



**CONSERVATION
OF THREATENED AND
ENDANGERED SPECIES OF**



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Nguyen Manh Cuong

CONSERVATION OF THREATENED AND ENDANGERED SPECIES OF GYMNOSPERMS IN NORTHWEST VIETNAM



ABBREVIATION:

CPNP: Cuc Phuong National Park

PLNR: Pu Luong Nature Reserve

HKPCNR: Hang Kia - Pa Co Nature Reserve

ACKNOWLEDGEMENTS

Northwest Vietnam is considered a high biodiversity value in Vietnam and the world. These precious natural resources and the rich biodiversity within must be protected and preserved. In line with this mission, a biodiversity conservation program was recently created and called the “Conservation of Threatened and Endangered Species of Gymnosperms in Northwest Vietnam”.

During the past year, research was undertaken in Cuc Phuong National Park, Pu Luong Nature Reserve, and Hang Kia–Pa Co Nature Reserve, in an effort to conserve threatened and endangered species of gymnosperms in these protected areas. As a result of this effort, valuable information has been gained and new knowledge has been documented. This report communicates the results of this research.

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CONSERVATION OF THREATENED AND ENDANGERED SPECIES OF GYMNOSPERM IN NORTHWEST VIETNAM

I. INTRODUCTION

The north-western region of Vietnam is recognized as a priority area for conservation. It is considered as one of the main regions of plant diversity in Vietnam, and includes Cuc Phuong National Park, Pu Luong Nature Reserve, and Hang Kia–Pa Co Nature Reserve (Map 1). These areas, our present study sites, lie in the limestone range that extends south-east from the Son La plateau through Pa Co-Hang Kia and Pu Luong Nature Reserve, to Cuc Phuong National Park.

This area comprises an interzone for limestone formation Pa Co-Hang Kia -Pu Luong-Cuc Phuong range, which serves as an example of limestone karst ecology of global importance, and the last lowland limestone forests and limestone forest habitat in the north-western Vietnam. The limestone range is believed to encompass much of the remaining limestone-associated species-richness in this region, and is recognized as a priority landscape for biodiversity conservation within the lower Mekong eco-region.

In this area, four species of gymnosperms have been recently evaluated as globally threatened (IUCN, 2009). They are: *Amentotaxus yunnanensis* H.L. Li (Taxaceae) (EN, A1c), *Cephalotaxus mannii* Hook.f. (Cephalotaxaceae) (VU, A1d), *Calocedrus macrolepis* Kurz (Cupressaceae) (VU, B1+2b), and *Pinus fenzeliana* Hand.-Mazz. (Synonym: *Pinus kwangtungensis* Chun Tsiang) (Pinaceae) (NT). Threatened species of gymnosperms are in urgent need of conservation action. However, because information on their ecology is incomplete, due to the fact that only a small proportion has been assessed in terms of extinction risk, there is an urgent need to gather information on the threats to the species, their ecological requirements, their geographic locations, and on information related to conservation actions that can be used to reduce threats and prevent extinction. Thus, the project addresses the need to assess the conservation status of threatened gymnosperm species in Vietnam. To fulfil this goal a comprehensive assessment of gymnosperm species was conducted at select national park and nature reserves in Vietnam.

Such information would help formulate guidelines for assessing the status of species at the national and global levels through the gathering of new information on the conservation status and distribution of threatened gymnosperms in Vietnam. The data thus acquired would allow us to establish a sound gymnosperm conservation policy and action. Additionally, the project would also serve as a model for any other conservation efforts in other protected areas in Vietnam.

II. PROJECT AIM AND OBJECTIVES

1. To prepare conservation profiles that will include mapping the distribution and abundance of threatened gymnosperm species through field surveys in Cuc Phuong National Park, Pu Luong, and Pa Co–Hang Kia Nature Reserves. Parameters will include habitat location, habitat size, population numbers, and size class distributions.

