

# CONSERVATION, UTILIZATION AND MANAGEMENT OF FOREST GENETIC RESOURCES IN VIETNAM

Nguyen Xuan Lieu<sup>1</sup>

*Central Forest Seed Company, Hanoi, Vietnam*

## **The geography and ecology of Vietnam**

Vietnam lies on the eastern coast of the Indochinese peninsula in Southeast Asia. The country covers an area of about 331,000km<sup>2</sup>, much of which is hilly and mountainous. The Truong Son mountain range stretches from the north to the south of the country. In northeast Vietnam, the mountains reach an average height of 1000m above sea level. The highest peaks in the watersheds of the Chay, Lo and Gam rivers are over 2000m in height. The mountains in the northwest of Vietnam are the country's highest, reaching over 3000m. These slope down to the southeast, where they terminate in the Red River delta. Vietnam has over 2500 rivers longer than 10km. On average, every 20km of coastline has one estuary.

Annual levels of rainfall vary between 1700mm and 1800mm, but can reach as much as 3000mm in mountainous areas. Because of the monsoon regime, rainfall is regulated into distinct dry and rainy seasons. In the southern part of the central coastal region, the rainy season lasts for only 3–4 months. In the north, the central highlands and the south, the rainy season continues from May to October. Up to 80–85% of Vietnam's annual rainfall comes during the rainy season.

Although Vietnam is situated entirely in the tropics, climatic conditions vary considerably owing to wide variations in longitude and elevation. Average temperatures increase gradually from 22°C in the north of the country to 25°C in the south, though temperatures at higher elevations are lower.

## ***Major forest formations***

Vietnam's topography, climate and soils combine to produce an extremely diverse and abundant forest vegetation. The country has a wide range of forest types typical of the monsoon tropics. The dominant forest formations are described below.

- **Tropical evergreen broadleaf forest.** Mixed stands of tropical tree families such as Fabaceae, Fagaceae and Lauraceae occur in hilly and mountainous areas below 800m in the north and 1000m in the south. In addition to the dominant woody species, medium-sized trees and shade-tolerant vegetation thrive under the forest canopy. Many epiphytic plants, such as orchids, lianas and various woody climbers, are found in these forests. Tropical evergreen broadleaf forests are a source of commercially valuable wood and non-wood forest products. These forests are also of special value as reservoirs of biological diversity.
- **Tropical evergreen broadleaf forest on limestone karst.** The relatively diverse vegetation on limestone karst is dominated by evergreen species with a mix of deciduous species. The endemic woody species found in this formation, including

---

<sup>1</sup> Chief of Technical Section, Central Forest Seed Company, 62 Cau Dien Township, Tu Liem, Hanoi, Vietnam, Tel: +84-4-837 2472, Fax: +84-4-837 2470, E-mail: nxlieucfsc@fpt.vn.

*Excentrodendron tonkinensis*, *Dacrydium pierrei*, *Fagraea fragrans* and *Diospyros mun*, supply valuable furniture timber. Limestone karst forests also shelter vulnerable wildlife species such as fox, civet cat, antelope, monkey, squirrel and large birds such as pheasant and grey peacock. The remains of ancient hunter-gatherer communities have been found in limestone caves in Bac Son, Hoa Binh and Cuc Phuong. Vietnam's first national park is also situated in Cuc Phuong.

