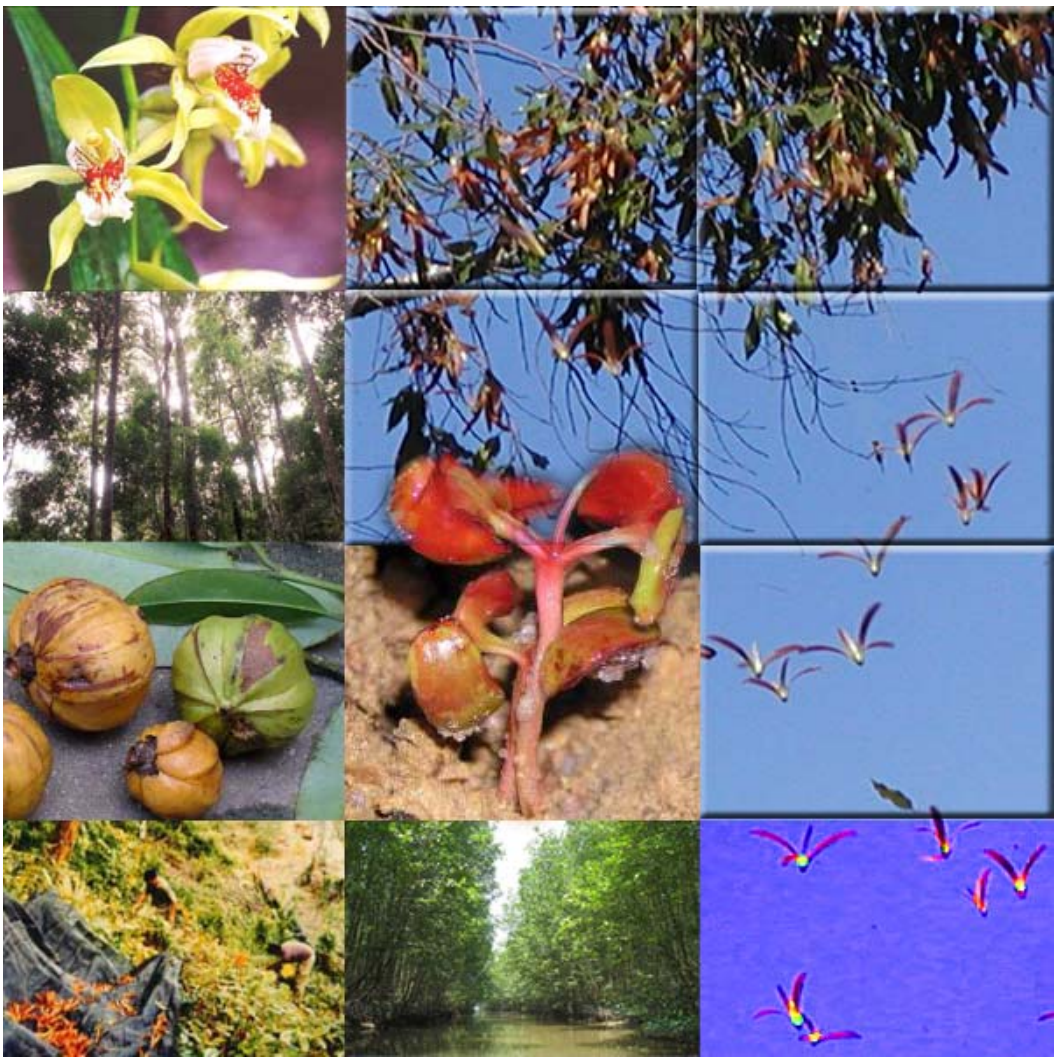
Forest Genetic Resources

Conservation and Management

Status in seven South and Southeast Asian countries

R. Jalonen, K.Y. Choo, L.T. Hong and H.C. Sim *editors*



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The Forest Research Institute Malaysia (FRIM) is the national forestry research organization of Malaysia. It was first established in 1929 as the Forest Research Institute, the research arm of the Peninsular Malayan (later Malaysian) Forest Department, and in 1985 was reorganized into the present FRIM, a statutory body.

FRIM's research focus and efforts through nearly a century's existence has meant that FRIM has not only built up a strong tradition of research, but backs this up with experience, expertise and supporting facilities perhaps unmatched anywhere in the tropics. Basic studies of the tropical forests conducted at FRIM had produced publications before and just after World War II that remain classic books in their field till today. Among the more notable ones are Symington's *Manual of Dipterocarps*, Watson's *Mangrove Forests of the Malay Peninsula*, and Wyatt-Smith's *Manual of Silviculture of Lowland Forests*.

Past research has also left behind many living laboratories in the field – a number of arboreta, sample plots and various experimental plantations of both local and exotic tree species. These sample plots and experimental areas are not just confined to the FRIM campus, which is located in the northern suburb 16 km outside the capital city of Kuala Lumpur; but are spread throughout peninsular Malaysia, covering various forest types and terrains.

FRIM has maintained a number of collections including a herbarium, an insect collection, and collections of wood and soil samples, which are widely regarded as reference collections for researchers and scientists in these fields. The many well-equipped laboratories in FRIM, which have been constantly and continuously upgraded, have put FRIM among the top forestry and forest products research institutions.

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Bioversity International (Bioversity) an autonomous international scientific organization, supported by the Consultative Group on International Agricultural Research (CGIAR). Bioversity's mandate is to advance the conservation and use of genetic diversity for the well-being of present and future generations. Bioveristy's headquarters is based in Rome, Italy, with offices in another 15 countries worldwide. It operates through three programmes: (1) the Plant Genetic Resources Programme, (2) the CGIAR Genetic Resources Support Programme, and (3) the International Network for the Improvement of Banana and Plantain (INIBAP).

The international status of Bioversity is conferred under an Establishment Agreement which, by January 1999, had been signed and ratified by the Governments of Algeria, Australia, Belgium, Benin, Bolivia, Brazil, Burkina Faso, Cameroon, Chile, China, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Greece, Guinea, Hungary, India, Indonesia, Iran, Israel, Italy, Jordan, Kenya, Malaysia, Mauritania, Morocco, Norway, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovakia, Sudan, Switzerland, Syria, Tunisia, Turkey, Uganda and Ukraine.

Financial support for the Research Agenda of Bioversity is provided by the Governments of Australia, Austria, Belgium, Brazil, Bulgaria, Canada, China, Croatia, Cyprus, Czech Republic, Denmark, Estonia, F.R. Yugoslavia (Serbia and Montenegro), Finland, France, Germany, Greece, Hungary, Iceland, India, Ireland, Israel, Italy, Japan, Republic of Korea, Latvia, Lithuania, Luxembourg, Macedonia (F.Y.R.), Malta, Malaysia, Mexico, Monaco, the Netherlands, Norway, Peru, the Philippines, Poland, Portugal, Romania, Slovakia, Slovenia, South Africa, Spain, Sweden, Switzerland, Turkey, the UK, the USA and by the Asian Development Bank, Common Fund for Commodities, Technical Centre for Agricultural and Rural Cooperation (CTA), European Union, Food and Agriculture Organization of the United Nations (FAO), International Development Research Centre (IDRC), International Fund for Agricultural Development (IFAD), International Association for the Promotion of Cooperation with Scientists from the New Independent States of the former Soviet Union (INTAS), Interamerican Development Bank, Natural Resources Institute (NRI), Centre de Coopération internationale en recherche agronomique pour le développement (CIRAD), Nordic Genebank, Rockefeller Foundation, United Nations Development Programme (UNDP), United Nations Environment Programme (UNEP), Taiwan Banana Research Institute (TBRI) and the World Bank.

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The Asia Pacific Association of Forestry Research Institutions (APAFRI) is an association of Institutions with an active interest in forestry research, conservation, management and other forestry related matters in the Asia Pacific. Its objective is to promote collaboration among institutions to enhance and increase the forestry research and conservation capacity in the Asia Pacific.

The establishment of APAFRI was prompted by the need to provide a viable institutional framework for research collaboration in the region. Since 1991, the Forestry Research Support Programme for Asia and the Pacific (FORSPA) has been fulfilling the networking function.

Countries in the region and the donor community wish to develop a more self-reliant, sustainable and participatory institutional mechanism as a logical follow-up of FORSPA. The feasibility of establishment of an Association was discussed in the FORSPA Pre-implementation seminar held at Kuala Lumpur in January 1992. A draft constitution was prepared and circulated and subsequently a drafting committee prepared a revision. This was discussed, modified and adopted during the meeting of Heads of Forestry Research Organizations in the Asia Pacific in Bogor on 21st February 1995, and resulted in the establishment of APAFRI.

