



Forest Genetic Resources Conservation and Management

Status in seven South and Southeast Asian
countries

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Status of the conservation and management of forest genetic resources in Thailand

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Thailand is located in the southeastern part of Asia, between the 5°35' and 20°15' North latitudes and 97°30' and 105°45' East longitudes. It encompasses an area of 513 115 sq. km. The country has common boundaries with four countries, Myanmar, the People's Democratic Republic of Laos, Cambodia and Malaysia.

The northern part of Thailand is of hilly landscape. From there the four main tributaries of the Chao Phraya River flow through the alluvial plain of central part of the country towards the Gulf of Thailand. There the river forms a great central alluvial plain known as the Chao Phra Delta. A long stretch of the peninsula extends far to the south where the population is predominantly Muslim. A third of the northern part of the landmass forms a large plateau, known as the north-east highland or the Korat plateau, which slopes eastwards to the bordering Mekong River.

Topographically, Thailand is divided into five regions: northern, northeastern, central, eastern and southern regions; with a total of 76 provinces and 716 districts. The natural vegetation is tremendously diverse. It is one of the richest countries of the world in biological resources. This is attributed to its biogeographic location at the junction of the three main floristic regions, namely the Indo-Burmese, Indo-Chinese and the Malaysian regions (Boontawee *et al.* 1994).

In the past, the Royal Forest Department (RFD) founded in 1896 was directly responsible for the conservation and management of forest genetic resources (FGR) in Thailand under the supervision of Ministry of Agriculture and Cooperatives. During the public sector reform in 2002, the RFD was divided into three departments: the RFD; the National Park, Wildlife and Plant Conservation Department (DNP); and the Department of Marine and Coastal Resources (DMCR). All departments are under the supervision of the Ministry of Natural Resources and Environment (MONRE).

The Royal Forest Department is responsible for forests outside of protected areas, which are the responsibility of the DNP. Resources of marine and coastal flora and fauna, including mangrove forests, are managed by the DMC through conservation and rehabilitation activities. In terms of FGR conservation and management, the RFD is still the leading organization with respect to any activities and in particular in aspects related to economic use.

Forest resources

In 1961, the total forest area of Thailand was 27 363 000 ha, covering over 53.3% of the country's land area. Subsequently, forest areas were encroached for several purposes, including slash-and-burn agriculture, shifting cultivation, land resettlement, construction of dams and roads, and land reform for agriculture. As a result, the share of forest area declined to 25.3% by 1998 (Table 1).

From the year 2000 onwards the forest cover of Thailand has been assessed by interpreting imageries of the LANDSAT-5 satellite, after a new protocol for the assessment with regards to image scale and methods were established. Since 2000 the annual rate of deforestation has been approximately 63 000 ha, which is higher than in the 1990s. The

current forest area is estimated at 15 865 000 ha or at 30.9% of the country's land area (Table 2). This estimate includes forests of all types, such as evergreen, pine, mangrove, mixed deciduous, dry dipterocarp, scrub, swamp, mangrove and beach forest, either in the national forest reserves, national parks, wildlife sanctuaries, or under a forest working plan. However, only forests with a minimum area of 5 hectares, a minimum tree height of 5 m and with a minimum canopy coverage of 10% of the ground area are included in the figures (Table 2). The majority of forest lands in Thailand belong to the state.

In an attempt to stop the process of forest loss and degradation, the government imposed a logging ban in natural forests in 1989 and introduced a master plan for reforestation. The plan aims to bring the forest cover back to 40% of the country's land area. The target is divided to that for protected forests for nature conservation, recreation and environmental protection (25% of land area), and economic forests for the production of timber and non-timber goods (15%).

Table 1. Forest cover in Thailand during 1961-2006 (RFD 2007).

Year	Forest cover	
	Area (1000 ha)	% of land area
1961	27 363	53.3
1973	22 171	43.2
1976	19 842	38.7
1978	17 522	34.1
1982	15 660	30.6
1985	15 087	29.4
1988	14 380	28.0
1989	14 342	27.9
1991	13 670	26.6
1993	13 355	26.0
1995	13 149	25.6
1998	12 972	25.3
2000	17 011	33.2
2004	16 759	32.7
2005	16 100	31.4
2006	15 865	30.9

Table 2. Land use and forest areas in five regions in year 2006 (RFD 2007). Data on forest area are acquired from LANDSAT 5 (TM) from interpretation imageries of the scale of 1 : 50 000.