- **Subtropical evergreen broadleaf alpine forest.** This formation occurs at elevations over 800m in the north of the country. Families represented include Fagaceae, Lauraceae, Ericaceae and Bambusaceae. Epiphytes such as orchids, *Asplenium nidus*, *Drynaria bonii* and other medicinal plants are also common. Ground conditions are favourable for the cultivation of many valuable medicinal herbs, in particular *Euonymus cochinchinensis*, *Cinnamomum cassia* and *Panax ginseng*.
- **Dry dipterocarp forest.** This occurs in parts of the central plateau and the southeast of Vietnam, including the south coast. In general, dry dipterocarp forests are found at elevations below 1000m with pronounced seasonal variations in rainfall. They include both deciduous and evergreen species, but are dominated by dipterocarps. Most dry forests in the central highlands are waterlogged during the rainy season and affected by forest fires in the dry season. These forests are open with scattered and slow-growing trees. On slopes with moderate rainfall or deeper soils, however, dry dipterocarp forests form a multi-layered canopy with species such as *Sindora cochinchinensis*, *Dalbergia cochinchinensis*, *Dalbergia oliveri*, *Pterocarpus pedatus*, *Anisoptera cochinchinensis*, *Hopea* spp. and *Dipterocarpus* spp. Dipterocarp forests provide habitats for a number of rare and endangered mammal species, including elephants, tigers and panthers.
- **Coniferous forest.** Coniferous species, namely *Pinus merkusii* and *Pinus kesiya*, grow at elevations above 1000m. In many cases, pines grow among subtropical evergreen stands at similar elevations and rainfall regimes. The Lam Dong highlands are famous for their large areas of natural pine forest. Pine forests provide wood for poles, veneers, furniture and pulp. Pine resin is tapped to produce turpentine for domestic use and export. Coniferous forests also support other valuable tree species such as *Fokienia hodginsii* and *Cunninghamia sinensis*, particularly in the Hoang Lien Son and Long mountain ranges.
- **Mangrove forest.** Species typical of mangrove forests include *Rhizophora conjugata*, *Sonneratia alba* and *Bruguiera gymnorhiza*. On the southernmost cape of Nam Can, the two dominant species *B. gymnorhiza* and *S. alba* often reach heights of 10–15m and form large stretches of mangrove forest covering many thousands of hectares. Mangrove forests also harbour a wide range of aquatic and semi-aquatic species.
- **Melaleuca forest.** *Melaleuca cajuputi* grows on acid soils in the south of Vietnam, particularly in Kien Giang, Dong Thap and other provinces in the southwest. At one time, stands of *M. cajuputi* reaching 15–20m covered many thousands of hectares. The tree grows fast and yields large volumes of wood for poles, firewood and charcoal. Its flowers are also a valuable resource for the bee-keeping industry. In addition, *M. cajuputi* forests help to ameliorate acid soils and protect freshwater resources.

- **Bamboo forest.** Bamboos grow either in pure stands or mixed with trees in evergreen or deciduous forests throughout Vietnam. They are water-tolerant, light-demanding and fast-growing, and develop steadily on flat lands, hills and along streams with a short rotation of 2–4 years. There are many economically important varieties of bamboo. *Neohouzeaua dullooa* in the north, *Bambusa procera* in the south, *Dendrocalamus membranaceus* in Thanh Hoa and *Arundinaria spathiflora* in Bac Can and Cao Bang provinces are grown on a large scale and have great potential for intensive plantation development.

### *The flora of Vietnam*

Vietnam lies at the crossroads of the Chinese, Himalayan and Indonesian vegetation zones. Notwithstanding the loss of forests over many years, the country's flora is still diverse and includes many economically valuable species. Vietnam's forests have many species with outstanding physical properties, suitable for fine handicrafts and furniture making. These include *Dalbergia cochinchinensis*, *Diospyros mun*, *Chukrasia tabularis*, *Sindora cochinchinensis*, *Dalbergia oliveri*, *Fokienia hodginsii* and *Dacrydium pierrei*. Other species such as *Markhamia pierrei*, *Erythrophleum fordii*, *Madhuca pasquieri*, *Vatica tonkinensis* and *Burretiodendron hsienmu* are resistant to certain pests and diseases.

According to an inventory by the Forest Inventory and Planning Institute (FIPI), Vietnam has about 12,000 plant species, of which about 1000 are known to be endemic. Some 354 tree species are regarded as commercially important with over 50 species providing high-quality timber. Forty-two tree species registered as rare and precious plants in Vietnam.

Among the large number of bamboo species, about 40 are commercially valuable. There are an estimated 40 species of rattan, and the annual harvest of rattan is about 50,000 tons. Inventory data indicate that two-thirds of Vietnam's 1800 medicinal herb species are found in natural forests. Preliminary inventories have shown that 76 species have aromatic resins, 600 contain tannin, 160 yield essential oils and 260 produce fatty oils. Today, however, many endemic plants are endangered and several species have already become extinct.

### **Overall status of forests and forest genetic resources**

#### *Trends in forest area and coverage*

Vietnam's natural forest cover has been depleted by a number of causes, particularly clearance for industrialization and urbanization, war-related damage, shifting cultivation, over-exploitation of timber and repeated burning. Vietnam's forest cover was estimated to be 14.3 million hectares in 1943, or 43% of the national territory. By 1995, the area of forest had declined to 9.3 million hectares, or 28.2% of the national territory. Of this, 8.25 million hectares was natural forest and 1.05 million hectares tree plantations. The total growing stock in 1995 was 583.6 million m<sup>3</sup>, and the bamboo stock was 6.96 million stems. In 1999, forest cover had grown to 10.9 million hectares, or 33% of the national territory (Table 1).

