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MANAGEMENT AND CONSERVATION OF PLANT BIODIVERSITY IN PU LUONG NATURAL RESERVE, THANH HOA PROVINCE

Major: Silviculture
Code: 96 20 205

DISSERTATION SUMMARY

Ha Noi - 2018

INTRODUCTION

1. Problem statement

Pu Luong Nature Reserve was established in 1999 according to Decision No.495/QĐ-UB dated 27/3/1999 by Thanh Hoa Provincial Peoples Committee, which covers an area of 17.171,03 ha, with the following objectives: Conserving ecosystems, fauna, and flora that characteristic of lowland limestone forests. Pu Luong Nature Reserve located in two districts of Quan Hoa and Ba Thuoc in the north-west of Thanh Hoa Province. The nature reserve (NR) has a rich fauna and flora ecosystem including of Broad leaves lowland forest on limestone, coniferous submontane forest on limestone and Broadleaves submontane forest on basalt. Also, the diverse culture of various ethnic minorities and some popular historical monuments such as Co Lung fort, Pu Luong airport etc. made Pu Luong NR recognized as a special used forest of highly scientific, social, economic, and ecotourism values.

In recent years, Management Board of Pu Luong NR has made significant efforts in biodiversity conservation, mainly focusing on plant biodiversity. However, because of many different reasons, the biodiversity at Pu Luong NR has been degraded. Timbers, especially rare timbers, none – timber forest products and medical plants have still been exploited. If this degradation is out of control, the timber plant resources will seriously decline, consequently the ecosystem imbalances.

The dissertation ***"Management and conservation of Plant biodiversity in Pu Luong Natural Reserve, Thanh Hoa Province"*** was conducted to provide better comprehensive literature and up-to-date profile on the flora and vegetation of the NR. The research focuses on to identify new plant species and conserves threatened plant species. Furthermore, the manuscript analyzes human and nature impacts that challenging the conservation activities and then to propose practical solutions for sustainable protection and development of Pu Luong Natural Reserve.

2. Objectives of the study

2.1. General objectives

Building scientific knowledge for conservation and management of plant resources in Pu Luong NR, Thanh Hoa province.

2.2. Specific objectives

To determine the diversity of vegetation types and indicate plant diversity at Pu Luong NR, Thanh Hoa province

To evaluate the biodiversity and characteristics of the flora of Pu Luong NR

To determine the status of conservation and recommend conservation and development of plant resources at Pu Luong NR, Thanh Hoa province

3. Subjects and scope

3.1. Study subjects

Flora and vegetation, plant management activities, and impact factors on the plant resources in Pu Luong NR, Thanh Hoa province.

3.2. Scope of study

Pu Luong Nature Reserve, Thanh Hoa province

The vascular plants at Pu Luong NR, Thanh Hoa province

4. Dissertation significance

4.1. Scientific significance

Providing scientific database on the diversity management of flora and vegetation in Pu Luong NR, Thanh Hoa Province

4.2. Practical significance

The outcomes of this research contribute a broad and deep knowledge of biodiversity that serves to propose better solutions for management, conservation, and development of plant resources in Pu Luong NR, Thanh Hoa province

5. New contributions of the dissertation

- Providing a list of vascular plants in Pu Luong NR with 1.556 species which contains 701 generas and 199 families; supplementing 343 new species, 88 new generas and 22 new families for the floras of Pu Luong NR, Thanh Hoa province.

- Providing 02 new records of plant species for the flora of Vietnam which are *Impatiens obesa* J.D. Hooker and *Begonia cavaleriei* Levl;

- Evaluating the indicators of plant diversity in Pu Luong NR, building the distribution map of vegetation and rare plant species in Pu Luong NR;

- Determining the status of conservation, impact factors on plant diversity and recommending solutions for conservation and development of plant resources at Pu Luong NR, Thanh Hoa province.

6. The contents of the dissertation

The thesis consists of 150 pages, 38 tables, 02 illustration pictures, 89 references and the appendix includes tables, illustration pictures, results of survey activities that is structured in five main sections: Introduction; Chapter 1: Literature review, Chapter 2: Contents and methods, Chapter 3: Results and discussion, Chapter 4: Conclusion and recommendations.

CHAPTER 1
LITERATURE REVIEW

1.1. Researches in the world

1.1.1. Researches on plant diversity and characteristics of vegetation

1.1.2. Research on the flora

1.1.3. Research on an application of diversity indicator

1.1.4. Management and impact factors on plant diversity

1.2. Researches in Viet Nam

1.2.1. Research on plant diversity and vegetation structure

1.2.2. Research on the flora

1.2.3. Research on an application of diversity indicator

1.2.4. Research on the regeneration of plant and breeding

1.2.5. Research on impact factors to management and conservation of plant resources

1.3. Basic characteristics of natural and social-economic conditions in Pu Luong NR

1.3.1. Natural conditions

1.3.2. Social-economic conditions

1.3.3. Diversity conservation and management

1.3.4. Impact of natural and social-economic conditions on plant resources management

1.4. Previous research on Pu Luong NR, Thanh Hoa province.

1.5. Problem statement

1.5.1. Vegetation classification

1.5.2. Research on diversity species

1.5.3. Research on silviculture characteristics and sexual reproduction of precious, rare, and dangerous plant species.

1.5.4. Research on the status of diversity conservation and management, impact factors and recommendations for conservation and development of plant resources in Pu Luong NR, Thanh Hoa province