Region	Area (1000 ha)	Forest area (1000 ha)	Forests area, % of land	Non-forest area (1000 ha)
North	16 964	8 837	52.1	8 128
North-east	16 885	2 455	14.5	14 430
Central	6 740	2 056	30.5	4 684
East	3 650	788	21.6	2 862
South	7 072	1 730	24.5	5 342
Total	51 312	15 865	30.9	35 446

Legal framework

The Government of Thailand has established stringent laws for the protection and conservation of forest areas including water reserves and biodiversity. Presently, there are five principal forest acts:

- Forest Act 1941, which concerns logging operations and the collection of non-wood forest products, transportation of timber and non-timber products, sawn wood production, and forest clearing
- National Park Act 1961, which covers the determinations of National Park land, National Park Committee, and the protection and maintenance of National Parks
- National Forest Reserve Act 1994, which includes the determination of National Reserved Forests and their control and maintenance
- Wildlife Conservation and Protection Act 1992, which establishes provision for the Nation Wildlife preservation, establishment of Protection Committee and identification of 15 species of reserved wildlife
- Forest Plantation Act 1992, which covers the determinations of reforestation, land registration of private reforestations, ownership and rights, and the exemption from royalty on forest products from reforested areas.

Characterization of forest genetic resources

There are two main types of forests in Thailand, *evergreen forest* and *deciduous forest*. *Evergreen forest* is further subdivided into four categories: (1) *Tropical evergreen forest* is found all over the moist part of the country. This type of forest is also subdivided into tropical rain forest, semi-evergreen forest and hill evergreen forest. (2) *Tropical rain forest* is characterized by a very rich flora and very dense undergrowth. This type of forest is commonly found in the southern and the eastern regions of the country where the annual rainfall is over 2000 mm. It is also found along rivers or in valleys in other parts of the country. The predominant species in the upper canopy level are, for example, *Dipterocarpus* spp., *Hopea* spp., *Lagerstroemia* spp. and *Shorea* spp., whereas the lower storey species are bamboos, palms and rattans. (3) *Semi-evergreen forest* is scattered all over the country in areas where the annual rainfall is between 1000 and 2000 mm. The predominant species are *Dipterocarpus* spp., *Hopea* spp., *Diospyros* spp., *Azalia* spp., *Terminalia* spp. and *Artocarpus* spp. The undergrowth consists mainly of bamboo and rattan species. (4) *Hill evergreen forest* is found on the highlands (> 1000 m above the sea level), where climatic conditions are humid subtropical. The presence of mosses and lichens on trees and rocks is an indicator of this forest type. The predominant species are oaks (*Quercus* spp.) and chestnuts (*Castanopsis* spp. and *Lithocarpus* spp.).

Deciduous forest is characterized by the presence of deciduous tree species and is commonly found throughout the country. It is broadly subdivided according to species composition to mixed deciduous forest (with and without teak) and dry dipterocarp forest. (i) *Mixed deciduous forest* is commercially among the most valuable forest of Thailand. In the northern region of the country, this type of forest is called the teak forest with *Tectona grandis*, *Xylia kerrii*, *Pterocarpus macrocarpus*, *Azalia xylocarpa* and *Dalbergia* spp. (rose wood) as dominant or common species. (ii) *Dry dipterocarp forest* is commonly found in dry areas with an annual rainfall less than 1000 mm on sandy or gravely lateritic infertile soils. The predominant species are mainly Dipterocarpaceae, such as *Dipterocarpus tuberculatus* and *D. obtusifolius*, and *Terminalia* spp.

Conservation and management practices of forest genetic resources

To improve its bureaucracy, the Thai government has introduced a structural and administrative reform that has resulted in the establishment of 21 ministries since 2002. The Ministry of Natural Resources and Environment (MONRE), a newly established ministry, has been given responsibility for natural resources and the environment. Regarding this restructuring, the Royal Forest Department (RFD) was divided into the three departments, the RFD, the Department of National Park, Wildlife and Plant Conservation (DNP), and the Department of Marine and Coastal Resources (DMCR) under MONRE.

Previously, the Silviculture Research Division was directly responsible for the study, research and operations related to the conservation and management of FGR in Thailand. As a result of the reform, the division was divided in two, one for which the RFD is responsible and the other for which the DNP is responsible. This made the RFD and the DNP the key departments in charge of FGR management in Thailand. The RFD focuses on FGR conservation and management in terms of economic use, while the DNP focuses on *in situ* conservation.

***In situ* conservation**

Thailand has set up a target of having 25% of the country's land area as protected areas. At present, protected areas declared by Royal Decrees (under the responsibility of the DNP) account for about 20% of the country's total land area. These protected areas represent *in situ* conservation, and FGR are generally well preserved there because of strict laws and regulations.

Intensive activities on *in situ* conservation were initiated with lowland *Pinus merkusii* in 1977. In this process, stakeholder analyses, conservation measures and management options were clarified (DFSC 2000). In 1979, Thailand had only 16 national parks which covered an area of 936 000 ha. Thereafter, numerous new national parks have been established, so that by 2008, the total number of parks was 110 and they covered an area of 5 514 000 ha. According to the DNP, there are still several national parks which have not been gazetted. All the 57 wildlife sanctuaries of Thailand are gazetted. In addition, the country has 113 forest parks which cover an area of 124 000 ha, and 60 non-hunting areas covering 523 000 ha (Table 3).