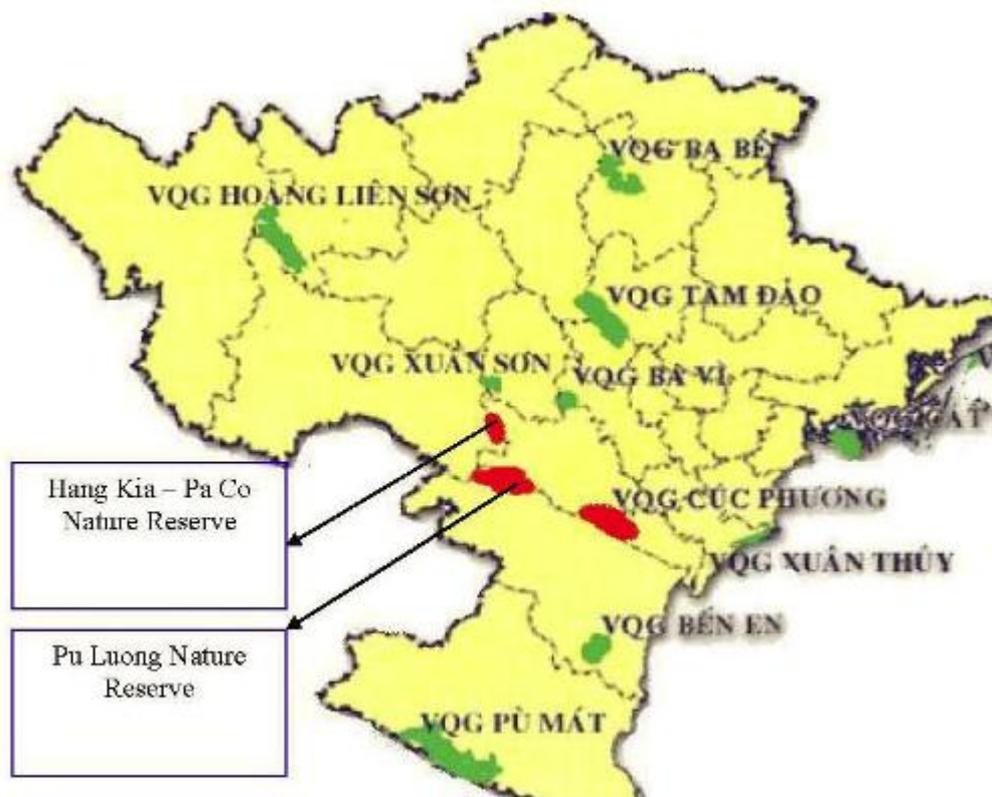
2. To provide distribution maps, that will include information on species identity, habitat, location, and population size. Data obtained are expected to justify site- and national-level action plans for plant conservation.

3. To build a long-lasting *in situ* conservation platform at the site level (at the parks and reserves listed above) through participatory conservation activities, involving the local people and the park staff. The project will also undertake follow-up *ex-situ* conservation studies of threatened gymnosperms, in cooperation with protected area managers and local communities at Cuc Phuong National Park (in particular, the project will upgrade the *ex-situ* Gymnosperm Conservation Area previously established through an RSG project grant).

4. To update the living gene bank of gymnosperm species at Cuc Phuong through the germination of seeds and propagation experiments in Cuc Phuong nursery, and to transfer them to the *ex-situ* Gymnosperm Conservation Area, and will also involve local people, students and volunteers as participants in the project.

III. METHODOLOGY

As stated in the Introduction, the present gymnosperm conservation study was undertaken in a national park and in two contiguous nature reserves (Map 1): Cuc Phuong National Park (20.000 ha, 20° 14'N, 105° 29'E), Pu Luong Nature Reserve (17.662 ha, 20° 21'N, 105° 20'E) in Thanh Hoa province and Pa Co–Hang Kia Nature Reserve (7,000 ha, 20° 41'N, 104° 51'E) in Hoa Binh province.



Map 1: Study location in northwest Vietnam

In the implementation of the project, the following activities were executed.

1. Study plots were set up to investigate community structure, regeneration, and to calculate number of individuals for each species. Follow-up activities included collection of voucher herbarium specimens of species being studied; measurement of altitude, longitude and latitude using a GPS instrument; to take photographs of the plants and their habitat location; and to record biological and ecological factors, including vegetation formation type, dominant species, natural regeneration, and responses to disturbance.

2. Seeds were collected and cuttings made to study the germination and cultivation requirements through the establishment of *ex situ* collection sites to be managed in partnership with the ethnic Muong, Thai and H'Mong people and the local communities.