CHAPTER 2
CONTENTS AND METHODS

2.1. Research contents

- Research on characteristics of vegetation type of plant diversity in Pu Luong NR
- Research on flora diversity at Pu Luong NR
- Research on silviculture characteristics and sexual reproduction of threatened plant species.
- Research on the status of diversity conservation and management, impact factors and solutions for conservation and development of plant resources in Pu Luong NR, Thanh Hoa province

2.2. Research methods

2.2.1. Secondary sources

Documents on natural, social-economic conditions, and relevant others to the thesis

2.2.2. Field investigation of vegetation and composition species method

2.2.3.1. Investigation method on the transects

A total of 15 transects were conducted with the total 43.6 km, ensuring cover all vegetation types and then marked on the map.

2.2.3.2. Investigationg method in the sample plots

Established representative plots, typical for elevations and forest status, which is divided into three main groups according to Thai Van Trung (1999), including tropical belt (elevation <700m), Sub-tropical belt (elevation > 700m). A total of 60 plots were established.

The area of each plot is 2000 m^2 (40x50m). In each plot, five small plots were arranged in four corners and one small plot (5mx5m) was in the center.

Data collected in the sample plots: In each plot, a survey of timber plant species was implemented. The timber tree stem diameter was determined at the position of 1.3m height (D1.3) comparing to the land surface, the height under the branch (Hdc), the height of the top of tree (Hvn), crown diameter (Dt) for all the timbers with D1.3 >= 6cm and plant specimens were collected.

2.2.3. Human impact assessment

2.2.3.1. Interview Pu Luong NR staffs and local people

A total of 20 Pu Luong staffs was interviewed to collect preliminary information on plant resource status, 150 households in five villages to have social-economic information, and data on the plant resources, especially valuable species for timber, and their dependence on the forest resources.

2.2.3.2. Participatory Rural Appraisal (PRA) method

Discussing with two different groups (local people and Pu Luong NR staffs) to develop the problem tree and figure out reasons for plant diversity degradation.

2.2.4. Data analysis method

2.2.4.1. Assessment method of vegetation structures

2.2.4.1.1 Assessment method of vegetation types

Applying the classification system of vegetation types based on Thai Van Trung (1978, 2000):

During describing vegetation types, using classification system of vegetation types of Loeschau (1960), which were FIPI supplement and develop to Norm of Forest business and Design QPN6-84)

Describing vegetation types based on the result of observation in the transects sample plots; describe the structure of forest floors (wood floor - A: A1, A2, A3, Bush floor - B, Grass floor -C) and dominion species (based on Importance Value - IV%).

2.2.4.1.2. Method of building vegetation types map, the distribution map of threatened plant species

Building the map of vegetation types based on inheritance satellite interpretation Spot5 results, terrain and vegetation map of Pu Luong NR development and Plan report towards 2020.

2.2.4.1.3. Forest structure assessment method

a. Wood level composition

Determining the wood floor composition, using Daniel Marmillod method:

$$IV_i\% = \frac{N_1\% + G_i\%}{2}$$

b. Density: Using formula*:* $\mathrm{N/ha} = \frac{\mathrm{n}}{\mathrm{S}} \times 10.000$

2.2.4.1.4. Research on regeneration characteristics

a. Regeneration composition: Determine regeneration composition, using formula:

$$\mathrm{n}_{\%} = \frac{\mathrm{ni}}{\sum_{\mathrm{i=1}}^{\mathrm{m}} \mathrm{ni}}.100 \ ;$$

b. Regeneration density:

Using formula:

$$N / ha = \frac{10.000 \times n}{S_{dt}} \ ;$$

c. Regeneration quality

Determining the ratio of good, medium and poor regeneration, using formula:

$$\mathrm{N\%} = \frac{\mathrm{n}}{\mathrm{N}} \times 100$$

d. Regeneration distribution accoording to height's level

Statistic quality of regeneration according to three height levels: <0,5m; từ 0,5-1m; >1m; following, trees' height with > 1m are good or medium growth and are considered as prospective regeneration.

2.2.4.2. *Flora diversity assessment methods*

- *The method of specimen identification and building the plant checklist*

Plant specimen identification and checklist building

Collected samples were processed as specimens following plant specimens technique (Nguyen Nghia Thin 1997 and 2007). The botanical books in Viet Nam and other countries were used to identify the specimens. Divisions in the plant list were arranged from low to high level of evolution. In each division, families and species were arranged according to the alphabetical order. In this list, the major columns include scientific names, Vietnamese names, life forms, usages, phyto-

geographic elements, new records (with the new species, genera and families for the flora of Pu Luong and for the flora of Vietnam).

Flora diversity

Plant diversity assessment of taxon

Diversity assessment of species, generas, and families: The ten families, ten generas with the highest diversity of species (dominant families and generas), the mono species families, the mono species generas.