**Table 1.** Change in forest area and coverage between 1976 and 1999 (in thousands of hectares). Source: Ministry of Forestry (1995); Forest Inventory and Planning Institute.

Forested land	1976	1980	1985	1990	1995	1999
Natural	11,076.7	10,186.0	9,308.3	8,430.7	8,252.5	9,444.2
Plantation	92.6	422.3	583.6	744.9	1,049.7	1,471.4
<b>Total</b>	<b>11,169.3</b>	<b>10,608.3</b>	<b>9,891.9</b>	<b>9,175.6</b>	<b>9,302.2</b>	<b>10,915.6</b>
<b>Coverage (%)</b>	<b>33.8</b>	<b>32.1</b>	<b>30.0</b>	<b>27.8</b>	<b>28.2</b>	<b>33.2</b>

From 1943 to 1997, the overall growth in forest cover concealed both negative and positive changes (Table 2). Between 1943 and 1990, five million hectares of forest were deforested at an annual rate of about 100,000ha. Between 1990 and 1997, 436,300ha were deforested at an annual rate of 60,000ha. However, although natural forests decreased, by 1995 the area of plantation forest had grown considerably.

**Table 2.** Changes in area of different land uses between 1990 and 1997 (in thousands of hectares). Source: Forest Inventory and Planning Institute.

Land Use	1990	1995	1997	Area change in period		
				1990-95	1996-97	1990-97
Forest lands	9,175.6	9,302.2	9,432.9	126.6	130.7	257.3
Non-forest lands	9,988.4	9,778.6	9,552.1	-209.8	-226.5	-436.3
Others	13,872.0	14,030.9	14,126.7	158.9	95.8	254.7

The distribution of natural forest area and forest resources by main zones in Vietnam is as follows:

**Table 3.** Natural forest resources in three major zones. Source: Ministry of Forestry (1995).

	Zone <sup>a)</sup>		
	North Central	South Central	Central Highlands
Natural forests ('1000 ha)	1,400	1,500	3,300
Volume of standing stemwood ('1000 m <sup>3</sup> )	118,200	132,100	289,300

<sup>a)</sup> Vietnam is divided into nine forestry zones: Northwest, Central North, Northeast, Red River Delta, North Central, South Central, Central Highlands, Southeast and Southwest (Mekong River Delta). The Central Highlands have 39% of the country's forest resources, the South Central zone has 18.1% and the North Central zone has 16.5%. The remaining zones have only 26.4%.

In areas where the forests have not been affected by human activities, the standing volume of timber is still high (up to 500–600m<sup>3</sup>/ha). These forests are small in area, however, and are found mainly at high elevations in steep, isolated sites.

**Table 4.** Forest area by forest type in 1997. Source: Nguyen Huy Phon (2000).

Forest Type	Area ('000 ha)	Proportion (%)
Natural forest	8,252.5	88.7
<i>Rich and medium</i>	2,165.3	23.3
<i>Poor and young</i>	4,621.7	49.7
<i>Bamboo</i>	846.0	9.1
<i>Mixed</i>	619.5	6.6
Plantation	1,049.7	11.3
<b>Total</b>	<b>9,302.2</b>	<b>100.0</b>

Vietnam's natural forest vegetation is divided into three categories: i) production forest, ii) protection forest, and iii) special-use forest (Table 5). Production forests are used mainly for wood and non-wood products, as well as environmental protection. To ensure appropriate management, these forests are split into different groups: timber production forests, industrial forests mainly for pulp, bamboo forests and non-wood product forests. Production forests are distributed as follows: rich forests (9.2%), medium forests (28.8%), poor forests (33.2%) and naturally regenerated forests (34.8%). Rich forests have a growing stock of more than 150m<sup>3</sup>/ha, whereas that of medium forests is 80–150m<sup>3</sup>/ha and that of poor forests is less than

**Table 5.** Area and proportion of each forest category. Source: Ministry of Forestry (1995).

	Production	Protection	Special-Use	Total
Area ('000 ha)	4,925.2	3,478.7	898.3	9,302.2
Proportion (%)	52.9	37.4	9.7	100.0

Protection forests are designated to conserve soil and water resources, guard against land erosion and natural hazards, and protect wildlife. The protection forest system is divided into environmental protection forests, watershed forests, wind and soil protection forests and coastal protection forests. Thirty forest areas covering 3.5 million hectares have been designated to prevent sedimentation in reservoirs, protect hydroelectric power plants and water construction projects, and regulate large, nationally significant water bodies.