3. Interview surveys with the Muong, Thai and H'Mong people were conducted to determine the current conservation status of each species, and to compile data on the exploitation of the gymnosperm species. Some villagers, especially the indigenous groups, have high familiarity with the flora of the national parks and the nature reserves. Forest managers, forest rangers and interested members of village communities were invited to participate in the field survey throughout the period of the study.

4. Species distribution in each park was mapped, using on-site GPS readings where individual plants were found. The team built a database (excel-based matrix) to record species parameters (distribution, habitat, population size).

5. A plan for conservation management of gymnosperm species was drawn, with the involvement of Park Managers and village authorities.

6. Seminars and meetings were organized with the participation of local communities, in order to raise their awareness to conserve these threatened plant taxa, hence, to get input for the action plan.

7. Findings from the study were disseminated to the local minority communities, and eventually to be presented to national level for inclusion in Vietnam's plant conservation regulations and action plans.

IV. RESULTS OF STUDIES

1. Conservation status of gymnosperm species in northwest Vietnam

The following is the description of the 4 species under study.

1. a. *Amentotaxus yunnanensis* H.L. Li (Taxaceae) (Fig. 1)

Amentotaxus yunnanensis is considered endangered in the IUCN Red List.

The study team found only an isolated population at Pu Luong Nature Reserve (PLNR), and this population is on the decline due to regeneration failures. In the PLNR, this species is considered on the brink of local extinction from the wild.



Figure 1: Amentotaxus yunnanensis

1. b. *Cephalotaxus mannii* Hook.f. (Cephalotaxaceae) (Fig. 2)



Fig. 2: Cephalotaxus mannii

This species has a narrow distribution range at Pu Luong Nature Reserve, because it has become a target of exploitation to satisfy timber demands. *Cephalotaxus mannii* has only 2 populations in Pu Luong Nature Reserve, both located in remote soil-based (non-rocky) forest locations. Their survival is at risk. According to Decree 32/2006/NĐ – CP March 30, 2006, on management of endangered, precious and rare forest plants and animals, this species is listed within Group IIA, on plants and wild animals, which limits the exploitation and use for commercial purposes.

1. c. *Calocedrus macrolepis* Kurz (Cupressaceae)



Figure 3: Pinus fenzeliana

1. d. *Pinus fenzeliana* Hand.-Mazz. (Synonym: *Pinus kwangtungensis* Chun Tsiang) (Pinaceae) (Fig. 3)

This species is considered at risk in the IUCN Red List. It has a narrow distribution range at Pu Luong and Hang Kia – Pa Co Nature Reserves. The species has two populations in Pu Luong and two populations in Hang Kia – Pa Co Nature Reserves, in both cases, they are located in remote limestone mountain forest locations, thus, their survival is at risk. This species is listed in Group IA of the Vietnam Government Decree 32, which prohibits exploitation of endangered, precious, and rare plants and animals for commercial purposes.

2. The major threats to gymnosperm species in northwest Vietnam



Figure 4: Human demand is major threat to gymnosperm species in northwest Vietnam

The threats to gymnosperm species in this part of Vietnam are the direct and indirect actions by human. Illegal agricultural land expansion, through clearance and conversion of natural forest into agricultural lands, is one of the biggest major threats. Illegal logging and exploitation to meet the affecting precious timber species, such as the gymnosperms. People who live in the protected areas of Hang Kia - Pa Co and Pu Luong Nature Reserve are heavily dependent on wood products for the building and making of furniture. They are also still heavily dependent on fuel wood for the processing of commercial products, such as tea (Fig. 4).

3. Recording of species distribution

The locations and number of populations of the four gymnosperm species found in several areas in Northwest Vietnam are presented in Map 2. Most species are found growing on limestone mountain peaks, and their exact geographic coordinate locations were determined by using a GPS instrument (Table 1). Collection data included voucher herbarium specimen number, exact location, date of collection, specific habitat, geographic coordinates, and field characteristics of the species.