Usage value diversity of plants species

The determination of plants' usage value was mainly based on the actual use of local people. These plants were divided into seven use categories: i) Medicine; ii Timber; iii) Other uses; iv) Food; v) Ornamental; vi) Oil and essences; vii) fibre. The usage of plant species was determined through documents on plants and based on local people interviews.

Plant life form diversity

Determining the life forms of species and the spectrum of biology based on the classification of Raunkiaer (1934) and Nguyen Nghia Thin (1997, 2008). The life forms information of species is determined through specialized documents**.**

Threatened level assessment of plant species

In order to protect species, in accordance with statistics all of the species compositions, it is necessary to assess the number and status of rare and endemic species in order to propose prior policies and impactive protection solutions. The research used the classification following documents: IUCN Red List of Threaded Plant Species (2016); The Red Data Book of Vietnam - Part Plants (2007); The Decree No.32 /of the Vietnamese Government.

- **Determining diversity index of wood tree class:**

- *Similar index SI:* $SI = \frac{2C}{(A+B)}$;

- *Entropy Rẽnyi index:*

$$H_\alpha = \frac{\ln\left(\sum_{i=1}^{s} p_i^\alpha\right)}{1-\alpha};$$

Determination diversity index

- Simpson index (1949):

$$Cd = \sum_{i=1}^{s}\left(\frac{Ni}{N}\right)^2$$

- Shannon-Wiener index: $H' = -\sum_{i=1}^{s} P_i * \ln(p_i)$;

- Mixed species ratio: $Hl = \frac{S}{N}$;

2.2.5. Sexual reproduction of rare and dangerous plant species

Nurturing: the study implemented on two nursery environments: wet sand and mixed soil: Ratio of sand and soil is 50:50; Making seedbed of sand and forest soil mixture with the layer of 15 cm, putting seed and cover by 3 cm sand layer, watering enough moisture.

The rate of grow of seed to be as: The number of growing on the total of seed testing

2.2.6. Expert method

Used in plant classification

Discussing with local leaders, specialists, and scientists who have experiences in the field of the research. Expert method was applied to analyse the research-relevant documents and discuss the plant distribution and its conservation status that guided by the Decree No.32 /of the Vietnamese Government.

CHAPTER 3

RESULTS AND DISCUSSION

3.1. Characteristics of vegetation types in Pu Luong Nature Reserve

3.1.1. Structural characteristics of vegetation types in Pu Luong Nature Reserve

The dissertation based on the vegetation classification of Thai Van Trung (1978, 2000) to divide vegetation types at Pu Luong Nature Reserve. Each belt is

divided into several different vegetation types as following:

Elevation belts are divided into two levels: Vegetation types in the tropical belt (<700m) and vegetation types in sub-tropical belt (>700). There are five main vegetation types:

- Evergreen broad-leaved tropical rainforest type on lowland (**LRTXĐT)**
- Evergreen broad-leaved tropical rainforest type on schist stone of lowland (**LRTXNT-ĐP)**
- Evergreen broad-leaved subtropical rainforest type on limestone (**LRTXNT-ĐV)**
- Coniferous evergreen subtropical rainforest type on limestone (**LKTXNT-ĐV)**
- Evergreen broad-leaved subtropical rainforest type on basalt (**LRTXNT-ĐBZ)**

Classification structure: Within five main vegetation types in Pu Luong NR, four of them contain four classes; the coniferous evergreen subtropical rainforest on limestone type contains four classes. This indicates that the classification structure of tropical rainforest at Pu Luong NR is entirely similar to the structure of tropical rainforest.

3.1.2. Flora diversity index

3.1.2.1. Rẽnyi diversity index

The result of studies for Rẽnyi diversity index with the value α =0; 0,25; 0,5; 1; 2; 3; 4; 5; 6; 7; 8, 9, 10 and ∞ is shown in Table 3.1.

Table 3.1. Rẽnyi diversity index in vegetation types

Hα	*Vegetation types*				
	LRTXĐT	**LRTXNT-ĐV**	**LRTXNT-ĐP**	**LKTXNT-ĐV**	**LRTXNT-ĐBZ**
H_0	**3,64**	**3,04**	**3,43**	**3,71**	**3,26**
$H_{0,25}$	3,49	2,97	3,36	3,63	2,11
$H_{0,5}$	3,35	2,91	3,29	3,56	2,98
H_1	3,12	2,80	3,15	3,42	2,77
H_2	**2,82**	**2,65**	**2,95**	**3,23**	**2,56**
H_3	2,66	2,55	2,83	3,12	2,46

Hα	*Vegetation types*				
	LRTXĐT	**LRTXNT-ĐV**	**LRTXNT-ĐP**	**LKTXNT-ĐV**	**LRTXNT-ĐBZ**
H_4	2,54	2,49	2,75	3,03	2,40
H_5	2,46	2,45	2,70	2,97	2,36
H_6	2,39	2,42	2,66	2,92	2,33
H_7	2,34	2,40	2,64	2,88	2,30
H_8	2,30	2,38	2,61	2,85	2,27
H_9	2,17	2,37	2,59	2,82	2,25
H_{10}	2,24	2,36	2,58	2,80	2,23
H∞	0,61	0,31	0,64	1,02	0,24

The result shows that Hα index at Pu Luong NR, the types of Broad-leaved evergreen lowland tropical rainforest on schist stone is richer than other types. Vegetation types at Pu Luong contain with medium Hα index.