The development of protection forests along the central and western coasts of southern Vietnam aims to reduce wind flow and sand movements. Many protection forests have also been established around industrial zones in densely populated areas, and special attention has been paid to creating green belts around the cities of Hanoi and Ho Chi Minh. In addition, protection forests have also been established to maintain sources of water for consumption and industrial use. Special-use forests are set aside for nature conservation, research, maintaining historical and cultural relics, beauty spots and for recreation and tourism. These forests include national parks and nature reserves.

Over half of Vietnam's natural forests are of low quality and many special-use forests have been and will be removed from the protected list. War and unsustainable logging have damaged large areas of forest. Many valuable plant species have become endangered because of uncontrolled harvesting. There is an urgent need, therefore, for biodiversity and wildlife conservation measures, including plant genetic resources conservation.

## **Current activities in conservation, use and management of forest genetic resources**

### ***The five million hectares reforestation programme***

Aware of the value of forests, the Vietnamese government, the Ministry of Agriculture and Rural Development (MARD) and the whole nation have taken action to protect existing forests and support sustainable forest sector development (CFSC 1998; MARD 1998; Nguyen Ngoc Binh 2000). The government has banned logging in natural forests in an effort to minimize further degradation. It has also launched major initiatives to rehabilitate forest cover, such as the five million hectare reforestation programme (5MHRP). The objectives of this programme, which is supported largely by international donors and institutions, are to:

- Rehabilitate degraded lands and bring them into effective production to alleviate poverty;
- Establish five million hectares of new forest and protect existing forests to increase forest cover from 28.2% (1995) to 43% by 2010; and
- Protect the environment, decrease the severity of natural disasters, increase water availability, preserve plant genetic resources and protect biodiversity.

Programme targets are:

- Two million hectares of protection and special-use forests will be planted. This will increase the total area of watershed forests to 6,515,000ha, windbreak forests to 130,000ha, wave-break forests to 155,000ha and special-use forests to 1,000,000ha.
- Three million hectares of production forests, of which two million hectares will be industrial forests and one million hectares cash crops and fruit trees.
- Promote scattered tree planting for environmental improvement and self-sufficiency in wood. An average of 350–400 million trees will be planted annually for this purpose.

Table 6 details the specific planting targets of 5MHRP in 1998–2000, 2001–2005 and 2006–2010.

*Table 6. 5MHRP planting targets (in thousands of hectares).*

Period	Assisted natural regeneration	Reforestation	Total
1998–2000	350	700	1,050
2001–2005	650	1,300	1,950
2006–2010	–	2,000	2,000
<b>Total</b>	<b>1,000</b>	<b>4,000</b>	<b>5,000</b>

### *The forest tree seed sector*

Forest plantations expanded throughout the 1990s. In 1991, the area of plantations was 126,576ha and in 1997 it was 240,000ha. Other tree planting activities have also consumed about 300 million seedlings every year. Consequently, the demand for forest seed has grown substantially.

Providing enough forest seed and seedlings to meet demand, while at the same time maintaining quality, has proved difficult. There is only enough good-quality seed in the country to satisfy 25–30% of the demand from new forest plantations. To increase the supply of seed, MARD has re-organized the National Forest Seed and Planting Material Company into the Central Forest Seed Company (CFSC). In addition to existing seed orchards, many natural forests and well-planted forests consisting of selected species have been converted into seed-production areas. Seed sources are listed in Appendix 2.

A programme to develop vegetative propagation technology (tissue culture and cutting methods) has made good progress. A vegetative propagation centre has been established, high-yielding clones have been selected and human resources in this area have been developed. Seven Regional Forest Seed Enterprises under the CFSC, the Forest Tree Improvement Research Centre of the Forest Science Institute of Vietnam, the Yen Lap Forestry Research and Technical Experimental Centre in Quang Ninh Province and the Phu Ninh Forestry Research Centre in Phu Tho have contributed to the programme. Their success has had great benefits for the implementation of 5MHRP.

Tables 7 and 8 detail the projected seed demand of 5MHRP, calculated on the basis of 45 target species and the programme's planting targets.

**Table 7.** Demand of seed and seedlings for production forests. Source: Nguyen Duong Tai (2000).

Stage	Seed demand (kg)	Seedling demand ('000 stems)
Annual average (1st stage)	117,362	248,172
Annual average (2nd stage)	152,037	321,496
Annual average (3rd stage)	257,663	544,851
<b>Total</b>	<b>2,400,588</b>	<b>5,076,255</b>

**Table 8.** Demand of seed and seedlings for the establishment of special-use forests and protection forests. Source: Nguyen Duong Tai (2000).