Table 1. Locations of the 4 gymnosperm species at Pu Luong and Hang Kia – Pa Co Nature Reserve

No	Species	Geographic location (GPS readings)	Location	Number of populations
1	<i>Amentotaxus yunnanensis</i>	20° 28' 017" N; 105° 05' 624" E	Pu Luong Nature Reserve	1
2	<i>Cephalotaxus mannii</i>	20° 28' 298" N; 105° 05' 156" E	Pu Luong Nature Reserve	2
3	<i>Calocedrus macrolepis</i>	20° 44' 216" N; 104° 53' 249" E	Hang Kia – Pa Co Nature Reserve	1
4	<i>Pinus fenzeliana</i> (Synonym: <i>Pinus kwangtungensis</i>)	20° 25' 981" N; 105° 14' 336" E	Pu Luong Nature Reserve	2
		20° 44' 216" N; 104° 53' 249" E	Hang Kia – Pa Co Nature Reserve	2

In each site, the study team performed survey to locate the plants, to prepare voucher herbarium specimens, to map the species, and to record other field data: life form, microhabitat, number of individuals on the site, state of flowering or fruiting, dispersers and pollinators, to collect seeds (if in fruiting state), and to take GPS readings.

Several populations of the 4 gymnosperm species were located, as presented in Table 1. These locations lie in the limestone range that extends south-east from the Son La plateau through Pa Co-Hang Kia and Pu Luong Nature Reserve.



Map 2: Pa Co-Hang Kia, Pu Luong and Cuc Phuong location

The research group set up several plots, each the size of 0.1 ha (20 x 50 m), in different locations within the Pu Luong and Hang Kia – Pa Co Nature Reserves. A database on ecological parameters of each species was constructed. For regeneration studies, all saplings found inside the study plots were also documented.

4. Plant communities and species associations

4. a. *Pinus fenzeliana*

The survey at Pu Luong Nature Reserve found only two isolated populations of *Pinus fenzeliana* on the peak of a limestone hill (20° 25' 981" N; 105° 14' 336" E). Within the survey plot of 1000 m² at this location, species frequencies are distributed as follows: *Pinus fenzeliana* 27.6%; *Pistacia cucphuongensis* 11.5%; *Schefflera pes-avis* 11.5%; *Illicium difengpi* 11.5%; *Eriobotrya bengalensis* 5.7%; *Platycarya strobilacea* 5.7%; *Sinosideroxylon wightianum* 5,7%; *Calophyllum balansae* 4.6%; *Quercus* sp. 4.6%; *Hippocratea oblongifolia* 3.4%; other species 8.2%.



Figure 5: Study group setting up study plots at the top of a limestone mountain in Co Lung commune – Pu Luong Nature Reserve.

The survey at Hang Kia – Pa Co Nature Reserve also found two isolated populations of *Pinus fenzeliana* on the peak of a limestone hill (20° 44' 216" N; 104° 53' 249" E). Within the survey plot of 1000 m² at the top of the hill, the following

occurrence of species frequencies were found: *Quercus* sp. 16.4%; *Pinus fenzeliana* 9.1%; *Planchonella obovata* 9.1%; *Schefflera octophylla* 9.1%; *Platycarya strobilacea* 7.3%; *Toxicodendron succedanea* 7.3%; *Calocedrus macrolepis* 7.3%; *Eriobotrya bengalensis* 7.3%. *Taxus chinensis* 3.6%; *Syzygium* sp. 3.6%; *Garcinia fagraeoides* 3.6%; and others 16.3%.

4. b. *Amentotaxus yunnanensis*

The field survey found some isolated populations at the peak of a terrestrial hill located at 20° 28' 017" N; 105° 05' 624" E in Pu Luong Nature Reserve. *Amentotaxus yunnanensis* population was found to consist of 5.9 % of the total individuals in this community: *Caryodaphnopsis tonkinensis* 15.9%; *Carya sinensis* 7.8%; *Lithocarpus dussaudii* 7.8%; *Lithocarpus bacgiangensis* 5.9%; *Amentotaxus yunnanensis* 5.9%, *Michelia chapensis* 5.9%; *Nageia fleuryi* 5.9%; *Pterospermum lancaefolium* 5.9%; *Dysoxylum binectariferum* 5.9%; *Burretiodendron hsienmu* 3.9%; *Cryptocarya oblongifolia* 3.9% and other 25,3%