In addition to taking the effort of creating the protected area system, Thailand has also created 1221 National Forest Reserves which cover an area of 2 302 800 ha. Of the five regions of Thailand, the northern region has the largest coverage of National Forest Reserves with 1 000 000 ha (Table 4). About 20% of the country's 56 000 villages are also located within forest reserves.

***Ex situ* conservation**

Ex situ conservation of FGR in Thailand is mainly carried out in the form of field conservation, field collections or field genebanks. The *ex situ* approach is often applied for living plant species for experimental purposes and for creating storages of diverse plant species. *Ex situ* conservation is conducted applying (i) plantation stands, e.g. in the form of genebanks, clone banks, gene conservation plots, botanical gardens and arboreta, and (ii) tree improvement plots, such as clone banks, progeny tests, provenance trials, clonal tests and seed orchards.

Table 3. Protected areas for *in situ* conservation in Thailand in 2008 (DNP 2008).

Categories	IUCN category ¹	Number	Total area (1000 ha)	% of country area
By Royal Decrees				
National Park	II	110	5 514	10.7
Wildlife Sanctuary	Ia & IIb	57	3 658	7.1
Non-hunting area	IV	60	523	1.0
By Ministerial Declarations				
Forest park	III	113	124	0.2
Total		340	9 818	19.1

¹IUCN categories (main management purpose; IUCN 1994): I Strict nature reserve/wilderness area (science, wilderness protection), II National park (ecosystem protection and recreation), III Natural monument (conservation of specific natural features), IV Habitat/Species Management Area (conservation through management intervention), V Protected Landscape/Seascape (landscape/seascape protection and recreation), VI Managed Resource Protected Area (sustainable use of natural ecosystems).

Table 4. National Forest Reserves in 2003-2007 (RFD 2007).

Region	2003		2007	
	Units	Area (1000 ha)	Units	Area (1000 ha)
North ¹	257	1 120	257	1 000
North-east	353	553	353	553
Central and east	143	349	143	468
South	468	282	468	282
Total²	1 221	2 304	1 221	2 303

¹Includes Nakhon Sawan, Kamphaeng Phet and Uthai Thani

²Compiled from the maps and corresponding forest areas published in the government gazette which occasionally overlapped each other. Some areas have already been revoked from the reserved category for other used.

Plantation stands

Seventy-one plantation stands covering an area of 8820 ha have been established throughout the country in the form of botanical gardens and arboretum (Table 5).

In terms of FGR conservation programme, Thailand joined the international organizations to establish *ex situ* conservation networks of both exotic and indigenous tree species. As to exotic species, *Pinus caribaea*, *P. oocarpa*, and *Eucalyptus camaldulensis* were conserved in plantation stands in north (Chiang Mai province) and north-east (Surin and Ubon Ratchathani Province) parts of the country under a FAO-coordinated *ex situ* FGR conservation programme in 1973 (Sumantakul 2004). For indigenous species, *ex situ* conservation plots of eight hardwood species were established under the cooperation of the RFD and DANIDA Forest Seed Centre in 1989-1993. The stands are located at five sites in central and north-eastern regions. In total 386 plus trees of eight timber species were selected and well conserved in five provinces on a total area of 360 ha (Table 6). There were, however, no detailed genecological studies on the natural variation within these stands.

In addition to the above-mentioned programme, plantation stands of *ex situ* gene conservation were established by the DNP during 2003-2007. In total 877 plus trees of 29 species from national parks, wildlife conservation areas, non-hunting areas and botanical gardens throughout the country were selected (Table 7). The conservation stands were planted at Sakaerat Silvicultural Station, Nakhon Ratchasima, Surat Thani Silvicultural Research Station, and Kamphaeng Phet Silvicultural Research Station.

Table 5. Protected areas for *ex situ* conservation in Thailand in 2008 (Protected by Ministerial declarations; DNP 2008).

Category	IUCN category ¹	Number	Total area (ha)
Botanical garden	VI	16	4 100
Arboretum	VI	55	4 300
Total		71	8 400

¹ see Table 3 for explanations**Table 6.** *Ex situ* conservation plots (ha) and plus trees (+) of indigenous species (adapted from FORGENMAP 2002a).