The International Union of Forestry Research Organizations (IUFRO) has recognised APAFRI as its Asia Pacific chapter. APAFRI has been collaborating closely with the IUFRO Special Programme for Developing Countries (SPDC) in strengthening research in the Asia Pacific region. Extending from that, APAFRI's Executive Director also acts as the Asia Pacific Regional Coordinator for IUFRO-SPDC.

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The **International Tropical Timber Organization (ITTO)** is the only intergovernmental organization that brings together countries that produce and consume tropical timber to discuss and exchange information and develop policies on all aspects of the world tropical timber economy and the management of the tropical timber resource base –tropical forests. As of November 2008, ITTO had 60 members, including the European Community, which together represent 90% of world trade in tropical timber and 80% of the world's closed tropical forests.

Under the ITTA 2006, ITTO has two closely related overarching objectives:

- To promote the expansion and diversification of international trade in tropical timber from sustainably managed and legally harvested forests
- To promote the sustainable management of tropical timber-producing forests.

The ITTA 2006 sets out the Organization's longstanding aims of enhancing the capacity of members to export tropical timber from sustainably managed forests and to improve market transparency, forest-based enterprises and sustainable forest management (SFM). It also expands the scope of previous agreements to include objectives related to poverty alleviation, forest law enforcement, non-timber forest products and environmental services, voluntary market mechanisms such as certification, and the role of forest-dependent communities.

ITTO develops internationally agreed policy documents to promote SFM and forest conservation. It assists tropical member countries to adapt such policies to local circumstances and to implement them in the field through projects. In addition, ITTO collects, analyses and disseminates data on the production and trade of tropical timber and funds a range of projects and other actions aimed at developing industries at both community and industrial scales.

By November 2008 the Organization had provided more than US$300 million to finance over 800 projects designed to encourage SFM, increase the efficiency of forest industries, and improve market intelligence and statistics. The vast majority of these projects were made possible through the voluntary financial contributions of consumer member countries. ITTO also supports capacity building through the development of manuals, workshops and a fellowship fund that supports young professionals.

ITTO cooperates closely with other international organizations with forest-related mandates. It is a founding member of the Collaborative Partnership on Forests (CPF), which was established in 2000 to support the work of the United Nations Forum on Forests (UNFF) and to enhance coordination among the international conventions, organizations and institutions with forest-related mandates. ITTO also cooperates with a wide range of regional and national-level organizations and other civil-society and private-sector stakeholders.

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APFORGEN

The Asia Pacific Forest Genetic Resources Programme (**APFORGEN**) was initiated in 2003. APFORGEN is a regional programme with a holistic approach to conservation and management of forest genetic resources. Its aim is to enhance technical and scientific cooperation, training and information exchange among countries in the region. It is managed by the Asia Pacific Association of Forestry Research Institutions (**APAFRI**) with technical support from Bioversity International (**Bioversity**). Target beneficiaries of this programme include forest research institutions, policy-makers, local communities, government forestry departments, NGOs and private forestry companies. Other international and regional organizations such as FAO are also participating in the development of the programme and its activities.

The objective of APFORGEN is to manage tropical forest genetic diversity more equitably, productively and sustainably in the participating countries, specifically the programme aims to:

- Strengthen national programmes on forest genetic diversity
- Enhance regional networking and collaboration
- Facilitate to locate and conserve genetic diversity of selected priority forest species
- Increase sustainable use of genetic diversity in natural and man-made forests

APFORGEN currently has fourteen participating country organizations from Bangladesh (*Bangladesh Forest Research Institute*), India (*Indian Council for Forestry Research and Education*), Nepal (*Department of Forest Research and Survey*), Pakistan (*Pakistan Forest Institute*), Sri Lanka (*Forest Department*), Cambodia (*Department of Forestry and Wildlife*), China (*Research Institute of Forestry, Chinese Academy of Forestry*), Indonesia (Centre for Plantation Research and Development, Bogor), Lao PDR (*Forest Research Centre*), Malaysia (*Forest Research Institute Malaysia*), Myanmar (*Forest Research Institute, Yezin*), Philippines (*College of Forestry and Natural Resources, University of Philippines Los Banos*), Thailand (*Royal Forest Department/National Park, Wildlife and Plant Conservation Department*) and Viet Nam (*Forest Science Institute of Viet Nam*).

The programme has held five meetings (2003 to 2007) in which the National Coordinators of each of the participating organizations attended. A draft action plan for the programme was drawn up for implementation. Currently, some activities of APFORGEN are partially supported by APAFRI and Bioversity. The bulk of the funding comes from the ITTO Project PD 199/03 Rev. 3(F) which has a duration of three years (2006–2009). The project has been extended for another year till February 2010.

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Contents

Preface

In February 2002, the Asia Pacific Association of Forestry Research Institutions (APAFRI), Bioversity International (formerly International Plant Genetic Resources Institute IPGRI) and the Forest Research Institute Malaysia (FRIM) initiated a consultation process with their partners in Asia. The institutions were planning a regional programme for increasing the exchange of information and national capacities in the conservation and management of forest genetic resources, especially in rapidly developing scientific and technical areas such as assessment of biodiversity and conservation methodologies. The objective of the consultation process was to identify partner institutions and countries in the region who were willing to participate in and to commit their own resources for the proposed programme. In addition, the consultation was aimed at identifying specific country-based needs for research and development in the conservation and use of forest genetic resources.

A total of 14 countries indicated their strong interest on the proposed programme and provided valuable feedback. These countries are Bangladesh (Bangladesh Forest Research Institute), India (Indian Council for Forestry Research and Education), Nepal (Department of Forest Research and Survey; Tree Improvement and Silviculture Component), Pakistan (Pakistan Forest Research Institute), Sri Lanka (Forest Department), Cambodia (Department of Forestry and Wildlife), Indonesia (Research and Development Centre for Biotechnology and Forest Tree Improvement), Lao PDR (Forest Research Centre), Malaysia (Forest Research Institute Malaysia), Myanmar (Forest Research Institute, Yezin), Philippines (College of Forestry and Natural Resources University of Philippines, Los Banos), Thailand (Royal Forest Department; Kasetsart University), Vietnam (Forest Science Institute of Vietnam) and PR China (Research Institute of Forestry and Research Institute of Tropical Forestry, both under the Chinese Academy of Forestry).

The results of the consultation process were presented during a regional inception workshop in Malaysia in 2003 for initiating the formation of the regional programme for collaboration in the conservation and management of forest genetic resources. Participants from 13 countries in the region as well as representatives from United Nations Food and Agriculture Organization (FAO) and DANIDA Forest Seed Centre (DFSC) attended the workshop. An important outcome of the workshop was the commitment to establish the Asia Pacific Forest Genetic Resources Programme (APFORGEN). The Secretariat of APFORGEN is hosted by the Secretariat of APAFRI with modest initial funding and technical support from Bioversity International.

The APFORGEN programme has held five meetings between 2003 and 2007. The National Coordinators of each participating country attended the meetings and presented updates of the status of forest genetic resources and related activities in their countries.

A major achievement of APFORGEN was to secure funding for the continuation of the programme activities from the International Tropical Timber Organization (ITTO) in 2005. The ITTO provided funding for a 3-year project titled *Strengthening National Capacity and Regional Collaboration for Sustainable Use of Forest Genetic Resources in Tropical Asia* (ITTO project PD 199/03Rev. 3(F)). The project, implemented in 2006-2009, has seven national partners: Cambodia (Department of Forestry and Wildlife), India (Indian Council for Forestry Research and Education), Indonesia (Research and Development Centre for Biotechnology and Forest Tree Improvement), Malaysia (Forest Research Institute Malaysia), Myanmar (Forest Research Institute, Yezin), Philippines (College of Forestry and Natural Resources, University of Philippines, Los Banos), and Thailand (Royal Forest Department). The implementation of the project is supported by FRIM in collaboration with APAFRI and Bioversity International,

This compilation of the national status reports from the seven participating countries of the ITTO Project is the second joint documentation of national activities for the conservation and management of forest genetic resources in South and South-east Asian countries. The first compilation of national status reports was published in the proceedings of the inception workshop of 2003[1]. The reports in this publication were provided by the National Focal Points of the ITTO project countries during the years 2007-2009, and they capture updates in the conservation and management activities and initiatives in the project countries since the inception workshop of the APFORGEN Programme in 2003.

Information on the conservation and management of forest genetic resources, such as compiled in these two publications, is invaluable to forest practioners, policy makers and researchers in the region. It forms a critical component for the basis for sustainable forest management, which is of imminent concern in the Asia-Pacific region. The present status reports indicate that fairly comprehensive legal and institutional frameworks for the conservation and sustainable management of forest genetic resources are already widely in place in the region, and many of the countries have initiated specific national programmes and strategies related to forest genetic resources. A major future task for the countries is to further develop these intitiatives and translate them to effective practical guidelines and measurable outputs in the conservation of genetic resources. In this process they will continue to benefit from the exchange of information and sharing of best current practices with their neighbours in similar situations – between the ITTO project participants, and the other countries in the region. Achieving sustainable improvements in human and institutional capacities to understand, protect and benefit from the enormous variety of forest genetic resources in the region requires time and persistency of efforts, also after attaining satisfactory capabilities at one time. Creating an enabling environment for these processes is the major justification and motivation for continuing the work of APFORGEN also after the current ITTO project comes to an end.