4. c. *Cephalotaxus mannii*

The survey found two isolated populations of *Cephalotaxus mannii* on soil-based terrains on the hills of Pu Luong Nature Reserve (20° 28' 298" N; 105° 05' 156" E). Within a 1000 m² plot area, *Cephalotaxus mannii* population makes up 6.4% of the individuals in this plot. Other species include *Caryodaphnopsis tonkinensis* 14.9%; *Cryptocarya oblongifolia* 10.6%; *Michelia chapensis* 8.5%; *Cephalotaxus mannii* 6.4%; *Turpinia nontana* 6.4%; *Camellia caudata* 6.4%, *Caryodaphnopsis baviensis* 6.4%; *Adina pilulifera* 4.3%; others 36.1%

4. d. *Calocedrus macrolepis*

The survey found only one isolated population of *Calocedrus macrolepis* on non-rocky hills of Hang Kia – Pa Co Nature Reserve (20° 44' 216" N; 104° 53' 249" E). The population makes up 7.3% of individuals plants found in this plot. The total percentages are: *Quercus* sp. 16.4%; *Pinus fenzeliana* 9.1%; *Planchonella obovata* 9.1%; *Schefflera octophylla* 9.1%; *Platycarya strobilacea* 7.3%; *Toxicodendron succedanea* 7.3%; *Calocedrus macrolepis* 7.3%; *Eriobotrya bengalensis* 7.3%; *Taxus chinensis* 3.6%; *Syzygium* sp. 3.6%; *Garcinia fagraeoides* 3.6%; and others 16.3%.

5. Regeneration Research

The study assessed standard sapling plant regeneration using technical norm to select healthy and weak plants, a method applied in forestry inventory. Healthy plants

present a good growth condition, symmetrical in shape, not twisted, not diseased plants. Weak plants show a poor growth condition, twisted, and diseased.

The study assessed regeneration of saplings, which have or which do not have the prospect to become part of the forest structure, by applying the norm used in forestry inventories and applying it at Pu Luong Nature Reserve and at Hang Kia – Pa Co Nature Reserve. Plant regenerations are classified into two height levels, namely, <40-100 cm (prospect not defined), and >100 cm (prospect defined). This method was applied only for the 4 gymnosperm species investigated in this research.

For *Pinus fenzeliana*, regeneration study found only 6 very small saplings within 1000 m²; these individuals were less than 20 cm in height. It was also observed that germination rate of *Pinus fenzeliana* was very low. There is no evidence of continuation of its generation development to the next in order to maintain their life cycle. Population of *Pinus fenzeliana* is on the decline due to regeneration failures. In the PLNR, this species is considered on the brink of local extinction from the wild, because their regeneration process did not maintain continuation from this generation to the next. This was evidenced by the fact that several saplings growing on limestone mountain were found to have a height of less than 20 cm. Thus, these individuals do not yet have the prospect to continue their life cycle to the next generation. Further observations did not find saplings higher than 20 cm in the study location at this Reserve. Only in Hang Kia – Pa Co Nature Reserve did the study team found 5 out of 9 saplings of *Pinus fenzeliana* that were taller than 100 cm; these individuals have the prospect to develop into 6).

Amentotaxus yunnanensis. The regeneration study found 16 saplings; all individual saplings were less than 20 – 60 cm. It was also observed that germination rate of this species outside of the plot study was too low. Therefore, population of *Amentotaxus yunnanensis* is on the decline due to regeneration failures. In the Pu Luong Nature Reserve, this species is considered on the brink of local extinction from the wild, because their regeneration had not been able to maintain continuation of the life cycle from this generation to the next. As evidence, the research team only found 16 saplings of less than 60 cm in height growing on soil base hill. Clearly, all individuals do not have the prospect to develop into maturity to become part of the forest structure (Table 2; Fig. 6).



Figure 6. Regeneration of gymnosperm species in Pu Luong and Hang Kia – Pa Co Nature Reserves.

The regeneration study of *Cephalotaxus mannii* found 12 saplings. It appears that the development of seedlings to reach maturity varies, and has taken place for quite a long period of time. Thus, it may be noted that the regeneration process is low. Of the 12 saplings found, 5 were less than 100 cm, while 7 were taller than 100 cm. It may be concluded that only *Cephalotaxus mannii* individuals that are > 100 cm in height have the prospect to develop into maturity to become part of the forest structure (Table 2; Fig. 6).

