of effective buffer zone economic development models for local people; developing a number of high economic value species with natural distribution in the study area.

#### ***3.4.3. Awareness raising for the community***

Building a qualified communication officials in charge of education for conserving natural resources for the community; developing forest protection regulations; forming a community network in the conservation of natural resources; training necessary knowledge and skills, promoting indigenous knowledge to serve the conservation of natural resources.

#### ***3.4.4. Science and technology application***

Develop a plan and roadmap for conservation of plant resources, especially rare, high economic and conservation value species, and single-family plant families.

For the grassland and shrub: Planting native tree species in this area.

For plantation vegetation type: Replacements by planting native tree species

In the ecological restoration sub-zone: apply measures to protect and conserve natural succession, combine natural regeneration with planting native tree species and other silvicultural measures.

Proposing to establish a botanical garden, museum and herbarium in Dong Son Ky Thuong nature reserve.

Strengthen scientific research activities

Applying high technology solutions for monitoring and management of forest resources.

## CONCLUSION AND RECOMMENDATION

### Conclusion:

Dong Son - Ky Thuong Nature Reserve is quite diverse in terms of vegetation types, the study results have identified Dong Son - Ky Thuong Nature Reserve including 2 main forest types with smaller classification units. Specifically: (1) *Tropical evergreen closed rainforest* includes 6 sub-types: (i) Tropical evergreen closed rainforest has experienced impacts; (ii) Tropical evergreen closed rainforest after exploitation; (iii) Tropical secondary bamboo rainforest; (iv) Tropical secondary rain shrubs; (v) Tropical secondary rain grassland; (vi) Reforestation. (2) *Sub-tropical evergreen closed rainforest on lowland including 04 sub-types*: (i) Sub-tropical evergreen closed rainforest on lowland has experienced impacts; (ii) Sub-tropical evergreen closed broadleaf rainforest after exploitation; (iii) Sub-tropical rain shrubs; (iv) Sub-tropical rain grassland.

The results of quantitative research on tree biodiversity indices show that: Shannon - Wiener ( $H'$ ) coefficient varies widely between forest vegetation types (from 2.97 to 3.70). The Cd index in forest vegetation types is relatively uniform, ranging from 0.039 to 0.064. SI index among forest vegetation types varies from 0.22 - 0.56. The results of calculating the  $H\alpha$  index range of the forest vegetation show that *impacted tropical evergreen closed rainforest* has more species richness than other forest vegetation types. Diversity index  $H'$  of the elevation below 700m is larger than that of the elevation above 700m. However, the dominance index (Cd) of the two elevations does not differ, showing that the two elevation have the same level of uniformity. The SI index between the two elevations is 0.32, indicating a similarity in species composition.

The flora of Dong Son - Ky Thuong Nature Reserve is diverse

and rich with 180 families, 688 genera and 1,246 species of 5 plant divisions. The study has supplemented the list of plants in the area 218 species, 71 genera and 12 families compared to the list published in 2011; adding 01 new record for the Vietnamese flora *Aquilaria yunnanensis* S. C. Huang of Thymelaeaceae.

The flora in the Dong Son - Ky Thuong Nature Reserve has high conservation value, with 115 rare species of plants belonging to 49 families. In particular, there are 53 species in the Vietnamese Red Book (2007), 47 species in the IUCN Red List (2020), 54 species under the Decree 06/2019/ND-CP (2019), and 40 species in the CITES (2017).

The dissertation has initially determined the current status of distribution and established distribution maps for 10 important precious and rare plant species in the area including: *Erythrophleum fordii* Oliv, *Hopea mollissima* C. Y. Wu, *Cinnamomum balansae* Lecomte, *Chukrasia tabularis* Juss, *Madhuca pasquieri* (Dubard) H. J. Lam, *Dacrycarpus imbricatus* (Blume) de Laub, *Nageia fleuryi* (Hickel) de Laub, *Podocarpus neriifolius* D. Don, *Podocarpus pilgeri* Foxw. This is an important basis for the conservation and management of rare plant species in Dong Son - Ky Thuong Nature Reserve.

The study identifies 07 direct threats including illegal logging of timber and firewood; forest fires and expansion of agricultural land; non-timber forest product exploitation; infrastructure and roads construction; free cattle grazing; forest fires; and illegal coal mining. There are 5 indirect threats from people (poverty; population growth; low awareness of the community; weak management capacity and law enforcement; negative effects of market economy) on plant resources in Dong Son - Ky Thuong Nature Reserve. Since then, the study proposes 4 groups of solutions: Strengthening forest management and protection; Socio-economic development solutions; science and technology application and raising public awareness.

**Recommendation:**

- Continuing in-depth study on the conservation status of rare and endemic species of Dong Son - Ky Thuong Nature Reserve.
- More research is needed to assess the role of forests impacting on the socio-economic development of the local people in the study area.
- Establishing models of planting advantaged non-timber forest products in the study area such as bamboo, medicinal plants...etc in order to minimize negative impacts of local people to forest resources.
- Further enhancing management and protection of forest resources, especially rare and high economic value species.