Kuala Lumpur, August 2009

Editors

[1] Luoma-aho T, Hong LT, Rao V. Ramanatha, Sim HC, editors. 2004. Forest Genetic Resources Conservation and Management. Proceedings of the Asia Pacific Forest Genetic Resources Programme (APFORGEN) Inception Workshop, Kepong, Malaysia, 15-18 July, 2003. IPGRI-APO, Serdang, Malaysia. Available from: http://www.apforgen.org/pub.htm

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We gratefully acknowledge the contributions of the National Focal Points of the seven countries participating in the ITTO Project PD 199/03Rev. 3(F): Strengthening National Capacity and Regional Collaboration for Sustainable Use of Forest Genetic Resources in Tropical Asia. Chann Sophal (Cambodia), GS Rawat (India), Harry Santoso (Indonesia), Lee Soon Leong (Malaysia), Lwin Ko Oo (Myanmar), Enrique L. Tolentino Jr. (Philippines) and Suwan Tangmitcharoen (Thailand) submitted original drafts of the reports and carefully edited and updated them.

Several colleagues in FRIM, Bioversity International and APAFRI have contributed time and effort towards the successful compilation and publishing of this volume. We are indebted to ITTO for funding the project under which this publication is produced.

Abbreviations

General

AAC	Annual allowable cut
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AFP	Asia Forest Partnership
AKECU	ASEAN-Korea Environmental Cooperation Unit
APAFRI	Asia Pacific Association of Forestry Research Institutions
APFORGEN	Asia Pacific Forest Genetic Resources Programme
ASEAN	Association of Southeast Asian Nations
AusAID	Australian Government's Overseas Aid Program
BCCI	Biodiversity Conservation Corridors Initiative
CBD	Convention on Biological Diversity
CI	Conservation International
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
COP	Conference of the Parties
CSIRO	Commonwealth Scientific and Industrial Research Organisation (Australia)
CSO	Clonal seed orchard
DANIDA	Danish International Development Agency
dbh	Diameter at breast height
DFSC	Danish Forest Seed Center
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FGR	Forest genetic resources
FIO	Forest Industry Organization
FSC	Forest Stewardship Council
GDP	Gross domestic product
GEF	Global Environmental Facility
GIS	Geographical Information System
IDRC	International Development Research Centre
IEC	Information, Education and Communication
INBAR	International Network for Bamboo and Rattan
ITPGRFA	International Treaty Plant Genetic Resources for Food and Agriculture
ITTO	International Tropical Timber Organization
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
LIL	Low-impact logging
MIS	Management Information System
NFP	National Forest Programme
NGO	Non-governmental organization
NTFP	Non-timber forest products
NWFP	Non-wood forest products
OECD	Organization for Economic Cooperation and Development

PAS	Protected area system
PEFC	Programme for the Endorsement of Forest Certification
PLSP	Public Sector Linkages Program (AusAID)
RAPD	Random Amplified Polymorphic DNA
RECOFTC	Regional Community Forest Training Center for Asia and the Pacific
RIL	Reduced impact logging
SFM	Sustainable forest management
SPA	Seed production area
SSO	Seedling seed orchard
TEAKNET	Asia-Pacific Teak Information Network
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Programme
UNEP	United Nations Environment Programme
UNESCO	United Nations Educational, Scientific and Cultural Organization
UNFF	United Nations Forum on Forests
UPOV	International Convention for the Protection of New Variety of Plants
USDA	United States Department for Agriculture
WB	World Bank
WTO	World Trade Organization
WWF	World Wide Fund for Nature

Cambodia

CTSP	Cambodia Tree Seed Project
FA	Forestry Administration
MAFF	Ministry of Agriculture, Forestry and Fisheries
MoE	Ministry of Environment
NPASMP	National Protected Area Strategic Management Plan
NSDP	National Strategic Development Plan
TWG-F&E	Technical Working Group for Forestry and Environment

India

AFRI	Arid Forest Research Institute
BDA	Biological Diversity Act
CSO	Clonal seed orchards
FRI	Forest Research Institute
FRLHT	Foundation for Revitalization of Local Health Traditions
FSI	Forest Survey of India
HFRI	Himalayan Forest Research Institute
ICAR	Indian Council of Agricultural Research
ICFRE	Indian Council of Forest Research and Education
IFGTB	Institute of Forest Genetics and Tree Breeding
IFP	Institute of Forest Productivity
IWST	Institute of Wood Science and Technology

MoEF	Ministry of Environment and Forests
NBPGR	National Bureau of Plant Genetic Resources
NFRP	National Forestry Research Plan
PPVFR	Protection of Plant Varieties and Farmers' Rights Act
RFRI	Rain Forest Research Institute
SSO	Seedling seed orchards
TFRI	Tropical Forest Research Institute
UT	Union Territory
VGM	Vegetative Multiplication Garden
WII	Wildlife Institute of India

Indonesia

CBFTI	Centre for Forest Biotechnology and Tree Improvement
CFNC	Centre for Forest and Nature Conservation Research and Development
CFP	Centre for Forest Product Research and Development
CPFRD	Centre for Plantation Forest Research and Development
FORDA	Forestry Research and Development Agency
GERHAN	National movement on forest and land rehabilitation
IBSAP	Indonesian Biodiversity Strategy and Action Plan
KSDGTH-TD	Concept on village level FGR conservation and management
UGM	University of Gadjah Mada

Malaysia

BBEC	Borneon Biodiversity and Ecosystem Conservation
FMU	Forest management unit
FOMISS	Forest Management Information System Sarawak
FRIM	Forest Research Institute Malaysia
GRA	Genetic Resources Area
ITA	Investment Tax Allowance
MARDI	Malaysia Agricultural Research and Development Institute
MC&I	Malaysian criteria and indicators (for sustainable forest management)
MOA	Ministry of Agriculture and Agro-based Industry
MOSTI	Ministry of Science, Technology and Innovation
MPOB	Malaysia Palm Oil Board
MTCC	Malaysian Timber Certification Council
MUS	Malayan Uniform System
NWG	National Working Group
NFC	National Forestry Council
NRE	Ministry of Natural Resources and Environment
PFE	Permanent Forest Estate
SMFLA	License agreement for sustainable forest management
SMS	Selective Management System
TPA	Totally Protected Area
UKM	Universiti Kebangsaan Malaysia
UM	University of Malaya
UNIMAS	Universiti Malaysia Sarawak

UPM	Universiti Putra Malaysia

Myanmar

CFDTC	Central Forestry Development Training Centre
DUMD	Dry mixed deciduous forest
DZGD	Dry Zone Greening Department of Ministry of Forestry
FD	Forest Department of Ministry of Forestry
FRI	Forest Research Institute
LMD	Lower mixed deciduous forest
MOF	Ministry of Forestry
MSS	Myanmar Selection System
MTE	Myanmar Timber Enterprise
MUMD	Moist upper mixed deciduous forest
PFE	Permanent Forest Estate
PSD	Planning and Statistics Department of Ministry of Forestry
THG	Teak hedge gardens

The Philippines

A&D	Certified alienable and disposable lands
AO	Administrative Order
ATSAL	Agroforestry Tree Seed Association of Lantapan
BFD	Bureau of Forestry Development
BFI	Bukidnon Forests Incorporated
BMS	Biodiversity Monitoring System
BRAHMS	Botanical Resources and Herbarium Management System
CFNR	College of Forestry and Natural Resources (University of the Philippines)
CPPAP	Conservation of Priority Protected Areas Project
DENR	Department of Environment and Natural Resources
ERDB	Ecosystems Research and Development Bureau
ERDS	Ecosystems Research and Development Service
FMB	Forest Management Bureau
FORTIP	Regional Project on Improved Productivity of Man-made Forests through Application of Technological Advances in Tree Breeding and Propagation
FRC	Forestry Research Centre
GRBS	Game refuge and bird sanctuary
IPA	Important Plant Areas
IPB	Institute of Plant Breeding
IPRA	Indigenous People's Rights Act
IPS	Important Plant Sites
ITPLA	Industrial Tree Plantation License Agreement
LNCA	Leon National College of Agriculture
MBG	Makiling Botanic Gardens
MC	Memorandum Circular
NIPAP	National Integrated Protected Areas Program
NIPAS	National Integrated Protected Areas System

PAMP	Protected Area Management Plan
PAWB	Protected Area and Wildlife Board
PICOP	PICOP Resources Incorporated
PTFI	Provident Tree Farms Incorporated
RA	Republic Act
SEP	Strategic Environmental Plan
SIBP	Samar Island Biodiversity Project
SUDECOR	Surigao Development Corporation
SUSTEC	Sustainable Ecosystems International Corporation
UP-CIDS	University of Philippines Center for Integrated Development Studies
UPLB	University of the Philippines, Los Baños
WA	Wildlife areas

Thailand

DMCR	Department of Marine and Coastal Resources
DNP	National Park, Wildlife and Plant Conservation Department
FORGENMAP	Forest Genetic Resources Conservation and Management Project
FRC	Forest Research Centre
IS	Identified stand
KUFF	Faculty of Forestry at the Kasetsart University
MONRE	Ministry of Natural Resources and Environment
PSS	Provenance seed stand
RFD	Royal Forest Department
SCZ	Seed collection zone (ecozone)
SO	Seed orchard
SS	Selected stand

Status of forest genetic resources in Cambodia

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The Kingdom of Cambodia is the country with the largest remaining proportion of forest cover in South-east Asia. The forests still cover 10 730 000 ha or 59.1% of the country's total land area. The full extent of Cambodia's biodiversity is not known, but it is expected to be rich in species diversity and may be considered a biodiversity hotspot. Compared with the neighboring countries, population density in Cambodia is low, and relatively large natural areas still remain intact.