For *Calocedrus macrolepis* regeneration study found only 3 saplings. It appears that the development of seedlings to reach maturity varies, and has taken place for a long period of time. Of the 3 saplings, 1 was less than 100 cm in height, and 2 were taller than 100 cm. Thus, for *Calocedrus macrolepis*, only saplings > 100 cm in height have the prospect to develop into maturity to become part of the forest structure (Table 2; Fig. 6).

Table 2. Species regeneration study at Pu Luong and Hang Kia – Pa Co Nature Reserve.

No.	Species	Location	Total plots (10 x 10m)	Subplots with re-generation	Plant number			Height			
					Total	Good plants	Weak plants	<100cm		>100cm	
								Plant no.	%	Plant no.	%
1	<i>Calocedrus macrolepis</i>	Hang Kia – Pa Co N 20° 44' 216 E 104° 53' 249	10	3	3	3	0	1	33	2	67
2	<i>Cephalotaxus mannii</i>	Pu luong N 20° 18 032 E 105° 39 826	10	8	12	11	1	5	42	7	58
3	<i>Amentotaxus yunnanensis</i>	Pu luong N 20° 21 694 E 105° 35 223	10	3	16	15	1	16	100	0	0
4	<i>Pinus fenzeliana</i>	Pu luong N 20° 18 377 E 105° 41 311	10	3	6	4	2	6	100	0	0
		Hang Kia – Pa Co N 20° 44' 216 E 104° 53' 249	103	5	9	8	1	4	44	5	56

The low regeneration ratio may be explained by the condition of the habitat, which consists only of limestone base mixed with only little amount of feralite soil. Only seeds that reach into feralite soil could maintain their life cycle. The plants are dioecious, so it is difficult to mate during pollination period. Additionally, gymnosperm population has restricted distribution, with the effect that small populations have decreased in size. Illegal exploitation of mature gymnosperm species to meet timber demands has been the primary cause of the decrease of mature individuals to take part in the reproduction process. The result is the lost opportunity in providing gene resources for the regeneration process in nature.

6. Propagation of gymnosperm species

6. a. Seed germination

As part of the field survey, gymnosperm conservation team collected seeds from 2 species (*Pinus fenzeliana*; *Calocedrus macrolepis*). The survey was initiated as part of the study to support *ex-situ* gymnosperm conservation program at Hang Kia – Pa Co, Pu Luong Nature Reserve, and at Cuc Phuong National Park. Propagation program has been implemented for the period from July, 2010 to May, 2011.

The study team collected seeds of *Pinus fenzeliana* and *Calocedrus macrolepis* for propagation in the nursery at Hang Kia – Pa Co Nature Reserve and at Cuc Phuong National Park. The study has taken several steps in order to achieve the goal of conserving endangered and threatened gymnosperm species (Fig. 7).

6. b. Cutting propagation

All cuttings of three species (*Amentotaxus yunnanensis*, *Cephalotaxus mannii*, *Pinus fenzeliana*) were collected during field surveys at Pu Luong and Hang Kia – Pa Co Nature Reserves, in order to serve as propagation conservation research. Entire cuttings were germinated at Cuc Phuong’s nursery in the park. The results show a very low rate of germination ratio of cuttings (Table 3).



Figure 7. Gymnosperm propagation

Table 3. Cuttings germination of 3 gymnosperm species

No.	Species	Collection date	Number of cuttings	Germination in substrate	Survival ratio
1	<i>Pinus fenzeliana</i>	7/11/2010	100	Sand	25%
2	<i>Cephalotaxus mannii</i>	7/11/2010	100		15%
3	<i>Amentotaxus yunnanensis</i>	7/11/2010	100		20%

7. Maintenance of a living gene bank of gymnosperm plants considered at risk in Northwest Vietnam

The project set aside 1.5 hectares of land, to serve as a Living Gene Bank of Endangered and Threatened Gymnosperms at Cuc Phuong National Park. This project is in line with the mission of Cuc Phuong National Park to manage and to protect natural resources, as well as to conduct scientific research.