3.1.2.2. SI similarity Index

SI Similarity Index or (Sorensen's Index) is used to evaluate the same level among vegetation types. Based on Sorensen's Index, the result of comparison SI Index of wood tree class of vegetation types is shown in table 3.2

Table 3.2. SI Index of wood class among vegetation types.

TTV	LRTXĐT	LRTXNT-ĐV	LRTXNT-ĐP	LKTXNT-ĐV	LRTXNT-ĐBZ
LRTXĐT	1	0,72	0,52	0,42	0,50
LRTXNT-ĐV		1	0,55	0,43	0,50
LRTXNT-ĐP			1	0,47	0,51
LKTXNT-ĐV				1	0,39
LRTXNT-ĐBZ					1

The result shows that SI Index changes from 0,39 to 0,72; maximum (0,72) beetween evergreen broad-leaved lowland tropical rainforest on limestone type and evergreen broad-leaved subtropical rainforest on limestone type. SI Index minimum (0,39) between Coniferous evergreen subtropical rainforest on limestone type and

Broad-leaved evergreen subtropical rainforest on basalt type. The result shows that not so much difference in species composition among vegetation types, however, there is an obvious difference in species between evergreen broad-leaved subtropical rainforest on basalt type and the other types.

3.1.3. The species composition changes under the belt

Based on the terrain of Pu Luong NR, to evaluate the changes of vegetation types under the belt, I used the 700m belt as a start and divided into three belts: Tropical belt (< 700m), sub - tropical belt (700-1400m), and temperate belt (>1400m). The features of the three belts show in table 3.3.

Table 3.3. Species division under the belt

No	Belt	Number of species	Species Rate (%)
1	< 700m	1.335	85,79
2	700 –1.400m	875	56,23
3	>1.400 m	342	21,97

The higher the belt is, the smaller the number of species is. At the belt height < 700m, there are 1.335 species, occupied 85,79 % in total species of flora; at 700-1400m, there are 875 species (56,23 %); the fewest number of species belongs to the belt height > 1400m, with 342 species (56,23 %) total of species of flora.

Determining some species diversity indexes under the belt

In order to evaluate the abundance and diversity level of flora composition under the belt, the author selects some diversity as shown in table 3.4.

Table 3.4. Diversity index under the belt

Belt	Number of wood species (S)	Number of Survey individuals (N)	Mix species Rate (HI)	H' Index	Cd Index
<700m	55	360	1/6,5	1,87	0,023
700m - 1400m	68	472	1/6,9	1,93	0,020
> 1400m	26	66	1/ 2,5	0,93	0,155

It is not only different in the number of wood species, but also different in biodiversity among belts. The number of wood species under the belt changes from 26 to 68 species, mix species rate from 1/2,5 to 1/6,9 (It means that there is one species within 2,5 to 6,9 wood species).

Shannon-Wiener (H') Index among three belts from 0,93 to 1,93, the vegetation structure among belts is different. The belt height 700-1400m contains hightest biodiversity index value (1,93) and the belt height > 1400m contain lowest biodiversity index value (0,93).

The belt >1400 m has hightest Cd Index (0,155) and belt 700-1400 has lowest Cd Index (0,020).

In order to determine the correlation and similarity of species's composition among belts, the researcher used Sorensen formula (table 3.5).

Table 3.5. Similarity index among belts

Belts	**Number of wood species**	**<700 m**	**700-1.400m**	**> 1.400m**
<700 m	55	1	0,35	0,22
700-1400m	68	0	1	0.49
> 1400m	26	0	0	1

Under the belt, there are so much similar species; the close index beetween < 700 belt and 700-1400 m belt is 0,35; the close index between < 700 belt and > 1400 m is 0,22; the close index betweenbetween 700-1400 belt and > 1400 m is 0,49. This is shown that the similarity in species's composition among belt is low. These results confirm Thai Van Trung's opinion (2000) for the difference from species composition among belts.

In order to determine correlation and similarity level of biodiversity index at different Directions. We calculated the biodiversity index (table 3.6).

Table 3.6. Biodiversity at different directions

Directions	Number of wood species (S)	Nember of Survey individuals (N)	H' Index	Cd Index	Equability Index	SI Index
East	86	482	1,72	0,031	0,88	0,84 (71 general species)
West	83	401	1,57	0,042	0,81	

The H' Index and E Index values in East direction are higher than those in West direction, but Cd Index value in the East direction is less than that in West direction. However, biodiversity values of 2 directions are not significantly different. The SI Index is high (SI = 0,84) that refers to the flora structure in Pu Luong NR has relatively homogeneous species composition betweenbetween the East and the West direction.

3.1.4. Changing in species composition of vegetation types under the belt and direction

Table 3.7 shows the result of change in species composition of vegetation types under the belt and direction.