Stage	Seed demand (kg)	Seedling demand ('000 stems)
Annual average (1st stage)	128,308	226,057
Annual average (2nd stage)	103,648	182,584
Annual average (3rd stage)	115,494	203,451
<b>Total</b>	<b>1,480,634</b>	<b>2,608,350</b>

To meet this demand with high-quality seed and seedlings, the major challenges for seed supply development are: i) establishing and managing seed networks from regional to national levels, ii) establishing and managing seed sources, and iii) establishing nurseries to produce large amounts of high-quality seedlings.

### ***Ex situ conservation***

*Ex situ* conservation in Vietnam is confined mainly to establishing a seed source system and demonstration plots. The major seed sources are listed in Appendix 2.

### ***The protected area system as an in situ conservation system***

The Vietnamese government has approved the extension of the reserve system to 107 protected areas, including 10 national parks, 65 nature reserves and 32 cultural, historic, scenic and environmental forests, covering a total area of almost one million hectares (Vietnam Scientific and Technical Association of Forestry 1995). In future, the reserve system is expected to increase to two million hectares (including 0.5 million hectares in buffer zones), and will protect a representative sample of almost all of the country's ecosystems.

The first national park of Vietnam, Cuc Phuong, was established in 1962. Covering a total area of 22,200ha, it represents low-mountain forests with a diverse flora of 987 genera in 217 families. Hoang Lien Son and Muong Nhe reserves were established to protect alpine forest ecosystems, whereas Yok Don national park was established to protect dry dipterocarp forest ecosystems. Cat Ba national park covers both forest and marine ecosystems, including many islands.

In future, there are plans to expand and develop ecotourism facilities across the country to attract local and foreign tourists. Management regulations for special-use forests, however, will be strictly controlled. Early *in situ* conservation efforts were carried out only in special-use forests, and *ex situ* conservation efforts were limited to the seed source system and some *ex situ* stands. There is now a strong need to develop and strengthen these conservation efforts.

## Conclusions

For the time being, conservation efforts should focus on the following priority species:

- Endangered species with high economic value;
- Endangered species with high scientific value;
- Valued local species for reforestation; and
- Valued exotic species for reforestation.

*In situ* conservation measures should be applied in tandem with *ex situ* measures. The following measures should be implemented to improve conservation of forest genetic resources in Vietnam:

- Botanical and genetic surveys;
- Collection, evaluation and publication of data;
- *In situ* and *ex situ* conservation measures; and
- Improved use.

Identification of priority areas and species for conservation should be based on the following factors:

- Diversity;
- Representativeness;
- Endemism;
- Degree of endangerment; and
- Scientific and economic values.

## References

- CFSC (1998) *Project document on production and supply of forest seed for the five million ha reforestation programme*. Central Forest Seed Company, Hanoi.
- MARD (1998) *Project document on five million ha reforestation programme*. Ministry of Agriculture and Rural Development, Hanoi.
- Ministry of Forestry (1995) *Vietnam Forestry*. Ministry of Forestry, Hanoi.
- Nguyen Duong Tai (2000) Seed quality for reforestation. In Schmidt, L. & Nguyen Xuan Lieu (eds.), *Proceedings of National Seminar on Priority Tree Species, Hanoi, 7–8 September 2000*. Indochina Tree Seed Programme/Central Forest Seed Company, Hanoi.
- Nguyen Hoang Nghia (2000) Integrated strategies and conservation of forest genetic resources in Vietnam. In Schmidt, L. & Nguyen Xuan Lieu (eds.), *Proceedings of National Seminar on Priority Tree Species, Hanoi, 7–8 September 2000*. Indochina Tree Seed Programme/Central Forest Seed Company, Hanoi.
- Nguyen Huy Phon (2000) *Discussion on Priority Species in Contemporary Vietnamese Forestry and Tree Seed Aspects*. Presentation at the Second Regional Consultation for Danish Supported Tree Seed Projects in South East Asia. Hanoi, February 2000.

- Nguyen Ngoc Binh (2000) Introduction to 5 million ha reforestation programme. In Schmidt, L. & Nguyen Xuan Lieu (eds.), *Proceedings of National Seminar on Priority Tree Species, Hanoi, 7–8 September 2000*. Indochina Tree Seed Programme/Central Forest Seed Company, Hanoi.
- Nguyen Xuan Lieu (2000) Summary and key findings of regional priority species workshops. In Schmidt, L. & Nguyen Xuan Lieu (eds.), *Proceedings of National Seminar on Priority Tree Species, Hanoi, 7–8 September 2000*. Indochina Tree Seed Programme/Central Forest Seed Company, Hanoi.
- Vietnam Scientific and Technical Association of Forestry (1995) *National Parks and Nature Reserves in Vietnam*. Vietnam Scientific and Technical Association of Forestry, Hanoi.