This program has been successful with the planting of 400 saplings of gymnosperm species, an integral part of the efforts to conserve rare, vulnerable, and endangered gymnosperm species of Northwest Vietnam. This *ex situ* conservation work was undertaken with the participation of local people, park staff and the British Embassy staff. Everyone helped to plant the 400 gymnosperm saplings at Cuc Phuong National Park. It may be noted that this project upgraded the *ex-situ* Gymnosperm Conservation Center previously established during the first gymnosperm conservation effort at Cuc Phuong National Park through the support of a grant from RSG. To date, the project has developed a living gene bank by way of germination of cuttings and propagation experiments in the Cuc Phuong nursery, then transferring the plants to the *ex-situ* Gymnosperm Conservation Center (Fig. 8).



Figure 8. Maintenance of the ex-situ Gymnosperm Conservation Area.

Weeding and caring of the plants in the conservation area were regularly performed year-long. To date, individuals planted in the Gymnosperm Conservation Area are growing and developing very well.

The Thai, Muong and H'Mong ethnic people (Fig. 9) participated in the planting and caring for gymnosperm species. They benefit from the income generated by the conservation research program at Cuc Phuong and Pu Luong Hang Kia - Pa Co Nature Reserve.

It should also be pointed out that Thai, Muong and H'Mong People had benefited from this research program, in the field surveys, plot structure studies, overall field research, reproduction, and breeding of gymnosperm species in Pu Luong and hang Kia - Pa Co Nature Reserve.



Figure 9. Gymnosperm conservation activities involving the Thai, Muong and H'Mong, staff of Pu Luong, Hang Kia – Pa Co staff and British Embassy personnel

The gymnosperm *ex-situ* conservation program (Fig. 10) in Cuc Phuong National Park and in Hang Kia - Pa Co Nature Reserve has shown a good success ratio of living gymnosperm individuals, proof of the success of the Gymnosperm Conservation Center effort. Clearly, this serves as a model for the conservation of rare and valuable gymnosperm species for other National Parks and Nature Reserves in Vietnam.

The gymnosperm conservation program at Cuc Phuong National Park is also a very important educational and research resource for students and visiting scientists from national and foreign institutions, in the study of morphology, ecology, and even molecular biology of gymnosperms.



Figure 10. Gymnosperm species planted in the Gymnosperm Conservation Area at Cuc Phuong National Park

The Gymnosperm Conservation program has encouraged and persuaded minority communities who live around Cuc Phuong National Park to help conserve natural resources. It has also helped to strengthen conservation awareness on the conservation and management of threatened and endangered species, both gymnosperms and other plant groups, at Pu Luong, Hang Kia Pa Co Nature Reserve and at Cuc Phuong National Park.

8. Gymnosperm Conservation project links



Figure 11. Dissemination of gymnosperm conservation results on mass media and the Website

Active conservation status assessment on the threat to the species is a very important step to identify the need for gathering more data towards an effective conservation measure of species. Thus, the project team participated in the *RED LISTING WORKSHOP* “Assessment of the Status and Distribution of Globally Threatened Plant Species in Indochina” jointly organized and convened in Hanoi by the Vietnam Academy Science and Technology (VAST), Missouri Botanical Garden (MBG), International Union for Conservation of Nature (IUCN) and Botanic Gardens Conservation International (BGCI), in December, 2010 (Fig 11). In this context, our research team on North Vietnam gymnosperm conservation project leader was invited to the workshop to give assessment of the status of gymnosperm species that are in danger. The information and data on the gymnosperm conservation status we gathered were provided to the RED LIST of the IUCN website (www.iucnredlist.org), as a manner of sharing the information with other scientists, conservationists, students, and stakeholders. This was also a good opportunity to provide important data to the media on the conservation status of North Vietnam

gymnosperm species, so that conservationists, scientists, and lawmakers can assist in planning for an effective solution and for action toward the conservation of gymnosperm species. Such information is the basis for having a good understanding on the need for finding an effective solution for the preservation of endangered and threatened gymnosperms in the future.