Cambodia is located on the peninsula of the South-East Asian mainland, adjacent to the gulf of Thailand. The country is dominated by agricultural lowlands along the Mekong River and the Great Lake of Tonle Sap, and three mountainous regions in the South-west, North and North-east. Majority of the country's 14.1 million inhabitants live in the lowland areas, leaving the mountain regions less populated and rich in forest resources. The climate in the country is tropical with seasonal monsoon rains. Annual precipitation varies between 1200 and 1875 mm over the plain areas and may reach up to 3000 mm on the Cardamom and Elephant mountain ranges in the south-west (Ministry of Environment 2002; Cambodia National Forest Programme 2008).

The forests of Cambodia supply its people with important sources of income and other livelihood benefits. Agriculture, forestry and fishery provide employment for 70% of the workforce and amount together to 34% of the gross domestic product. According to official estimates, the share of forestry ranges between 6.4 and 10% of the GDP. This is, however, probably an underestimate, as little or no quantitative data exist on the economic importance of many forest products and services, such as non-timber forest products (NTFP), fuel wood, other subsistence products and environmental benefits (Cambodia National Forest Programme 2008). For example, 84% of Cambodia's households depend on fuel wood as a source of energy. The forests are important especially for the rural people, 80% of the country's population. In provincial villages the poor households earn an average income of 280 US$ annually from non-timber forest products, and 42% of their total incomes originate from forest (Hansen & Top 2006).

Natural resources are the mainstay of Cambodia's economy. However, although the forest cover is still extensive, deforestation occurs at a rapid rate. Between the years 2002-2006 alone, approximately 373 500 ha of forests were lost, along with an unknown extent of degradation in forest density and diversity (Cambodia National Forest Programme 2008). Many species have been exploited to the extent that they are now listed as vulnerable or endangered, with a distinct number of species threatened with extinction. Cambodia's increasing population is among the main causes of biodiversity loss, as it acts as a basis of many of the other threats, such as agricultural encroachment, development of infrastructure, and harvest of timber and non-timber forest products. Other causes of biodiversity loss include unsustainable or ineffective policies, global trading in plants and wildlife, inequity, lack of participation, ignorance, natural and man-made disasters, climate change, pollution and invasive alien species (Ministry of Environment 2009).

This article outlines the status of forest genetic resources, their conservation and management initiatives in Cambodia. It also introduces the legal and political framework related to forests and their genetic resources, assessment of capacities of governmental organizations and stakeholders in natural resource management, and the future priorities for the conservation and sustained use of the resources in the country.

Forest resources

Forest and vegetation types

Forests in Cambodia are classified into three major types: evergreen, semi-evergreen and deciduous forests (Table 1). *Evergreen forests* are usually multi-storied forests where trees maintain their leaves year-round. They comprise the lowland tropical rain forests, the hill evergreen forests and the dry evergreen forest. They are also found along streams and rivers (gallery forests). *Semi-evergreen forests* contain evergreen and deciduous trees in variable proportions, the percentage of evergreen trees being between 30% and 70%. *Deciduous forests* comprise dry mixed deciduous forests and dry dipterocarp forests. In deciduous forests the trees drop all or nearly all their leaves during the dry season. Human impact such as fire is usually much higher than in the other forest types. Dry dipterocarp forests naturally have an open character: even in undisturbed forests the crown cover may be as low as 40% of land area (TWG Forestry and Environment 2007; FAO 2005).

In addition to these main forest types, some other forest types, bamboos, and wood and shrubland vegetation cover part of the country's forest lands. The category of other forest types includes regrowth, stunted forests, mangrove forests, inundated forests and forest plantations. Regrowth of secondary forests is representative of a continuous, usually dense layer of smaller trees in areas which are regenerating after clear-cutting. Stunted, slowly-growing forests occur on poor soils, e.g. hydromorphic soils and rock outcrops. Mangrove and rear-mangrove forests occupy coastlines of Koh Kong, Kampot provinces, Sihanouk Ville and Kep town. The state has established approximately 13 000 ha of plantation forests. In addition, private land concessionaires have planted an unknown area on former forest lands with tree species for pulp and rubber production (ITTO 2005). Other types included in this main category are heavily disturbed forests such as mosaics of forest, and cropping related to shifting agriculture in areas where forests cover at least 40% of land (TWG Forestry and Environment 2007; FAO 2005).

Wood and shrublands are covered by a mixture of shrubs, grass and trees. The shrubs and grass usually form a dense layer, and tree canopies cover less than 20% of land area. This vegetation type can be found mainly on shallow soils, on mountain tops under climax conditions, or as a result of unsustainable land use. Theoretically, there is a chance for the area to become forested again. Young regrowth after shifting cultivation is also included in this class after the mosaic of cultivation becomes invisible. Whereas most of this vegetation type is evergreen, a variant of dry vegetation can be found in dry plateaus, on dry and sun-exposed slopes.

The remaining land in Cambodia is classified as non-forest, and it comprises agricultural areas, urban areas, water bodies, grass land and barren land (TWG Forestry and Environment 2007).

According to the forest resource assessment by FAO (2005), Cambodia would rank among the countries with highest forest loss during the past few decades (Table 2). For example, mangrove forests were reduced by 17% between the years of 1993 and 2003. In addition, satellite imageries indicate that much of the remaining forest is degraded. Primary forests, which are biologically the most diverse, comprise 322 000 hectares or 3.1% of the remaining forest area (Ministry of Environment 2009).

Table 1. Forest types in Cambodia in 2006 (Forestry Administration 2003; Cambodia National Forest Programme 2008).

Category	Area (1000 ha)	% of forest land	Change (%) from 2002
Evergreen forest	3 669	33.8	-1.4
Semi-evergreen forest	1 363	12.5	-6.3
Deciduous forest	4 692	43.2	-2.9
Other forest	971	8.9	-8.9
Bamboo	36	0.3	24.1
Total forests	**10 731**	**98.8**	**-3.4**
Wood shrubland (dry)	37	0.3	-73.4
Wood shrubland (evergreen)	96	0.9	-36.0
Total forest land	**10 864**	**100%**	**-4.6**

Table 2. Change in forest cover in Cambodia 1965-2006 (TWG Forestry and Environment 2007)

Year of assessment	Forest land	
	Area (1000 ha)	% of land area
1965	13 227	73.0
1992-1993	10 860	59.8
1996-1997	10 638	58.6
2002	11 104	61.2
2005-2006	10 731	59.1

Flora

Dominating tree species in Cambodian forests usually belong to the families of Dipterocarpaceae, Leguminosae, Lythraceae or Fagaceae, and in some areas Pinaceae and Podocarpaceae. Bamboo species dominate in certain areas. The flora of lower elevations are typical of the Indochinese floristic province and contrasts, therefore, with that of the Chinese, Indo-Burman and Indo-Malayan provinces. The flora at higher elevations, in turn, share affinity with that of the Indo-Malayan region (Dy Phon 1982; CTSP, FA and DANIDA 2004). In moist evergreen and semi-evergreen areas in the lowlands, the dominating species most commonly are *Dipterocarpus costatus, Hopea odorata, Parkia streptocarpa, Heritiera javanica* and *Syzygium cinereum*. Other common species include *Shorea hypochra, Anisoptera costata* and *A. glabra*. In higher elevations, *Lithocarpus* spp., *Quercus cambodiensis* and *Castanopsis cambodiana* are found. In deciduous forest the dominating species are commonly *Lagerstroemia* spp., *Xylia dolabriformis, Terminalia* spp., *Dipterocarpus intricatus* and *Pterocarpus pedatus* (ITTO 2005).