**Appendix 1.** Value and use of target, important species in Vietnam

Species Name	Value Code <sup>a)</sup>	Present, future or potential use <sup>b)</sup>											
		ti	po	wo	nw	pu	fo	fd	sh	ag	co	am	xx
<i>Afzelia xylocarpa</i>	1	✓											
<i>Aleurites montana</i>	2				✓								
<i>Aquilaria crassna</i>	1				✓						✓	✓	
<i>Bambusa</i> sp.	1					✓	✓	✓	✓	✓	✓	✓	
<i>Calamus rudentum</i>	2				✓					✓		✓	
<i>Calamus tenuis</i>	2				✓					✓		✓	
<i>Camellia sasanqua</i>	2				✓		✓			✓			
<i>Canarium</i> spp.	1	✓			✓		✓			✓	✓	✓	
<i>Cassia glauca</i>	2	✓											✓
<i>Cassia siamea</i>	1	✓							✓	✓	✓		
<i>Castanopsis/Quercus</i> spp.	2	✓		✓			✓		✓	✓	✓		
<i>Chukrasia tabularis</i>	1	✓								✓	✓	✓	✓
<i>Cinnamomum balansae</i>	1				✓							✓	
<i>Cinnamomum cassia</i>	1				✓		✓			✓			
<i>Cinnamomum parthenoxylon</i>	1	✓	✓									✓	
<i>Cocos nucifera</i>	2				✓		✓		✓				
<i>Cunninghamia lanceolata</i>	1	✓	✓										✓
<i>Dendrocalamus membranaceus</i>	1					✓	✓	✓	✓	✓	✓	✓	
<i>Dimocarpus longan</i>	2	✓					✓		✓	✓	✓		
<i>Dipterocarpus alatus</i>	1	✓	✓						✓				
<i>Dracontomelon mangiferum</i>	2	✓	✓				✓		✓	✓	✓		
<i>Endospermum chinense</i>	2	✓										✓	
<i>Erythrophleum fordii</i>	1	✓										✓	
<i>Hopea odorata</i>	1	✓	✓										
<i>Illicium verum</i>	1				✓		✓		✓	✓	✓	✓	
<i>Litchi sinensis</i>	2	✓					✓		✓	✓	✓		
<i>Litsea sebifera</i>	2				✓					✓			
<i>Madhuca pasquieri</i>	2	✓			✓		✓		✓	✓	✓		
<i>Mangifera minor</i>	2	✓					✓		✓	✓	✓	✓	
<i>Manglietia glauca</i>	1	✓	✓			✓			✓		✓	✓	
<i>Parashorea chinensis</i>	1	✓	✓						✓		✓	✓	
<i>Paulownia fortunei</i>	2					✓				✓			
<i>Peltophorum ferrugineum</i>	2	✓	✓							✓		✓	
<i>Phoebe cuneata</i>	2	✓	✓									✓	
<i>Pinus kesiya</i>	1	✓	✓		✓	✓							
<i>Pinus massoniana</i>	1	✓	✓		✓								
<i>Pinus merkusii</i>	1	✓	✓		✓								
<i>Pterocarpus</i> spp.	1	✓										✓	
<i>Rhizophora</i> spp.	1	✓	✓	✓								✓	
<i>Schima wallichii</i>	2	✓								✓	✓		
<i>Sindora siamensis</i>	1	✓										✓	
<i>Sterculia lychnophora</i>	2	✓			✓							✓	
<i>Styrax tonkinensis</i>	1				✓	✓							
<i>Talauma gioi</i>	1	✓							✓		✓	✓	
<i>Tarrietia javanica</i>	1	✓	✓							✓	✓		
<i>Tectona grandis</i>	1	✓	✓										
<i>Toona sinensis</i>	2	✓	✓		✓				✓		✓		

<sup>a)</sup> 1 = Species of current socio-economic importance; 2 = Species with clear potential or future value, 3 = Species of unknown value given present knowledge and technology.

<sup>b)</sup> ti = timber production; po = posts, poles, roundwood; pu = pulp and paper; wo = fuelwood, charcoal; nw = non-wood products (gums, resins, oils, tannins, medicines, dyes etc.); fo = food; fd = fodder; sh = shade, shelter; ag = agroforestry systems; co = soil and water conservation; am = amenity, aesthetic, ethical values; xx = other.