Table 3.7. Features of plant species under the belt of vegetation types

Belt	Vegetation types and feature plant species
< 700 m	**Evergreen broad-leaved lowland tropical rainforest on limestone type (LRTXĐT)**
	Streblus ilicifolius, Antidesma bunius, Mallotus philippinensis, Excentrodendron tonkinensis, Garcinia fagraeoides, Nephelium lappaceum, Heritiera macrophylla, Aglaia spectabilis, Millettia ichthyochtona, Anogeissus acuminata, Diospyros sussarticulata, Dracontomelon duperreanum, Pometia pinnata.
	Evergreen broad-leaved lowland tropical rainforest on schiststone type (**LRTXNT-ĐP)**
	Heritiera macrophylla, Streblus ilicifolius, Pterospermum heterophyllum, Dacrycarpus imbricatus, Caryodaphnopsis tonkinensis, Michelia foveolata,

Belt	Vegetation types and feature plant species
	Duabanga grandiflora, Castanopsis indica, Anogeissus acuminata, Millettia ichthyochotona.
>700 m	Evergreen broad-leaved subtropical rainforest on limestone type (**LRTXNT-ĐV)**
	Streblus ilicifolius, Garcinia fagraeoides, Excentrodendron tonkinensis, Heritiera macrophylla, Ficus nevosa, Dacrycarpus imbricatus, Anogeissus acuminata, Quercus rupestric, Syzygium levinei, Antidesma dubius, Polyathia cerasoides, Sterculia hymenocalyx, Acer tonkinensis, Aglaia spectabilis, Cinamomum ovantum.
	Evergreen coniferous subtropical rainforest on limestone type (**LKTXNT-ĐV)**
	Schefflera heptaphylla, Syzygium levinei, Nageia fleuryi, Podocarpus pilgeri, Litsea glutinosa, Pinus kwantungensis, Carpinus viminea, Eriobotrya bengalensis, Platycarya strobilifera, Mangifera longipes, Sinosideroxylon racemosum,Camellia pleurocarpa.
	Evergreen broad-leaved subtropical rainforest on basalt type (**LRTXNT-ĐBZ)**
	Caryodaphnopsis tonkinensis, Sterculia hymenocarlyx, Albizia chinensis, Ficus langkokensis, Dimocarpus longan, Michelia foveolata, Castanopsis armata, Lithocarpus fenestratus, Archidendron chevalier), Diospyros sussarticulata, Cephalotaxus mannii, Amentotaxus yunnanensis, Smilax petelotii, Anneslea fragrans.

There have different plant compositions among belts, at the belt heigh > 700m, plant composition features are clearly sub-tropical plants and appears short forest type on the high mountain.

3.1.5. Research on natural regeneration of wood plant in different vegetation types

3.1.5.1. Regenerating composition and density of wood plant in vegetation types

Vegetation type LRTXĐT with the amount of 13-16 regenerating species, in which, the species taking part in the composition formula are 4-6. Vegetation type

LRTXNT-ĐV consists of 12 - 14 regenerating tree species, the amount of species takes part in the composition formula are 4-6. Vegetation type LRTXNT-ĐP consists of 14-15 regenerating species, the amount of them takes part in the composition formula are 4-9 species.Vegetation type LKTXNT-ĐV, regenerating tree species are 14-16, in which, the composition formula contains 8-9 species. Vegetation type LRTXNT-ĐBZ consists of 15-16 regenerating tree species, and 5-8 species belong to composition formula.

The density of regenerating trees vary 5.300 – 8.700 trees/ha, the average is 7.200 trees/ha. The highest regenerating trees density appears in LRTXĐT type and the lowest regenerating trees density belongs to LRTXNT-ĐP type.

The quality of regenerating trees: the percentage of good regenerating trees varies 50,3 - 60,5%, the average is 56,7 %; medium regenerating tree percentage occupies 20-30,6%, the average is 25,2%; the number of remaining are poor regenerating trees with the rate of 14-21%, the average is 18,1%. Regenerating trees growing seeds vary 65,6- 78,4%, the average is 72,2 %

3.1.5.2. Distribution of regeneration trees in accordance to the high level

The density of regenerating trees mainly grows at the level of 50-100cm height, varies 2.300-3.666 trees/ha, the average is 3.160 trees/ha. The lowest density of regenerating trees grows at the level < 50cm height, vary 1.400-1.966 trees/ha, the average is 1.832 trees/ha. At the height level > 100cm, the regenerating trees density varies from 1,500 - 2.634 individuals/ha, the average number of trees is 2.208 trees/ha.

3.1.5.3. Diversity index of regenerating wood trees in vegetation types

Amount of regenerating trees vary 16-22 species, Mix rate varies 1/9,35 - 1/12,43 (it means that every 9,35 to 12,43 trees appear one regenerating species). Shannon-Wiener (H') index vary 2,74 – 3,02, Cd index in vegetation types vary 0,051–0,068; LRTXĐT-ĐP vegetation type has highest Cd index and the lowest belongs to LRTXNT-ĐV type.

3.2. Floristics in Pu Luong NR

3.2.1. The diversity of taxa at Pu Luong NR

3.2.1.1. Diversity of taxa

There were 1.556 vascular plants species; belonging to 199 families, 701 genera of 6 divisions. Their distribution of the major plant groups is shown in table 3.8.