Flora of Cambodia were for the first time extensively described in the seven volumes of *Flore Generale de l'Indochine* (Lecompte 1907-1942), which listed over 8000 plant species of Cambodia, Laos and Vietnam. Dy Phon (1982) later showed that 2308 of these species, belonging to 852 genera in 164 families, occur in Cambodia. Taxonomic revisions of the last few decades suggest that many more species will certainly be discovered in Cambodia, so that the total number of plant species may attain 3000. It may be assumed that a minimum of 10% of these species are endemic (Dy Phon 1982; CTSP, FA and DANIDA 2004). In particular, the wet forests of the Cardamom and Elephant Mountains and the swamp forests of the Tonle Sap floodplain may be expected to harbour locally distributed species (Ministry

of Environment 2002).

Cambodians have habitually utilized at least 931 plant species of the known approximately 2300 species. In total 586 plant species belonging to 134 families have been recorded as medicinal plants for traditional therapies (Ministry of Environment 2009).

Several plant species or varieties occurring in Cambodia are currently at risk of becoming endangered or even extinct. Out of the known plant species, 38 are on the IUCN Red List. Threatened species include valuable tree species such as chankreussna (*Aquilaria crassna*), cheuteal (*Dipterocarpus* spp.) and koki (*Hopea* sp.), rare endemics such as the highly valued coniferous tree *Fokienia hodginsii*, and several species of orchids (Ministry of Environment 2002; see also FAO 2005). Major threats to the terrestrial flora are the encroachment of human settlements, deforestation, cultivation, landscape gardening and livestock grazing, as well as illegal logging or collecting of plants for local or international markets (Ministry of Environment 2002). The situation is worsened by high demand and subsequent high prices for commercial tree species.

Land use and ownership

The state-owned forests of Cambodia are called permanent forest reserves. According to the Forestry Law of 2002, they are classified into production forest, protection forest and conversion forestland for other development purposes.

Production forests cover approximately 3 460 000 ha, and their primary function is the sustainable production of timber and non-timber forest products. Production forest includes subclasses of forest under concession, forest permitted for harvesting, degraded forest, forest to be rehabilitated, areas reserved for forest regeneration or plantation, reforested areas and community forests. Currently, a logging moratorium has been imposed on all existing logging concessions. Production forests may be reclassified as conversion forests (Cambodia National Forest Programme 2008).

By 2008, 264 community forests had been designated in Cambodia, with a total area of 179 020 ha (Ministry of Environment 2009). These areas remain state owned, but the Forestry Administration and the local people have an agreement which permits management and utilization of the forest in a sustainable manner by the community or other organized group of people who live within or nearby the forest and depend upon it for subsistence. The state also recognizes and ensures their user rights in the forests for the purpose of traditional customs, beliefs, religion and living. In addition, state may grant user rights to individuals to plant trees on state-owned land and to harvest and sell forest products from these areas (Cambodia National Forest Programme 2008).

Protection forests (4 620 000 ha) have as their primary function the protection of forest ecosystems. These protective functions include regulation of water resources; conservation of biodiversity, land, water, watershed and catchment areas; wildlife and fish habitats; prevention of floods, erosion and sea water intrusion; soil fertility; and religious forests and other values of cultural heritage which serve the public interests. Upon approval and designation of a protection forest, it is the responsibility of the Forest Administration to create a management plan for the area, which is then approved by the Ministry of Agriculture, Forestry and Fisheries (MAFF). Protection forests are permanent forests by definition, but they can also be subjected to reclassification for other uses. Protection forest does not include the protected areas, which are under the jurisdiction of the Ministry of Environment pursuant to the Environmental Protection and Natural Resources Management Law.

Some of Cambodia's forests are privately owned. The Forestry Law guarantees the owners the right to maintain, develop, harvest and sell the products they derive from the

forest, including timber trees.

Some recent forest sector reviews have shown the need to rationalize forest land classification, demarcate and delineate forest areas, and better link forests and forestry to broader land use issues. The Forestry Administration is currently developing the criteria, procedures and technical means to identify and demarcate forested lands which form part of the Permanent Forest Estate areas (Cambodia National Forest Programme 2008).

Legal and policy framework

Legislation

The Forestry Law 2002

The current Forestry Law of 2002 provides the framework for the management, harvesting, use, development and conservation of the forests in Cambodia. According to the law itself, its objective is to ensure the sustainable management of the country's forests for their social, economic and environmental benefits, including conservation of biological diversity and cultural heritage.

The law defines the classification of forest lands, management systems, enforcement, and fiscal and other mechanisms for the regulation of the forestry sector. It sets out basic regulations related to concession management, wildlife management, community forestry and traditional user rights, acknowledging the customary user rights of forest products and by-products for local communities. The law also provides for public participation in the decision-making processes. Furthermore, it requires an Environmental and Social Impact Assessment for any major forest-related activities that may cause significant adverse social and environmental impacts.

Royal Decree on Creation and Designation of Protected Areas (1993)

In November 1993, His Majesty King Norodom Sihanouk issued a Royal Decree (or Kret) on the designation of protected areas in Cambodia. In total 23 protected areas, covering about 3.1 million ha, were established by the decree. These areas belong to four categories – national parks, wildlife sanctuaries, protected landscapes and multiple-use areas – which reflect the different characteristics and management objectives for each area and correspond to international classifications, such as those of the International Union for Conservation of Nature (IUCN; IUCN 1994; Ministry of Environment 2002).

The Protected Area Law 2008

The development of Cambodia's Protected Area Law was initiated in 2001, and the law came into force in 2008. To ensure its applicability to and acceptability by the beneficiaries of protected areas, affected communities and individuals, the preparation process of the law included consultations with participants representing key civil and governmental provincial departments, community representatives at communal and district levels in and adjacent to protected areas, and local non-governmental organizations.

The law defines, among other things, the government organizations involved in the management of protected areas and their responsibilities, the establishment of protected areas or their modifications, assessment of environmental and social impacts, development of management plans, prohibited activities in protected areas, public participation in

decision-making and conservation, the rights of indigenous people, awareness-creating activities, conflict resolution, law enforcement and penalties in case of offences. The law states that the establishment or modification of any protected area should be subject to research results, management objectives, and access rights to resource use.

The Environmental Protection and Natural Resources Law

The Law on Environmental Protection and Natural Resource Management (1996) sets up the basic provision for environmental protection and preservation of natural resources within Cambodia, including important provisions on the requirement for environmental impact assessments. The law calls for the development of a National Environmental Plan, under which regional plans should be developed and reviewed every five years. However, the law primarily focuses on the responsibilities of the Ministry of Environment over issues of pollution control, not protected areas (Cambodia National Forest Programme 2008).

Policies

The forest sector in Cambodia is directed by several national and cross-sectoral strategies. The principle function of sector-related strategies is to support and contribute to the fulfilment of these overall strategies (Cambodia National Forest Programme 2008). The National Strategic Development Plan (NSDP) of Cambodia establishes the overall development course for the country. Within this framework, forestry reform is prioritized on the basis of the development of a National Forest Programme. The NSDP (2006-2010) emphasizes the following aspects of forest conservation and use:

- Sustainable forest management policy
- Protected areas system to protect biodiversity and endangered species
- Community Forestry Program

In addition to the NSDP, Cambodia's Millennium Development Goals outline specific targets related to forests under the overall goal of environmentally sustainable development (TWG Forestry and Environment 2006). The targets are to be reached by the year of 2015.

- Maintaining forest coverage at the year 2000 level of 60% of the total land area
- Maintaining the 23 protected areas at the year 1993 level of 3.3 million ha
- Maintaining the surface of the 6 new forest-protected areas at the present level of 1.35 million ha
- Maintaining the number of rangers in forest protected areas at 500

The main policy documents specific to the forest sector are presented in the following sections.

The Forest Policy Statement

The Statement of the Royal Government of Cambodia on National Forest Sector Policy was signed by the Prime Minister in 2002. The statement provides overall goals in a national and international perspective and serves as an instrument to pursue sustainability in forest management. It sets national objectives regarding the country's forest resources and defines tasks required for attaining these objectives. The following tasks are outlined in the statement for the conservation of forest resources:

- To reclassify and to dedicate the major part of remaining natural forest stands to their ecosystems protection and biodiversity conservation functions

- To promote conservation and protection strategies such as protected forests, watershed management, genetic and wildlife resources conservation, eco-tourism, and special management areas with a maximum participation of the local population
- To implement the strict application of the Code of Practice as regulatory framework for the sustainable management of forest resources and forest concessions
- To conduct extension, education and public awareness campaigns at all levels of the Cambodian society.