Species	Site										Total per species	
	1		2		3		4		5		ha	+
	ha	+	ha	+	ha	+	ha	+	ha	+		
<i>Dipterocarpus alatus</i>	16	30	26	14	10	-	10	-	-	-	52	44
<i>Dalbergia cochinchinensis</i>	16	25	10	-	10	-	10	-	10	13	56	38
<i>Xylia xylocarpa</i>	20	30	10	30	10	-	-	-	10	25	50	85
<i>Pterocarpus macrocarpus</i>	16	25	10	30	10	-	-	-	10	26	46	81
<i>Shorea roxburghii</i>	16	25	10	-	10	-	-	-	-	-	36	25
<i>Azalia xylocarpa</i>	16	25	4	-	10	-	-	-	10	28	40	53
<i>Dalbergia oliveri</i>	20	30	4	-	10	-	-	-	-	-	34	30
<i>Hopea odorata</i>	16	25	26	5	10	-	-	-	-	-	42	30
Total											356	386

Sites: (1) Kamphangphet Sivicultural Research Station, Kamphangphet, (2) Sakaerat Sivicultural Research Station, Nakhonratchasima, (3) Nongku Sivicultural Research Station, Surin, (4) Ubonratchatani Sivicultural Research Station, Ubonratchatani, (5) Central Sivicultural Research Center, Kanchanaburi.

Table 7. Plus tree species of *ex situ* gene conservation established during 2003-2007 (Tiyanon 2007).

Species	No. of trees	Species	No. of trees
<i>Acacia mangium</i>	20	<i>Adenantha pavonina</i>	10
<i>Aquilaria malaccensis</i>	23	<i>Azalia xylocarpa</i>	18
<i>Eugenia grandis</i>	10	<i>Mangifera quadrifida</i>	10
<i>Artocarpus lanceifolius</i>	20	<i>Mangifera caloneura</i>	88
<i>Cassia siamea</i> Britt	20	<i>Artocarpus lakoocha</i>	10
<i>Cotylelobium melanoxydon</i>	46	<i>Toona ciliata</i>	23
<i>Palaquium obovatum</i>	20	<i>Chukrasia velutina</i>	71
<i>Dalbergia oliveri</i>	20	<i>Dipterocarpus alatus</i>	68
<i>Gmelina arborea</i>	24	<i>Azadirachta indica</i>	22
<i>Xylia kerrii</i>	95	<i>Sandoricum koetjape</i>	10
<i>Anthocephalus chinensis</i>	19	<i>Tectona grandis</i>	32
<i>Hopea odorata</i>	35	<i>Sterculia foetida</i>	10
<i>Alstonia scholaris</i>	5	<i>Parkia javanica</i>	10
<i>Pterocarpus macrocarpus</i>	85	<i>Dalbergia cochinchinensis</i>	43
<i>Shorea roxburghii</i>	10		

Tree improvement plots

Forest tree improvement in Thailand is mainly focused on economic tree species such as *Tectona grandis*, *Aquilaria* spp., *Chukrasia* spp., *Pinus caribaea*, *Gluta usitata*, as well as on fast-growing trees for economic forest plantation both native species like *Melia azedarach*, *Casuarina equisetifolia*. Exotic tree species, for example *Acacia* spp., *Casuarina junghuhniana*, *Eucalyptus* spp., and *Azadirachta excelsa* are also included. In addition, progeny tests (which shall be later transformed into seed orchards) have recently been established for *Phyllanthus emblica*, *Pterocarpus macrocarpus*, *Dalbergia cochinchinensis*, *Azadirachta indica*, and *Pinus caribaea*.

In particular, a programme for teak improvement was initiated in Thailand in 1965, and a number of research projects related to the programme have been conducted since then. The first seed orchard was established in 1965 at Maegar seed orchard, Phayao province. In 1966, provenance tests of 30 provenances were established in Lampang province. At the age of eight years, the Ngao provenance (S88) from Lampang province performed best in terms of height.

In 1974, international provenance tests of provenances from India, Laos, Indonesia, Africa and Thailand were established at the provinces of Lampang (8 provenances with 3 from India, 4 from Thailand and 1 from Indonesia) and Khonkean (25 provenances with 9 from India, 5 from Indonesia, 6 from Thailand, 4 from Africa and 1 landrace). The tests were evaluated when the trees were nine years old. For the provenance test in Lampang, the stem forms of the trees of the Thai and Indonesian provenances were better than those of the Indian provenances. For the Khonkean provenance test, trees from the Thai and Lao provenances had a superior stem form. However, in terms of growth performance, trees from the semi-moist regions in Indonesia and India were better than those from the moist regions in Thailand, Laos, and India.

For progeny tests, 50 full-sib families have been established since 2007 in different regions of Thailand (Lampang, Pitsanulok, Khonkaen, Prachubkirikhun). They cover a total area of 16 ha. As to clonal tests, major field trials were conducted in 2000. In order to reselect teak plus trees and select suitable clones for planting in various sites, 400 clones (4 sets of 100 clones) were planted in 4 sites (Lampang, Songkhla, Kanchanaburi and Khamphangphet) covering an area of 8 ha. In addition, clonal tests of teak in the north-east of Thailand were planted in 2008. Fifty clones were planted in two sites of 1.3 ha each at the end of August and early September at Udonthani and Khonkean Provinces, respectively.