Table 3.8. The vascular plant divisions in Pu Luong

No	Taxa	Family		Genera		Species	
		Number	%	Number	%	Number	%
1	Psilotophyta	1	0.50	1	0.14	1	0.06
2	Lycopodiophyta	2	1.01	3	0.43	11	0.71
3	Equisetophyta	1	0.50	1	0.14	2	0.13
4	Polypodiophyta	26	13.07	72	10.27	161	10.35
5	Gymnospermae	7	3.52	10	1.43	20	1.29
6	Angiospermae	162	81.41	614	87.59	1361	87.47
6.1	*Dicotyledonae*	*136*	*68.34*	*495*	*70.61*	*1135*	*72.94*
6.2	*Monocotyledonae*	*26*	*13.07*	*119*	*16.98*	*226*	*14.52*
Tổng		**199**	**100.00**	**701**	**100.00**	**1.556**	**100.00**

Angiospermae was more dominant than other taxas, including the number of families, genera and species with 162 families (81,41%), 614 genera (87,59%), and 1.361 species (87,47%). The next one was Polypodiophyta with 26 families (13,07%), 72 genera (10,27%), 161 species (10,35%). Other divisions as Pinophyta, Lycopodiophyta, Equisetophyta, and Psilotophyta were with less density.

3.2.2. *Diversity index of taxa*

Biodiversity index of family and genera are low. Family index varies from 1 to 8,4; the genera index is lower when it ranges from 1,4 to 2,2; and the number of genera per family varies from 1,0 to 3,79. In general, the family index of this area is about 7.82; corresponding to the average of 7,82 species per family. The genera index is 2,2 corresponding to the average of each genera has more than two species; The genera index is 3,52, or each family has an average of 3,52 genera.

3.2.3. The diversity of taxa under division

3.2.3.1. Diversity of families

The ten families with the highest diversity of species (dominant families) in Pu Luong NR include 531 species, accounting for 34,13% of the total species. In which, two families: Fagaceae and Myrsinaceae with 33 species, Polypodiaceae with 32 species. In Pu Luong, the most diverse families are mainly like those in Viet Nam, such as Euphorbiaceae, Orchidaceae, Rubiaceae, Lauraceae, and Annonaceae.

3.2.3.2. Diversity of genera

The flora in Pu Luong with 701 genera, in which 14 genera with 190 species, accounting for 27,1% the total of species of flora. The biggest genera is Ficus with 33 species, accounting for 4,71%; following by Lithocarpus with 19 species, accounting for 2,71%; two genera Ardisia, and Asplenium with 16 species, accounting for 2,28%; Lindernia genera with 12 species accounting for 1,71%; Cinnamomum, Glochidion, Litsea and Maesa genera with 11 species, accounting for 1,57%; Bauhinia, Castanopsis, Diospyros, Mallotu and Pteris with 10 species.

3.2.3.3. New taxon records for flora of Pu Luong and Viet Nam

Comparing to the list of flora in Pu Luong of FFI organization in 2003 and Dau Ba Thin in 2013; The result of study identified 343 new species of vascular plants.

Within 22 supplemental families for flora of Pu Luong, it is variable from 1-3 species per families such as Caryophyllaceae family supplemented 3 species, 2 genera; Ophioglossaceae families supplemented 2 species, 2 genera; Salviniaceae family was added to 2 more species, 1 genera; Cuscutaceae family also added 2 more species, 1 genera; and others family supplemented 1 species, 1 genera.

For the 88 supplemental genera for the flora of Pu Luong, in which Ficus and Lithocarpus genera supplemented 5 species; Elaeocarpus, Glochidion, Lindernia and Maesa plus 4 more species; and others genera supplemented 1-3 species.

Especially, for the 343 new recorded species for Pu Luong flora, the study provides two new records for the flora of Viet Nam, those are Impatiens obesa J.D. Hooker belonging to Balsaminaceae and Begonia cavaleriei Levl belonging to Begoniaceae.

3.2.4. The diversity of life form

The study discovered the Spectrum of Biology (SB) for the flora of Pu Luong NR as following:

SB = 76,48Ph + 1,41Ch + 9,13Hm + 9,70Cr + 3,28Th

3.2.5. The diversity of plant use value

The result of research shows that in the total of 1.556 plant species of Pu Luong NR, there are 1.493 species are belonging to different use groups. The group of medicinal plants consists of 662 species, accounting for 42.54% of the number of total species.

3.2.6. The diversity of threatened plants

There is a total of 177 species, accounting for 11,37% the total of species in Pu Luong NR (1556 species); these species belong to 65 families which are rare plants, accounting for 32,66 % total of families, which also have high values in conservation and need to be conserved at not only in the national but also the international level.