National Forest Programme

The Forest Policy statement of 2002 commanded for the preparation of a National Forest Programme (NFP) for Cambodia. The purpose of the programme is to create a social and political framework for the conservation, management and sustainable development of all types of forests, and, thereby, increase the effectiveness and efficiency of public and private operations, funding, and subsequently the contribution of forests to sustainable livelihoods in Cambodia.

The programme comprises policies, strategies and courses of action, as well as mechanisms for their implementation, monitoring, evaluation and updating. It has been prepared in a process of participation and dialogue of varied stakeholder groups, including representatives of government agencies, civil society organizations, private sector and donors (Cambodia National Forest Programme 2008). Currently the programme is being finalized and it should be operational by the end of the year 2009 (TWG Forestry and Environment 2009).

National Biodiversity Strategy and Action Plan

Cambodia ratified the United Nations Convention on Biological Diversity (CBD) in 1995. One of the key obligations for ratifying parties is to prepare a national strategy for biodiversity conservation. Cambodia's National Biodiversity Strategy and Action Plan (Ministry of Environment 2002) was developed as a response to this obligation and to guide the implementation of the convention in the country. The strategy sets general goals and guiding principles for biodiversity conservation, monitoring and evaluation activities. It also analyzes threats and identifies priority activities for different ecosystem types and themes related to biodiversity conservation.

Action Plan 2007-2010 for Forestry and Environment

In 2006, the Technical Working Group on Forestry & Environment under the Forestry Administration formulated an *Action Plan 2007-2010 for Forestry and Environment* (TWG Forestry and Environment 2006). The objective of the plan was to identify and prioritize activities in order to promote the development of the forest sector and its contribution to national strategies and policy objectives. The priorities were agreed by the government agencies and their immediate development partners.

The action plan is the first holistically planned operational translation of the current policy framework (Cambodia National Forest Programme 2008). It consists of reviews of national policies and priorities related to forests, results of interviews with stakeholders, identification of the priorities for the planning period, and the actual plan with a budget. The action plan calls, among other things, for the implementation of a Forest Gene Conservation

Programme which secures seed sources of indigenous trees for tree planting, including rehabilitation of the natural forest.

The Cambodian code of sustainable forest management

The Cambodian code of forest management refers to a set of technical guidelines for the implementation of sustainable practices for forest management in Cambodia (Cambodia National Forest Programme 2008). They include the following:

- The Cambodian Code of Practice for Forest Harvesting
- Guidelines for Forest Concession Management Planning System
- Guidelines for Special Area Management
- Biodiversity Conservation Guidelines for Managed Forests
- Guidelines for Socio-Economic Surveys of Communities Surrounding Forest Concession Areas
- Guidelines for Environmental Impact Assessment for Forest Concessions
- Guidelines for the Evaluation of Environmental Impact Assessment for Forest Concessions.

National Protected Area Strategic Management Plan

The Protected Areas Law 2008 states that the Ministry of Environment shall develop a National Protected Area Strategic Management Plan (NPASMP). The Plan will include the following definitions:

- Current status of natural resources and ecosystems within each zone including flora and fauna species, genetic resources and socio-cultural aspects
- Assessment of the potential contribution of each protected area in achieving the objectives of protection and conservation of biodiversity and natural resources
- Objectives of the conservation, rehabilitation, prevention, suppression of illegal activities, and sustainable use of natural resources and ecosystems within the individual protected area
- Recommended actions for the implementation of management plans for priority protected areas and for the successful achievement of the set objectives.

The Protected Areas Law was enforced only recently, thus the development of the strategic management plans is underway.

International agreements and commitments

Cambodia has ratified several international conventions within natural resource management and conservation. These include the Agreement on the Cooperation for the Sustainable Development of the Mekong River Basin (MRC, 1995), the Convention on Biological Diversity (CBD, 1995), the International Tropical Timber Agreement (ITTA, 1997), the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES, 1997), the Convention Concerning the Protection of the World Cultural and Natural Heritage (1992), and the process of the United Nations Forestry Forum (UNFF). Cambodia is a member of the Association of Southeast Asian Nations (ASEAN) and is, thus, bound by its agreements, particularly the Agreement on the Conservation of Nature and Natural Resources (1995; Cambodia National Forest Programme 2008).

Institutional framework

The Forestry Administration (FA) under the Ministry of Agriculture, Forestry and Fisheries (MAFF) is the lead institution for conservation and management of forests, including their genetic resources, in Cambodia. It manages the resources in accordance with the National Forest Sector Policy and the Forestry Law. Reforms within the Forestry Administration (FA) have established a new organizational structure, where conservation of forest genetic resources is integrated in the planning processes and guidelines at decentralized levels (Sok Srun 2008).

The Technical Working Group for Forestry and Environment (TWG-F&E) provides a mechanism for the coordination of government and donor activities in supporting and strengthening development within the sectors of forestry and environment. The working group acts as a forum for discussion on the conservation, planning and management of forest genetic resources at national level. It is also a channel for distributing resources to different activities within the framework of the forestry action plan (Sok Srun 2008).

The Department of Nature Conservation and Protection of the Ministry of Environment (MoE) is responsible for the conservation of forests within protected areas under its jurisdiction.

In summary, a fairly comprehensive policy, legislative and institutional framework for the forest sector is to a large extent in place in Cambodia. However, this framework has yet to be translated into operational policy guidelines for practice in general. The Cambodian code for sustainable forest management is an example of such guidelines, but it is, however, largely limited to concession management (Cambodia National Forest Programme 2008). The Action Plan 2007-2010 for Forestry and Environment (TWG Forestry and Environment 2006) was the first holistically planned translation of the current policy framework to practice. It is soon to be followed by the implementation of the National Forest Programme, and hopefully by other similar efforts in the future.

Protected areas system

Protected areas in Cambodia cover in total 3.3 million ha or 18.2% of total land area of the country. The Protected Area Law categorizes the protected areas into several categories: national parks, wildlife sanctuaries, protected landscapes, multiple use areas, Ramsar sites for the protection of wetlands, biosphere reserves, natural heritage sites, marine parks, wetlands and other areas, and provincial or municipal protected areas. Specific objectives for the management are defined for each of these types by the law. Majority of the protected areas were designated by the Royal Degree of 1993 (Table 3). In addition to the existing seven national parks, preparations for the demarcation of the new Botum Sakor National Park were initiated in 2008 (TWG Forestry and Environment 2009).

In addition to the aforementioned protected areas, six protected forest areas, covering in total 1 350 000 ha, have been established in Cambodia (Table 4; Ministry of Environment 2009). They mainly cover lowland evergreen forests and wetlands and are classified under the IUCN categories II and IV of protected areas. Cambodia has 82 Community Protected Areas for the conservation and management of forest and fisheries, and in 2008 the Ministry

of Environment initiated the preparations for the establishment of 10 new such protected areas (TWG Forestry and Environment 2009). Altogether the existing protected areas and protected forests cover over 26% of Cambodia's land area.

Table 3. Areas protected by the Royal Degree of 1993 (Ministry of Environment 2009)

Type	No.	Area (ha)	IUCN category*	Main ecosystems covered
National park	7	742 300	II, IV	Lowland evergreen forest; also coastal forest, mangroves, *Dacrydium* or *Podocarpus* sp. forests, swamp forests; coral reefs and seagrass
Wildlife sanctuary	10	2 030 000	II, IV	Evergreen forest, mangroves; coral reefs
Protected landscape	3	9 700	V	Lowland evergreen forest
Multiple use area	3	403 900	VI	Flooded forest, mangrove and coastal wetland
Total	**23**	**3 185 900**		

* IUCN 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. Protected forests (Forestry Administration 2003).

Name	Province or municipality	Year design.	Area (ha)
Ang Trapeang Thmor Sarus Crane Conservation Area	Banteay Meanchey	2000	12 650
Protected Forest Mondul Kiri for Genetic Resources and Wildlife Conservation	Mondul Kiri	2002	429 440
Protected Forest Preah Vihear for Genetic Resources and Wildlife Conservation	Preah Vihear	2002	190 030
Protected Forest Cardamom for Watershed and Biodiversity Conservation	Koh Kong, Pursat, Kg Speu	2002	401 310
Seima Biodiversity Conservation Area	Mondul Kiri, Kratie	2002	305 440
Southern Cardamon	Koh Kong	2004	144 275

The Protected Areas Law divides Cambodia's protected areas into four zones:

(i) The core zone is a significant area for conserving endangered and threatened species of flora and fauna and ecosystems there are vulnerable. Access to these areas is prohibited.

(ii) The conservation zone is in the vicinity of the core zone. It is valuable in conserving natural resources, ecosystems, watersheds, and aesthetic beauty. Access to the area is restricted. Small-scale collection and use of non-timber forest products may be allowed under strict control to support the livelihoods of local ethnic minorities, provided that the activities do not present serious adverse impacts on biodiversity within the zone.