**Appendix 2.** Area of selected forest seed sources in Vietnam (in hectares)

Species Name	Total Area	Regional distribution						
		NW	CN	NE	NC	SC	CH	S
<i>Pinus massoniana</i>	352	50	100	202				
<i>Pinus merkusii</i>	710.6			30	409.2	11.4	260	
<i>Pinus caribaea</i>	57.1				57.1			
<i>Pinus kesiya</i>	1,720	80					1,640	
<i>Cunninghamia lanceolata</i>	140		80	60				
<i>Chukrasia tabularis</i>	70	57	3		10			
<i>Aleurites montana</i>	174	174						
<i>Canarium album</i>	275	20					255	
<i>Castanopsis</i> spp.	286			190	96			
<i>Manglietia glauca</i>	217		217					
<i>Styrax tonkinensis</i>	92		92					
<i>Erythrophleum fordii</i>	196		86		110			
<i>Alnus nepalensis</i>	28		28					
<i>Schima wallichii</i>	108		76	32				
<i>Tectona grandis</i>	379	20					9	350
<i>Dendrocalamus membranaceus</i>	80	80						
<i>Schleichera oleosa</i>	24	12			12			
<i>Cinnamomum cassia</i>	141		61		80			
<i>Illicium verum</i>	40			40				
<i>Engelhardtia chrysolepis</i>	50			50				
<i>Toona sinensis</i>	40			40				
<i>Altingia takhtajanii</i>	30	30						
<i>Aquilaria crassna</i>	77.1				77.1			
<i>Talauma gioi</i>	2				2			
<i>Casuarina equisetifolia</i>	191.3				141.3	50		
<i>Endospermum chinense</i>	185				15		170	
<i>Calophyllum saigonense</i>	20				20			
<i>Symplocos laurina</i>	66.6				66.6			
<i>Tarrietia javanica</i>	79				79			
<i>Acacia auriculiformis</i>	273.5				55.5	18.3	50	150
<i>Acacia mangium</i>	144.5	5	37.6		31.9		50	20
<i>Sindora tonkinensis</i>	170				170			
<i>Neolitsea cambodiana</i>	33.3				33.3			
<i>Madhuca pasquieri</i>	182				182			
<i>Camellia sasanqua</i>	30				30			
<i>Lagerstroemia cochinchinensis</i>	130				70		60	
<i>Pterocarpus macrocarpus</i>	230				40		70	120
<i>Xylia dolabriformis</i>	282					212	70	
<i>Dipterocarpus alatus</i>	175					55		120
<i>Hopea odorata</i>	160					50		110
<i>Cassia siamea</i>	106						106	
<i>Dalbergia cochinchinensis</i>	60					10	50	
<i>Eucalyptus</i> spp.	182		8			110	50	13
<i>Anisoptera cochinchinensis</i>	100							100
<i>Anacardium occidentale</i>	36					36		
<i>Hopea dealbata</i>	7						7	
<i>Dipterocarpus dyeri</i>	120							120
<i>Sindora cochinchinensis</i>	100							100
<i>Rhizophora conjugata</i>	543							543
<i>Melaleuca leucadendron</i>	327							327
<i>Dacrydium pierrei</i>	50						50	
<i>Fokienia hodginsii</i> + <i>Pinus excelsa</i>	50						50	
<i>Michelia mediocris</i>	218						218	
<i>Shorea cochinchinensis</i>	150					150		
Others	27				27			
<b>Total</b>	<b>9,716.8</b>	<b>528</b>	<b>788.9</b>	<b>644</b>	<b>1,814.5</b>	<b>703.7</b>	<b>3,165</b>	<b>2,073</b>