Table 3.9. The rare species at the international and Vietnamese levels

No	**Symbol**	**Classification**	**Number**	**% species relates to rare species**	**% species relate to total species**
Total of rare species				**177**	**1556**
I. According to the IUCN Red List (2016)			***112***	***63,27***	***7,2***
1	CR	Critically endangered	2	1,1	0,13
2	EN	Endangered	7	3,85	0,45
3	VU	Vulnerable	13	7,14	0,84
4	DD	Data deficient	2	1,10	0,13
5	LR	Lower Risk	19	10,44	1,22
6	LC	Least concern	66	36,26	4,24
7	NT	Near threatened	3	1,65	0,19
II. According to data from Red			***68***	***38,41***	***4,37***

No	Symbol	Classification	Number	% species relates to rare species	% species relate to total species
book of Viet Nam (2007)					
1	CR	Critically endangered	4	2,25	0,25
2	EN	Endangered	19	10,73	1,22
3	VU	Vulnerable	44	24,85	2,82
4	LR	Least concern	1	0,56	0,06
III. No. 32 /2006 of the Vietnamese government			***27***	***15,25***	***1.73***
1	IA	Prohibition of exploitation and use	8	4,51	0,51
2	IIA	Limit on exploitation and use	19	10,73	1,22

Total of rare species according to the IUCN Red List (2016)

The flora in Pu Luong NR contains 112 species; occupies 7,2 % the total of species and 61,54 % the total of rare species. The number of rare species in whole of 7 dangerous levels of IUCN Red List (2016); including 01 species at CR level; 7 species at EN level; 13 species at VU level; 2 species at DD level; 19 species at LR level; 66 species at LC level, and 3 species at NT level.

Total of rare species according to the data in Red book of Viet Nam (2007)

Pu Luong NR contains 68 species according to the dataset in the Red book of Viet Nam (2007); accounting for 4,37 % the total of species and 38,41% the total of rare species. In which, 4 species at CR level, 19 species at EN, 1 species at LR, 44 species at VU.

Total of rare species according to No. 32 /2006 of Vietnamese Government

Pu Luong NR contains 27 species in No. 32/2006 of Vietnamese Government, accounting for 15,25 % total of rare species and 1,73% total of species. In which, eight species at IA group and 19 species at II A group.

3.3. Research on silviculture characteristics and sexual reproduction the rare and dangerous plant species.

3.3.1. Research on silviculture characteristics of rare and dangerous plant species

The research only focuses on studying silviculture characteristics of 15 rare and dangerous species, as following: Excentrodendron tonkinensis Gagnep Chiang & Miau; Garcinia fagracoides A.Chev; Pinus kwangtungensis Chun ex Tsiang; Taxus chinensis Pilger; Nageia fleuryi Hickel de Laub; Podocarpus pilgeri D.Don; Podocarpus neriifolius D. Don; Amentotaxus argotaenia Hance Pilger; Cephabtaxus manii Hook.f; Cycas balansae Warrb; Diospiros mun A. Chev ;Madhuca pasquieri Dubard H.J. Lam;Paphiopedilum hirsutissimum Lindl. ex Hook; Anoectochilus calcareus Aver and Gynostemma pentaphyllum Thunb.

3.3.2. Research on sexual reproduction rare and dangerous plant species

In the scope of the dissertation, *Garcinia fagracoides* A. Chev; *Nageia fleuryi* Hickel de Laub, and *Podocarpus pilgeri* D.Don were three rare, dangerous, and featured species chosen to test the sexual reproducing

For the Garcinia fagracoides A. Chev: The best nursing environment is wet sand + forest soil; sprout rate of seed obtain 80%. For the *Nageia fleuryi* (Hickel)de Laub and *Podocarpus pilgeri* D.Don. The best nursing environment are wet sand; sprout rate of seed are alternatively 90% and 80%. This achievements were opening a new conservation method by reproducing seedling from seeds rare and dangerous plant species.

3.4. Status of diversity conservation and management, impact factors and solutions for plant resource conservation and development at Pu Luong NR, Thanh Hoa province

3.4.1. Plants resources management status

The dissertation presents a summary of the plants management status in Pu Luong NR. Analyse planning status of sustainable development and conservation special use forest; Building positioning plot system to monitor plant changing; Contracting forest protection for villages in the buffer zone of Nature Reserve, establishing protection groups at the village level, supporting development activities to improve

income for local communities; conservation law and policies analyzation. These activities both bring positive and negative impacts to plant resources.

3.4.2. Impact factors identification to plant resources

The dissertation has identified factors impact on the plant resources in two groups of direct and indirect group.

Direct factor:

Illegal-forest plant resources exploitation for selling and using; Overexploitation of Firewood and Non-timber forest production; exploitation of limestone and gold mining in score zone; Illegal-Livestock farming and grazing within special use forest; Infrastructure buildings and settlements Fire and fire suppression.

Indirect factor:

Inefficient cooperation between Pu Luong management Board and local authorities in biodiversity management, inefficient law enforcement and high poverty rates.