(iii) The sustainable use zone is a managed area significant for national socio-economic development. It may be managed for the purposes of national cultural and heritage values, ecotourism, wildlife conservation and recreational services,

biological rehabilitation, infrastructure development (including irrigation, reservoir, hydro-electricity and electric networks), mining, or as community protected area or botanic garden.

(iv) The community zone is an area managed for supporting the existing social and economic development activities of the local and indigenous people. The zoning is based on the criteria of management objectives, potential values of the natural resources, socio-economic and cultural implications, carrying capacity of the natural resources, and geographical location of the area (Cambodia National Forest Programme 2008).

Unfortunately, several protected areas are still subjected to unrestricted grazing by livestock, unmanaged fishing, illegal logging, collection of fuel wood and non-timber forest products, and habitat degradation and disturbance resulting from other human activities. The government of Cambodia realizes that these issues can be best addressed through the development and implementation of management underpinned by the participation of local communities (Ministry of Environment 2002). This recognition is reflected in the attention given to public and community participation in legislation and policies related to natural resources.

Conservation and management practices related to forest genetic resources

National forest gene conservation strategy and programme

A number of strategies and plans have addressed the conservation of forest genetic resources in Cambodia, especially since the early 2000s. In particular, implementation of forest gene conservation was supported by the Cambodia Tree Seed Project (CTSP, 2001-2006)[2], funded by the Danish International Development Assistance (DANIDA). The objective of the project was to encourage the conservation of genetic resources of endangered, indigenous forest tree species through promoting their use in tree planting programmes. The project emphasized the linkages between these specific targets and the general objectives of poverty reduction and sustainable development. Encouragement of tree planting helps, for example, to supply the people's needs for fuel wood while also reducing the pressure on natural forests.

With the support of the CTSP project, a National Forest Gene Conservation Strategy was formulated for Cambodia and launched in December 2003 (CTSP, FA and DANIDA 2003a). The strategy identifies and prioritizes endangered tree species and defines conservation methods, required management plans and protection measures. Its implementation ensures that seed and planting material of desired tree species are available when needs for species planting arises in the country.

The strategy defines *in situ* conservation of forest genetic resources as the principal conservation method. Participatory approach is essential for the success of *in situ* conservation, and conservation efforts should, therefore, be integrated with local development efforts. For example, some of the gene conservation or seed source areas established during the CTSP project are managed by local communities. Furthermore, it is necessary to complement *in situ* conservation with *ex situ* conservation activities, for example by establishing gene conservation stands. *Ex situ* is a more expensive approach to conservation, yet effective especially in remote areas or in areas experiencing rapid forest loss and degradation (CTSP, FA and DANIDA 2003a).

[2] For more information on the CTSP, see the project website at http://www.treeseedfa.org/.

The major activities included in the preparation of the national strategy and supported by the project were the identification of priority species, gene ecological zones, definition of the needs for gene conservation stands and their distribution, and establishment of the conservation stands. A multi-disciplinary working group was established to develop the strategy, involving representatives of the Forestry Administration, the Ministries of Health and of Environment, universities, the WWF and the International Union for Conservation of Nature (IUCN).

Based on available information, potential uses of species and conservation criteria of the IUCN, the working group identified 34 indigenous endangered or threatened species as priority species for conservation activities (Table 5). Furthermore, empiric data and experience on these species was collected and analyzed based on a comprehensive literature search, workshops and working sessions with selected experts. As a result, monographs for 21 most important priority species were compiled which included information on the distribution and habitat, ecological zonation, botanical description, flowering and fruiting habits, fruit and seed description, seed handling, sowing and germination, current conservation status, uses and IUCN classification. This kind of information is crucial for designing effective conservation strategies for the species (Conservation of valuable and endangered…2006).

Table 5. Priority tree species for gene conservation in Cambodia. For threat level of the species, 5 denotes the most and 1 the least threatened species. (Conservation of valuable and endangered…2006).

Species	Threat level	Species	Threat level
Dalbergia oliveri Gamble ex Prain	5	*Sterculia lychnophora* Hance	4
Aquilaria crassna Pierre	5	*Cananga latifolia* Finet & Gagnep.	4
Dalbergia cochinchinensis Pierre *	5	*Albizia lebbeck* (L.) Benth.	4
Gardenia angkorensis Pit.	5	*Hopea odorata* Roxb.	4
Afzelia xylocarpa (Kruz.) Craib *	5	*Tarrietia javanica* Blume	3
Pterocarpus macrocarpus Kurz. *	5	*Diospyros pilosanthera* Blanco	3
Dysoxylum loureiri Pierre	5	*Hopea ferrea* Lanessan *	3
Diospyros crumenata Thwaites	5	*Xylia dolabriformis* Benth.	3
Lasianthus kamputensis Pierre ex Pit.	5	*Fibraurea tinctoria* Lour.	3
Diospyros bejaudii Lecomte	4	*Shorea hypochra* Hance *	3
Fagraea fragrans Roxb. *	4	*Shorea vulgaris* Pierre ex Laness.	3
Dasymaschalon lomentaceum Finet & Gagnep	4	*Diospyros nitida* Merr.	3
Shorea cochinchinensis Pierre	4	*Cassia garretiana* Craib	2
Hopea helferi Brandis	4	*Dipterocarpus alatus* Roxb. G. Don	2
Pinus merkusii Jungh & de Vriese	4	*Anisoptera costata* Korth.	2
Garcinia hanburyi Hook.f.	4	*Melanorrhoea laccifera* Pierre	2
Cinnamomum cambodianum Lecomte	4	*Artocarpus chaplasha* Roxb.	1

* Gene conservation stands exist, see table 6.

A system for gene ecological zonation for Cambodia was created using a variety of environmental data collected within and around the country. Gene ecological zones are defined so that each zone exhibits fairly uniform ecological conditions and a limited degree of gene flow with the surrounding regions. Similarity in the genetic constitution of flora within the zone can, therefore, be expected. For satisfactory results, it was decided that the zonation in Cambodia be based on the following attributes: annual rainfall, length of dry seasons, temperature of the coldest month, soil type and fertility, and vegetation and land use (Conservation of valuable and endangered…2006). The zonation model provides an extremely useful tool for the planning of an effective gene conservation network in which the

genetic diversity within species is adequately represented (Sok Srun 2008). It can be applied e.g. for the purposes of determining seed availability, matching seed sources to planting sites, planning of tree improvement activities, botanical studies and establishing extension or education plots (Conservation of valuable and endangered…2006).

Strategies for selecting stands for gene conservation and seed sourcing were formulated based on the species conservation status and biology, the gene ecological zones, land tenure issues and other related aspects. Criteria for stand selection are explained in detail in the project documents (Conservation of valuable and endangered…2006; see also FAO, DFSC and IPGRI 2001). Currently, 20 high value tree species, including 6 priority species, are conserved at 16 different gene conservation stands (Table 6). The stands cover a total area of 691 ha and are distributed within 6 of the 10 gene ecological zones. Five species are conserved in more than one gene ecological zone (Conservation of valuable and endangered…2006).

The National Forest Gene Conservation Strategy served as a basis for the development of a National Forest Gene Conservation Programme, which provides the framework for the conservation and sustainable use of tree species in Cambodia. In particular, the objective of the programme is to ensure the conservation of endangered, economically valuable and indigenous tree species populations, and secure the availability of quality planting materials which is fundamental to the success of future tree planting and improvement. The gene conservation programme is linked to the National Forest Programme under preparation, and the implementation of the programme was also included in the Forestry Action Plan 2004–2008. The broader implementation of the gene conservation programme requires additional funding, and it has been allocated a high priority within the Forestry Administration (Sok Srun 2008).

Table 6. Species on gene conservation stands in Cambodia (Conservation of valuable and endangered…2006). Note that several species are conserved together on some stands, the total number of stands being 16.

Species	Stands	Total area (ha)	Mother trees marked
Afzelia xylocarpa *	2	38	53
Anisoptera glabra	1	117	323
Azadirachta indica	1	50	90
Dalbergia bariensis	6	186	263
Dalbergia cochinchinensis *	2	69	147
Dipterocarpus alatus	1	20	43
Dipterocarpus costatus	1	117	396
Fagraea fragrans *	1	104	72
Haldinia cordifolia	1	100	62
Hopea ferrea *	1	30	88
Pinus merkusii	1	104	72
Pterocarpus macrocarpus *	5	177	310
Scaphium macropodum	1	10	78
Shorea guiso	1	117	19
Shorea hypochra *	1	117	22
Sindora cochinchinensis	5	352	273
Tarrietia javanica	1	117	39
Toona sureni	1	4	26
Xylia xylocarpa	2	121	163

* National priority species, see Table 5.