**Appendix 4.** *Endangered species with high economic value in Vietnam. Source: Nguyen Hoang Nghia (2000).*

Species	Family	Distribution	Value
<i>Afzelia xylocarpa</i>	Leguminosae	CS	****
<i>Altingia chinensis</i>	Altingiaceae	NC	**
<i>Aquilaria crassna</i>	Thymeleaceae	NCS	****
<i>Chukrasia tabularis</i>	Meliaceae	NC	****
<i>Cupressus torulosa</i>	Cupressaceae	N	****
<i>Dacrydium pierrei</i>	Podocarpaceae	NCS	***
<i>Dalbergia annamensis</i>	Leguminosae	CS	****
<i>Dalbergia bariensis</i>	Leguminosae	CS	****
<i>Dalbergia cochinchinensis</i>	Leguminosae	CS	****
<i>Diospyros mun</i>	Ebenaceae	C	****
<i>Erythrophleum fordii</i>	Leguminosae	NC	****
<i>Fokienia hodginsii</i>	Cupressaceae	NC	****
<i>Keteleeria davidiana</i>	Pinaceae	NC	**
<i>Madhuca pasquieri</i>	Sapotaceae	NC	****
<i>Manglietia fordiana</i>	Magnoliaceae	NC	****
<i>Markhamia stipulata</i>	Bignoniaceae	NC	****
<i>Parapentace tonkinensis</i>	Tiliaceae	N	****
<i>Parashorea chinensis</i>	Dipterocarpaceae	NC	***
<i>Podocarpus fleuryi</i>	Podocarpaceae	NC	***
<i>Pterocarpus macrocarpus</i>	Leguminosae	CS	****
<i>Sindora siamensis</i>	Leguminosae	CS	***
<i>Sindora tonkinensis</i>	Leguminosae	NC	***
<i>Taxus chinensis</i>	Taxaceae	N	***
<i>Taxus wallichiana</i>	Taxaceae	C	****
<i>Xylia xylocarpa</i>	Leguminosae	CS	***

**Appendix 5.** *Endangered species with high scientific value in Vietnam. Source: Nguyen Hoang Nghia (2000).*

Species	Family	Distribution	Value
<i>Abies nukiangensis</i>	Pinaceae	N	Rare
<i>Amentotaxus argotaenia</i>	Taxaceae	N	Rare
<i>Annamocarya sinensis</i>	Juglandaceae	N	Rare
<i>Bambusa ventricosa</i>	Poaceae	NC	***
<i>Calocedrus macrolepis</i>	Cupressaceae	NC	***
<i>Carya tonkinensis</i>	Juglandaceae	N	Rare
<i>Cephalotaxus fortunei</i>	Cephalotaxaceae	NCS	**
<i>Chimonobambusa quadrangularis</i>	Poaceae	N	***
<i>Ducampopinus krempfii</i>	Pinaceae	C	Rare
<i>Fagus longipetiolata</i>	Fagaceae	N	**
<i>Fraxinus chinensis</i>	Oleaceae	NC	**
<i>Garcinia fagraeoides</i>	Clusiaceae	NC	***
<i>Glyptostrobus pensilis</i>	Taxodiaceae	C	Rare
<i>Hopea cordata</i>	Dipterocarpaceae	C	**
<i>Hopea hainanensis</i>	Dipterocarpaceae	C	**
<i>Hopea pierrei</i>	Dipterocarpaceae	CS	****
<i>Liriodendron chinense</i>	Magnoliaceae	N	***
<i>Phyllostachys nigra</i>	Poaceae	N	Rare
<i>Pinus dalatensis</i>	Pinaceae	C	Rare
<i>Pinus kwangtungensis</i>	Pinaceae	N	Rare
<i>Podocarpus nerifolius</i>	Podocarpaceae	NCS	Rare
<i>Podocarpus pilgeri</i>	Podocarpaceae	NS	Rare
<i>Rhoiptelea chiliantha</i>	Rhoipteleaceae	N	**
<i>Tsuga dumosa</i>	Pinaceae	N	Rare

**Appendix 6.** *Highly valued native species with re/afforestation potential in Vietnam.*  
*Source: Nguyen Hoang Nghia (2000).*

<b>Species</b>	<b>Family</b>	<b>Distribution</b>	<b>Value</b>
<i>Anisoptera costata</i>	Dipterocarpaceae	CS	***
<i>Bambusa stenostachya</i>	Poaceae	NCS	**
<i>Canarium</i> sp.	Burseraceae	NC	***
<i>Cinnamomum cassia</i>	Lauraceae	NC	****
<i>Dendrocalamus flagellifer</i>	Poaceae	CS	**
<i>Dendrocalamus membranaceus</i>	Poaceae	NC	**
<i>Dendrocalamus strictus</i>	Poaceae	CS	**
<i>Dipterocarpus alatus</i>	Dipterocarpaceae	CS	***
<i>Hopea odorata</i>	Dipterocarpaceae	CS	***
<i>Illicium verum</i>	Illiciaceae	N	****
<i>Michelia</i> sp.	Magnoliaceae	NC	***
<i>Phyllostachys pubescens</i>	Poaceae	N	***
<i>Pinus kesiya</i>	Pinaceae	NC	**
<i>Pinus merkusii</i>	Pinaceae	NC	**

**Notes to Appendixes 4, 5 & 6:**

Distribution: N = North; C = Central (including central highland); S = South.

Value: \*\*\*\* = Very high value; \*\*\* = High value; \*\* = Valuable.