Development of the sources of genetic materials

Development of the sources of germplasm is one of the management practices of FGR which the RFD operates. The activities focus on the establishment and development of sources of genetic material, including the sources for seed production of forest trees. In addition, the RFD develops field plots on which certain trees are selected as plus trees and seed trees. The aim is to produce and promote the use of high-quality genetic material for both sexual reproduction (using seeds) and asexual reproduction (cutting or grafting).

The Forest Genetic Resources Conservation and Management Project (FORGENMAP, 1997-2002), was one of the projects playing a vital role in FGR conservation and management in Thailand. Its main objectives were germplasm development in particular, and also seed source development and FGR conservation.

With regard to the development of the seed sources, the RFD adopted a system for the classification of seed sources as part of FORGENMAP. The system is based on the pattern of the Organization for Economic Cooperation and Development (OECD 1974) and that of the Danish Forest Seed Center (DFSC), with some adjustments made to suit forest

conditions in Thailand. It classifies seed sources in six classes according to their characteristics. The classes from lowest to the highest stand quality are Seed Collection Zone or Ecozone (SCZ), Identified Stand (IS), Selected Stand (SS), Seed Production Area (SPA), Provenance Seed Stand (PSS) and Seed Orchard (SO; Figure 2). Identified stands, classified as being of low to medium quality, are the most common source registered in the seed documentation system (Figure 3). However, the RFD has made an effort to improve the quality of seed sources and increase the proportion of sources of higher quality through several activities, such as conducting tree improvement projects and establishing additional seed orchards.

Apart from the classification and improvement of seed sources, the RFD has recently developed seed sources in accordance with a plot rehabilitation scheme under the Work Plan for Developing the Potential of Forest Research (2008-2012). According to this scheme, the trial plots of various species which occupy a total area of approximately 3200 ha will be rehabilitated to good-quality seed sources. Moreover, by using genetic material, these plots will be developed to areas of *ex situ* conservation of various valuable species.

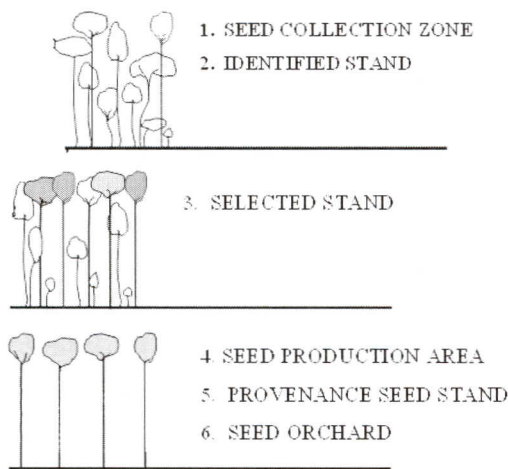


Figure 1. Classification of seed sources into six classes based on stand quality (Tangmitcharoen 2007).

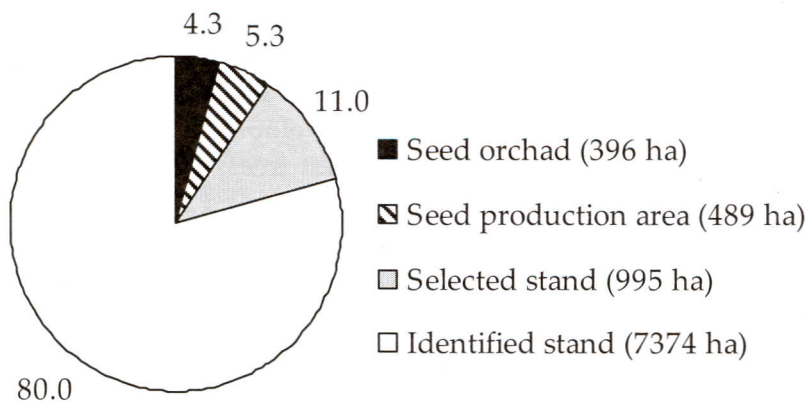


Figure 2. Proportion of seed sources during the years 1998-2002 (% and ha; FORGENMAP 2002b).

Collaborative networks for the management and use of forest genetic resources

National Collaborative Network

In addition to the RFD and the DNP, the two key departments in charge of forest genetic resources, also other agencies and bodies are involved in the management, administration and use of FGR in Thailand. The participants of the national workshop on strengthening FGR management in Thailand (held on 12 March 2008 at Rama Gardens Hotel, Bangkok) are an example of these institutions (Table 8).