3.4.3. Proposing solutions for conservation and development of plant resources in Pu Luong NR.

Based on the factors impact on the plant resources in Pu Luong NR. The dissertation has proposed seven solution groups for plant resources management including:

Checking and supplementing the planning of Pu Luong Nature Reserve

Technological and scientific solutions

social economic solutions

Policies mechanism, and investment attraction solutions

law enforcement solution

International cooperation solutions

Infrastructure investment and human resources training solutions

CONCLUSIONS

The vegetation types in Pu Luong NR is diverse with five natural vegetation types: Broad-leaved evergreen lowland tropical rainforest on limestone type; Broad-leaved evergreen lowland tropical rainforest on schist stone type; Broad-leaved evergreen subtropical rainforest on limestone type; Coniferous evergreen subtropical rainforest on limestone type; Broad-leaved evergreen subtropical rainforest on basalt type. The SI Index is highest 0,72 between Broad-leaved evergreen lowland tropical rainforest on limestone type and Broad-leaved evergreen subtropical rainforest on limestone type. SI Index lowest 0,39 beetween Coniferous evergreen subtropical rainforest on limestone type and Broad-leaved evergreen subtropical rainforest on basalt type.

Amount of species in < 700 belt with 1.335 species accounting for 85,79 % total of species of flora in Pu Luong, the 700-1400 belt with 875 species accounting for 56,23 % total of species of flora; at least > 1400 belt with 342 species accounting for 56,23 % total of species of flora. Among belts have a difference for biodiversity index.

Vegetation type LRTXĐT, amount of regenerated trees very 13-16 species, amount of species take part in the composition formula 4-6 species. Vegetation type LRTXNT-ĐV, regenerated trees very 12-14 species, amount of species take part in the composition formula 4-6 species. Vegetation type LRTXNT-ĐP regenerated trees very 14-15 species, amount of species take part in the composition formula 4-9 species. Vegetation type LKTXNT-ĐV regenerated trees very 14-16 species, amount of species take part in the composition formula 8-9 species. Vegetation type LRTXNT-ĐBZ regenerated trees very 15-16 species, amount of species take part in the composition formula 5-8 species.

The Cd index highest in Broad-leaved evergreen lowland tropical rainforest on schist stone type and lowest in Broad-leaved evergreen subtropical rainforest on limestone type. Shannon-Wiener (H’) index highest in Broad-leaved evergreen subtropical rainforest on basalt type and lowest in Broad-leaved evergreen lowland tropical rainforest on schist stone type.

The flora of Pu Luong NR is diverse with a total of 1556 vascular plant species belonging to 701 genera, 199 families. The research recorded 343 new species, 88 new genera, 22 families compared to the 2003 and 2013 declaration for the flora of Pu Luong.

Two new records for the flora of Viet Nam are (*Impatiens obesa* J.D. Hooker) and (*Begonia cavaleriei* Levl.).

The Spectrum of Biology (SB) for the flora of Pu Luong NR are: SB = 76,48Ph + 1,41Ch + 9,13Hm + 9,70Cr + 3,28 Th.

The flora of Pu Luong has high conservation value with 177 threatened species; accounting for 11,37 % total of flora; 112 species are listed in the red data list of IUCN (2016), 68 species are listed in the red data book of Viet Nam (2007), and 27 species are listed in the Decree No. 32 /2006 of the Vietnamese government.

Development the database for 15 feature, rare, and dangerous species of Pu Luong NR with fully information for ecology, distribution and regeneration character; conservation status, distribution maps and image of species

The dissertation also covered experiment on sexual breeding of three rare, dangerous, and feature species: Garcinia fagracoides A. Chev; Nageia fleuryi Hickel de Laub and Podocarpus pilgeri D.Don. In which, the best nursing environment of the Garcinia fagracoides are wet sand+ forest soil. The best nursing environment of Nageia fleuryi and Podocarpus pilgeri are wet sand.

The dissertation has identified impact factor to plant resources in two groups of direct and indirect groups.

Based on result on research, the research has proposed seven solution groups for better management of plant resources, including: Checking and supplementing the planing of Pu Luong Nature Reserve; technological and scientific solutions; Indentification of social economis solutions; Policies mechenism, and investment attraction solutions; Internacification law enforcement solutions; International cooperation solutions; Infrastructure investment and human resources training solutions.

List of publication

1. **Cao Van Cuong**, Hoang Van Sam (2017), The diversity of hight conservation value plant species in Pu Luong Nature Reserve, Thanh Hoa province, Journal of Agriculture and rural development, (No 3+4), page. 244-54.
2. **Cao Van Cuong,**, Hoang Van Sam (2017), Diversity and conservation status of gymnospermae in Pu Luong Nature Reserve, Thanh Hoa province , Journal of Agriculture and rural development, (No 1), Page. 108-114.
3. **Cao Van Cuong,**, Hoang Van Sam (2018), Charaterristic of vegetation in Pu Luong nature Reserve, Thanh Hoa provience, Journal of Agriculture and rural development, (No 1). Page. 111-117.
4. **Cao Van Cuong,** Tran Huu Vien, Hoang Van Sam (2018), Quantitative biodiversity indexs of tree species in in Pu Luong Nature Reserve, Thanh Hoa provience. Journal of Agriculture and rural development (No 8) Page 112-116
5. **Cao Van Cuong,** Tran Huu Vien, Hoang Van Sam, (2018), The research of Effect factor and solution proposal to plan resourse conservation in Pu Luong Nature Reserve, Thanh Hoa provience. Journal of Agriculture and rural development (No 11) Page 120-126