Based on data presented in the report on the results of the previous Gymnosperm Conservation Project at Cuc Phuong National Park funded by RSG website (http://www.ruffordsmallgrants.org/rsg/projects/cuong_nguyen_manh) and (http://www.ruffordsmallgrants.org/rsg/projects/cuong_nguyen_manh_0), the RSG Director and the Cuc Phuong project staff agreed to release photos of the endangered *Cycas sexseminifera* for use on the ARKive (Fig. 11). The pictures provide links to the previous RSG study on gymnosperm conservation at Cuc Phuong National Park. The pictures on ARKive website (<http://www.arkive.org/cycad/cycas-sexseminifera/photos.html>) provide one of the avenues to disseminate findings of the study. This posting of *Cycas sexseminifera* provides an important link to the previous study on gymnosperm conservation at Cuc Phuong National Park funded by RSG. Dissemination of research and conservation results via the Internet is a very important part to share information and research experience on gymnosperms species for researchers and conservationists.

V. CONCLUSIONS AND RECOMMENDATIONS

The results of the present Gymnosperm Conservation Study indicate that individuals of 4 species of gymnosperm occurring in north-western Vietnam are presently decreasing in numbers in their natural environments. A low regeneration ratio appears to impact on the maintenance of their populations in their natural habitats. Therefore, it is necessary to promote interest in the propagation and maintenance activities to safeguard and care for mature female plants in their natural conditions, as well as to strengthen effort in long-term *ex-situ* conservation toward the future.

Effort to evaluate and determine the conservation status of endangered gymnosperm species through the participation of the Thai, Muong and H'Mong people will provide conservation managers with more complete information on the conservation status of gymnosperm species. A more comprehensive understanding on the conservation status and needs would lead to the realization of the gymnosperm conservation goals.

Criminal investigation needs to be undertaken to determine serious cases of illegal sale, purchase, and transportation of timber trees and criminals must be prosecuted under the provisions of the law.

Strengthening investments in *in-situ* and *ex-situ* gymnosperm conservation is necessary, not only at Pu Luong, Hang Kia – Pa Co Nature Reserves, and in Cuc Phuong National Park, but also in the north-western region of Vietnam as a whole. Although the priority to implement *in – situ* conservation measures to enhance gymnosperm species rehabilitation in their home range is high, *ex-situ* conservation measures are also important and should not be overlooked.

It is necessary to continue to upgrade gymnosperm conservation area and effort at Cuc Phuong National Park. The park has more than adequate space to nurse gymnosperm individuals of species that are currently on the brink of local extinction, so that they are safely rescued and their survival in Northwest Vietnam toward the future is assured.

It is important to increase gymnosperm conservation awareness among the Muong, Thai and H'Mong people at Pu Luong, Hang Kia – Pa Co and Cuc Phuong, through the building of gymnosperm conservation infrastructures, that would benefit local people as well as to give them responsibility and incentive to participate in a long-term gymnosperm conservation effort in Northwest Vietnam.

Interdisciplinary co-operation and regulations involving conservation agencies, and creation of conditions that would allow for the establishment of local self-

managed conservation organizations, can enhance the protection of threatened gymnosperm species at Cuc Phuong National Park, Pu Luong and Hang Kia – Pa Co nature reserve.

Regulations and specific remedies need to be enacted to ensure conditions for strengthening community participation in wildlife protection. Experience learned during the course of our gymnosperm conservation project indicates that, if local communities are not informed, not consulted, and do not participate in the conservation process, monitoring and control of the conservation work will not be effective.

The gymnosperm species of Northwest Vietnam represent a precious genetic resource that has taken millions of years to evolve and to form. We should manage and monitor their survival status and conservation toward sustainable use, based on principles of modern science. This resource is a treasure that could provide seed source for plant conservation programs and development in the country. It is important that we be fully aware of the enormous value of the ecosystems, and genetic resources of rare gymnosperm species for the benefits of the present and future generations.

Based on the results of our research and on the considerations presented above, the following proposals and recommendations are presented:

V.1. To increase investment in *in-situ* and *ex-situ* gymnosperm conservation programs in national parks and nature reserves.

V.2. To increase funding for an intensive training of conservation staff in protected areas; for comprehensive monitoring of the biodiversity in general, and endangered species in particular; for strengthening resources to upgrade the effort in the conservation of gymnosperm species that are at risk or under conservationists on the preservation of rare and valuable genetic resources.

V.3. To strengthen cooperation and research coordination on genetic conservation study with organizations, students, stakeholders and conservationists to determine gymnosperm species as conservation targets toward the future within the management plan of the Cuc Phuong National Park, Pu Luong Nature Reserve, and Hang Kia - Pa.

VI. REFERENCES

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