Table 8. Summary of stakeholders involved in forest genetic resources issues in Thailand (RFD 2008).

Organization	Management			Admini- stration	Utili- zation
	<i>Ex situ</i> facilities	<i>In situ</i> areas	Molec. makers		
Royal Forest Department (RFD)	x	x			
National Park, Wildlife and Plant Conservation Department (DNP)		x	x	x	
Department of Marine and Coastal Resources (DMCR)	x	x			x
Faculty of Forestry, Kasetsart University	x		x		x
Forest Restoration Research Unit, Chiang Mai University		x	x		x
Thai Plywood co., Ltd.	x	x		x	x
Regional Community Forest Training Center for Asia and the Pacific (RECOFTC)		x			x
Non-governmental organizations, community leaders in north-east & south					x
Biodiversity Office, Ministry of Natural Resource and Environment				x	

International Collaborative Network

In the past the RFD enjoyed the benefits of technical cooperation with several countries on FGR conservation and management, including many programmes for tree improvement of various tree species. Each programme had its own objectives and courses of action. Examples of the projects are the Thai-Danish cooperation for teak improvement (launched in 1965) and for pine and fast-growing species improvement (launched in 1968), ASEAN-Canada forest tree seed center (established in 1977), Thai-Japanese cooperation in research and training related to forest plantations (launched in 1981), the improvement of fast-growing species of the *Acacia* and *Eucalyptus* genera in cooperation with Australia under the programmes of the Australian Centre for International Agricultural Research (ACIAR), and FORGENMAP in cooperation with Denmark (launched in 1997; Forest Research Office, 1996).

Regional and international collaboration activities in FGR conservation are established in the form of networking. The active networks in the region at the moment include the International Neem Network, the International Network on Bamboo and Rattan (INBAR), and TEAKNET on teak. Currently, Thailand also participates in the collaborative network between countries in the Asia Pacific region for the conservation and use of forest genetic

resources. The network is called the Asia Pacific Forest Genetic Resources Programme (APFORGEN), and it has members from 14 countries: Bangladesh, Cambodia, China, India, Indonesia, Laos, Malaysia, Myanmar, Nepal, Pakistan, Philippines, Sri Lanka, Vietnam and Thailand. The countries share the common objective of building a strong partnership in the conservation and sustainable use of genetic resources, and they work together to develop links between their various activities and the regional network to strengthen the management of forest genetic resources in Asia and the Pacific. The programme is currently mainly funded by the International Tropical Timber Organization (ITTO, in 2006-2009), with the Asia Pacific Association of Forestry Research Institutions (APAFRI) and Bioversity International providing support to programme activities.

Capacity building activities, education and training

Universities and other bodies

The Faculty of Forestry at the Kasetsart University (KUFF) conducts research in important areas covering forest management, silviculture, forest biology, wood products, watershed management and forest engineering. The Faculty is actively engaged in inter-disciplinary research and education activities of critical issues of sustainable management and utilization of forests. The research programme is carried out by individual faculty members through the Forest Research Centre (FRC), which is basically the national centre for research and development in all fields of forestry. The Centre has 67 staff members of whom 58% hold a PhD degree.

Areas of current and future research include community based eco-tourism, analysis of forest fire policies, remote sensing and GIS applications in resource planning, system analysis and planning of protected areas, mechanical properties of rubber wood, agroforestry, reforestation of highlands, biodiversity of forest insects, watershed modeling, and mangrove ecology and coastal zone management. The KUFF has 2 research stations, one in Chiang Mai and other one in the south of the country.

Research is mainly funded through the Kasetsart University Research and Development Institute (KURDI). Funds for forestry research have been quite limited. At present forestry represents only 2% of the KU research budget.

Besides the KUFF and the RFD, research on different aspects of forestry is also conducted by other state and private sector institutions. Chiang Mai University and Farming Systems Research Institute of the Department of Agriculture conduct research on upland and highland farming systems. Khon Kaen University and the Social Research Institute of Chulalongkorn University conduct research on community forestry. Research on environmental conservation and medicinal plants has been carried out by Mahidol University. The Forest Industry Organization (FIO) has carried out research on commercial teak growing, fast-growing trees, nursery techniques, thinning of teak trees and agroforestry. In addition, the private sector conducts research activities, particularly on the development of forest plantations. For example the Thai Cement Company Limited, Phoenix Pulp and Paper Company Limited, and the Kitti Plantation Company Limited in research in this area.

Various non-governmental organizations are also carrying out valuable research on site specific issues. Some have also done policy analysis to define their agenda. These have served as valuable inputs for the policy process, especially as other research on policy issues is limited.

Education

Several universities in Thailand offer bachelor's and master's degree courses related to forests and natural resources, each with a different emphasis on technical subjects. The Kasetsart University offers courses on forestry, agriculture and fisheries, Chiang Mai Agriculture University courses on farming systems and natural resource management, and Khon Kaen University courses on rural development and regional planning. Furthermore, Mae Jo University offers courses on land use and ecotourism and Chulalongkorn University on community development, including aspects of community forestry.

Kasetsart University has the only full-fledged forestry faculty in the entire country. It offers bachelor's, master's and doctoral degree programmes in forestry and related subjects. The four-year bachelor's programme presently includes three specific subjects: forestry, wood sciences and technology, and pulp and paper technology. The forestry course covers aspects of forest resource management, forest engineering, social forestry and biological forest sciences.

The master's programme, which started in 1967, include four specialized subjects: forestry, parks and recreation, forest resource administration and tropical forestry. The forestry program has five major areas of specialization, namely forest management, forest biology, forest products, watershed management and silviculture. The master's programme on forest resource administration also includes a special weekend course on management and silviculture designed to accommodate people who cannot attend regular weekday classes.

The doctoral degree programme in forestry, which started in 1992, focuses on five subjects: silviculture, forest management, management of watersheds and the environment, forest ecology and tropical forestry (international program).

There are approximately 65 faculty staff members (professors, associate and assistant professors and instructors) and some 90 members of the administrative and support staff, including technicians. According to the enrolment record in 2002, there were 1013 bachelor students (478 female), 397 masters (116 female) and 34 doctoral students (8 female). By the year of 2009, the Forestry Faculty has produced 833 diploma graduates, 3814 undergraduates (bachelors), 479 graduates (masters) and 13 PhD graduates. The number of female students in forestry has increased significantly in recent years.

There seems to be no problem for forestry graduates in finding jobs as they become easily employed by various departments of the Ministry of Natural Resources and Environment (MONRE), NGOs and the private sector. The majority of the forestry professionals in MONRE are reported to have studied at the Kasetsart University.

Training

Prior to splitting into two departments, the RFD had a training division with several training centres in different parts of the country. The most important ones included the training centers located at the central office and in the Phrae, Khao Yai, Cha Am, Chiang Rai and Tak provinces. However, following MONRE's decision to restructure the RFD, the training division was removed, placing all the respective human and financial resources and facilities under the DNP. At the time of its new mission, the annual programme of the RFD did not include any training activities. At the time of writing, the RFD already had established a Training Division, however there were no regional training courses in the conservation and management of FGR to train officials and other stakeholders. The DNP plans and conducts in total some 150 training activities each year, involving over 3000 trainees.

Public Awareness

Extensive efforts to increase public awareness on the aspects and importance of FGR conservation and management have been conducted in Thailand. Several campaigns have been run on afforestation, reforestation, and tree plantation at particular occasions. These include the reforestation campaign in Commemoration of the Royal Golden Jubilee (1994-2007), tree planting campaigns for the public as well as the private sector. In the private sector, tree planting is implemented by major companies for industrial purposes, and by community associations which establish woodlots and integrated land-use systems. City greening campaigns have also been continually emphasized.

In addition, public awareness is also raised through forest community activities. In total 11 400 villages (15.5% of all villages) are reported to be involved in managing community forests in the country, and about half of them have formally registered their community forest with the RFD. These community forests are reported to cover an area of 196 700 ha, both within national forest reserves (112 900 ha) and outside, accounting for approximately 1.2% of the total forest area of the country (Wichawutipong 2005).

Identification of national priorities for forest genetic resources

Priorities for FGR conservation and management were set in 2002 as reported in the consultancy report no. 20 of the Forest Genetic Resources Conservation and Management Programme (FORGENMAP 2002a). The report provided useful information on priority actions for the conservation of FGR of indigenous tree species in Thailand, for example studying the status of *in situ* and *ex situ* conservation, strategies of FGR conservation, and research needs regarding some of the priority species (Appendix 1).

The recruitment of a new Committee on Research and Management of Forest Genetic Resources, endorsed by the Director General of the RFD, facilitates the realization of the national priorities regarding forest genetic resources and identification and implementation of related research and development strategies.

To improve the management and sustainable use of forest genetic resources in Thailand, follow-up of previous activities should be considered for implementation as listed below:

- Updating of FGR status including the finding of better germplasm
- Extensively support the availability of better germplasm to tree farmers
- Establish networks or partnerships between stakeholders within the country
- Cooperate through networks within the region to share knowledge and germplasm

Conclusion

Thailand has directly and continually engaged in the management of forest genetic resources. Substantial amount of know-how in the improvement of economically important tree species has been obtained during the past four decades with the assistance of the Royal Danish Government. The genetic resources of many species have been conserved and developed, for example teak, pines and some hardwood species. However, the reform of the public sector, as mentioned earlier, has hindered some operating activities in the wake of reshuffle or transfer of the duties and responsibilities between the key departments.

Adaptation is therefore necessary to gain a clear understanding of the duties and responsibilities of each department. Moreover, experience-sharing sessions between the departments are important in order to come up with an integration-oriented action plan for the management of forest genetic resources, including both operational guidelines and research frameworks. These activities are necessary in order to achieve the main goal – benefits for the humankind from the sustainable use of forest genetic resources.

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Appendix 1.

Summary of priority actions for the conservation of the genetic resources of indigenous tree species in Thailand (adapted from FORGENMAP 2002a)

Species	Research needs			Conservation strategy	In situ conservation		Ex situ conservation	
	Taxonomy	Genetic process & variation	Distrib. and status		Current situation	Additional sites	Current situation	Additional stands
Top priority								
<i>Azela xylocarpa</i> Craib.		3	3	3	•••	1 (S)	•	1
<i>Dipterocarpus alatus</i> Roxb.		3*	3	3	•••		•	1
<i>Hopea odorata</i> Roxb.		3	3	3	•••		•	1
<i>Pterocarpus macrocarpus</i> Kurz.		3+	3	3*	•••		••	1
<i>Tectona grandis</i> Linn.		3+	2	+	•••	1	•	1
Very high priority								
<i>Alstonia scholaris</i> (L.)R.Br.		2	2	2	•••		•	2
<i>Aquilaria crassna</i> Pierre ex Lec.		2	3	2	••			1
<i>Dalbergia cochinchinensis</i> Pierre.		2+	3	2*	••		•	1
<i>D. oliveri</i> Gemble.		2	3	2	••		•	1
<i>Intsia palembanica</i> Miq.		2	2	2	•••			2
<i>Mangifera</i> (wild species)	1	2	3	2	•••			2
<i>Milletia kangensis</i> Craib.		2	3	2	•	2 (N)		2
<i>Pinus merkusii</i> Jungn & De Vriese.		1+	1+	+	•••	2 (NE)	••	2
<i>Wrightia tomentosa</i> Roem. & Schult.		2	2	2	•••			2
<i>Xylia xylocarpa</i> var. <i>kerrii</i> Craib & Hutch.		2	2	2	•••		••	2
Other priority								
<i>Azadirachta excelsa</i> (Jack) Jacobs		1	1	1	••			3
<i>Chukrasia tabularis</i> A.Juss	2	1*	1	1*	•••		••	3
<i>Cotylelobium melanoxylon</i> Pierre.		1+	1	1	••	2 (S)		3
<i>Dipterocarpus tuberculatus</i> Roxb.		1	1	-	•••			3

Species	Research needs			Conservation strategy	In situ conservation		Ex situ conservation	
	Taxonomy	Genetic process & variation	Distrib. and status		Current situation	Additional sites	Current situation	Additional stands
<i>Durio mansoni</i> Bakh.		1	1	1	••	2 (S)		3
<i>Fagraea fragrans</i> Roxb.		1	1	1	••	2 (C,E)		3
<i>Gmelina arborea</i> Roxb.		1+	1	1	•••		•	3
<i>Holoptelea integrifolia</i> (Roxb.) Planch.		1	1	1	••	2 (NE,E,W)		3
<i>Hopea ferrea</i> Pierre.		1	1	1	•••	2 (W,C)		3
<i>Manglietia garretti</i> Craib.		1	1	1	••	2 (W,C)		3
<i>Mansonia gagei</i> Drumm.		1	1	1	••			3
<i>Melia azedarach</i> Linn.		1	1	-	•••			3
<i>Melientha suavis</i> Pierre.		1	1	1	•••			3
<i>Parashorea stellata</i> Kurz.		1	1	1	••	2 (E)		3
<i>Parkia speciosa</i> Hassk.		1	1	1	•••	2 (C)		3
<i>Pinus kesiya</i> Royle ex Gordon.		1+	1+	1	•••		•	3
<i>Shorea henryana</i> Pierre.		1	1	1	•	2 (S,E,W)		3
<i>S. roxburghii</i> G. Don.		1	1	1	•••	2 (C,E,W)	•	3
<i>Tetrameles nudiflora</i> R.Br.		1	1	-	•••			3
<i>Toona ciliata</i> M. Roem.	*	1	1	1	•••	2 (C,W)		3

Field codes:

Research needs and Conservation strategy:

3 = Top priority: to be undertaken within the next three years

2 = High priority: to be undertaken within the next five years

1 = Medium priority: to be undertaken within the next ten years

* = study in progress

+ = study completed

In situ conservation and ex situ conservation:

••• very well conserved

•• well conserved

• partly conserved

Additional sites

NE = north-east, N = north, C = central, E = east, W = west, S = south/peninsula