National forest programme

The National Forest Programme of Cambodia includes a sub-programme for the conservation of forest genetic resources through their sustainable management and use. The programme is implemented through collaborative partnerships with local communities. The activities conducted under the sub-programme include the following:

- Identify and establish *ex situ* and *in situ* forest gene conservation stands
- Integrate monitoring and management of conservation stands in local forest management plans
- Establish field demonstrations of tree improvement through the use of quality planting material from the conservation stands
- Initiate tree improvement and tree breeding of selected species
- Create awareness of the importance of using quality seed
- Demonstrate use and non-use values of the indigenous tree species
- Develop sales and marketing systems to enhance local income from seed sources.

Expected results of the sub-programme include an effective conservation of populations of rare or valuable tree species in a network of conservation stands, increased availability of high quality planting material for forest rehabilitation and afforestation activities, mechanisms for the sharing of benefits of forest management and seed sales with participating communities, and increased awareness of the economic and ecological attributes of the native species promoted (National Forest Resource…2009).

In addition, a sub-programme of multi-purpose tree plantations is involved in identifying suitable tree species for multi-purpose plantations and developing nurseries in order to ensure a stable supply of locally suitable quality seedlings. The general objective of the sub-programme is to enhance the potential of domestic timber supply, increase incomes of local communities, and improve the environment through watershed protection and erosion control (National Forest Resource…2009).

Ex situ conservation initiatives

The application of quality germplasm is fundamental for the successful implementation of tree breeding and planting programmes and initiatives. It is directly linked to the production of high quality trees and tree products, which attract higher market prices (Sok Srun 2008). In order to improve the availability of indigenous seed sources, a demonstration plot for *ex situ* conservation, seedling orchard and awareness raising was established in Khbal Chhay in Sihanoukville in 2003. The project has been supported by the Government of Denmark as a part of the Cambodia Tree Seed Project.

Activities carried out in the area include the establishment of a 10-ha seed orchard, provenance trials for 4 species, and studies of direct seeding for 6 indigenous species (Sok Srun 2008; So Thea 2006a). The trialed species include the valuable and endangered indigenous species of *Dipterocarpus turbinatus*, *Aquilaria crassna*, *Hopea odorata, Afzelia xylocarpa, Shorea vulgaris* and *Tarrietia javanica*. Seeds for the studies were collected from identified mother trees in natural forests (CTSP, FA and DANIDA 2003b). The individual plots are regularly measured and the data recorded in a computer database. Preliminary results from the trials already illustrate that native species are able to grow quickly and healthily in open areas. In addition, a number of laboratory tests have been conducted for seed collection, handling and storage techniques and germination tests (Sok Srun 2008).

A species elimination trial with 21 tree species has been conducted in the Khbal Chhay as a basis for tree planting programmes. These species included are *Afzelia xylocarpa*, *Aquilaria crassna*, *Archidendron quocense*, *Azadirachta indica*, *Cassia fistula*, *C. siamea*, *Dalbergia*

bariensis, *D. cochinchinensis*, *Dipterocarpus alatus*, *D. retusus*, *Hopea recopi*, *H. odorata*, *Irvingia malayana*, *Khaya senegalensis*, *Leucaena leucocephala*, *Peltophorum dasyrrhachis*, *Pterocarpus macrocarpus*, *Shorea guiso*, *Sterculia lychnophora*, *Syzygium cumini* and *Tarrietia javanica*. In consideration of growth performance and survival rates three years after planting, the recommended species for tree planting are *Dalbergia cochinchinensis*, *Hopea odorata*, *Khaya senegalensis* and *Peltophorum dasyrrhachis*. All these species are fast-growing and their survival rates in plantations were high. If those seedlings are not available, *Aquilaria crassna*, *Cassia siamea*, *Hopea recopi*, *Pterocarpus macrocarpus* and *Tarrietia javanica* are recommended for plantation as second choice (Moy Ratha 2008).

Other conservation initiatives

Recent initiatives and projects for the conservation and sustainable use of forest genetic resources have been realized or planned with the support from international development agencies and international and civil society organizations. These include the following:

- A project for the strengthening of capacities and regional collaboration in forest gene conservation, funded by the International Tropical Timber Organization (ITTO, 2006-2009). The project is being conducted with the support from the Asia-Pacific Association of Forestry Research Institutions (APAFRI) and Bioversity International.
- Community Based Forest Gene Conservation (2006-2008) project with the support from the Danish Government. The project was designed to address the threats to forest species, lack of market places for tree seeds and lack of awareness about the importance of seed quality. The activities included establishment of *in situ* and *ex situ* conservation stands in collaboration with local communities, assisting them in establishing and managing demonstration plots of tree improvement and direct seeding, and in developing marketing strategies for the products (So Thea 2006b).
- Biodiversity Conservation Corridors Initiative (BCCI), funded by the Asian Development Bank (ABD). Two pilot projects are carried out in Cambodia, one in the Cardamom Mountains and the other in the Eastern Plains. The objectives include restoration of ecosystem connectivity, harmonization of land management and governance regimes, and capacity building.
- Several recent or ongoing research, capacity building and training projects funded by Darwin Initiative. These include the establishment of a forest restoration research unit in the Province of Siem Reap to facilitate biodiversity recovery (2009-2011). The project will establish an experimental tree nursery, a phenology trail to study the reproductive ecology of forest tree species, and train project staff in the collection and storage of tree seeds, developing effective tree propagation techniques, and establishing field trial plots for studies of species performance [3].
- Activities and case studies by the Community Based Natural Resource Management Learning Institute[4] who works with partners to analyze and improve its approach as an integral component of poverty alleviation, sustainable livelihoods and resource management, conservation, and decentralization policies and strategies of the Royal Government of Cambodia.

The National Forest Gene Conservation Programme allows flexibility and dynamism in conducting separate projects related to forest genetic resources. Programme components can be added to it and implemented in a coordinated manner. Further international collaboration

[3] For more information, see http://darwin.defra.gov.uk/world/country/Cambodia/
[4] For more information, see the organizations website: http://www.cbnrmli.org/english.html

and future initiatives should be integrated into the programme to harmonize the objectives and activities of governments, donors and partnerships. Opportunities for collaboration include capacity building in the management and use of non-timber forest products by communities, and regional cooperation and support for the research of *ex situ* conservation, such as seed orchards, provenance trials and trials of species elimination (Sok Srun 2008).

Public participation

Participatory approaches to natural resource management have the potential to contribute to poverty reduction through improved resource management and creation of sustainable livelihoods. Their importance in providing subsistence and simultaneously addressing deforestation and forest degradation are widely recognized in the legal and political framework of forest resource management in Cambodia. The National Forest Gene Conservation Strategy (CTSP, FA and DANIDA 2003a) identifies participatory approaches as essential for *in situ* conservation. As detailed in the previous chapters, participatory approach, and in particular community involvement, are integral parts of many conservation and management activities of forest genetic resources throughout the country. Stakeholders of these processes may include for example local communities, ethnic minorities, small landowners, private entrepreneurs, companies exporting forest products, and the international community for whom the forests provide environmental services and conservation of biodiversity (Cambodia National Forest Programme 2008).

The government of Cambodia has recognized that participation is far more than instrumental involvement of people in consultations, projects and activities. Instead, true participation signifies a more fundamental involvement in decision-making, e.g. participation in the policy processes, setting priorities and designing programmes. Clauses that permit and expect public participation in the planning processes have been increasingly included in the legal framework in the recent years. However, further efforts are required to standardize these practices. Currently, the power in the decision-making process is still mainly distributed throughout the government machinery such as ministries, various committees and councils, and interests of some powerful stakeholders may dominate the process. The transparency of planning and decision-making should be further strengthened to guarantee equal opportunities for the participation of different stakeholders (Cambodia National Forest Programme 2008).

As to participatory approaches in the actual practices of forest conservation, it should be noted that the efforts can only be sustained if the participants themselves perceive clear benefits for their efforts. Conservation of forest genetic resources is unlikely to provide large, direct monetary benefits to local communities. Conservation activities should, therefore, be integrated into wider forestry-related activities, such as the establishment of gene conservation areas within community forests. This would provide a wider buffer for the protection of the forest genetic resources while securing access to a range of non-timber forest products for communities. In addition to the rights of access to and use of forests, further attention should be paid to devolving responsibilities, removing barriers to market entry and creating other enabling conditions in order to overcome the existing constraints to sustained livelihoods (Sok Srun 2008).

Public awareness on biodiversity issues is mainly raised through activities of environmental education and awareness campaigns. Although they are not explicitly included in the education curricula of primary and secondary schools, the education policy opens opportunities for the mainstreaming of relevant social and environmental issues.

Conservation and sustainable use of biodiversity is among the themes most welcomed by the Ministry of Education, Youth and Sports to be integration in education programmes. Teacher's guidebooks and students' manuals on biodiversity-related issues have been developed under various initiatives and are used in schools haphazardly throughout the country (Ministry of Environment 2009).

Awareness campaigns are undertaken on semi-regular basis by the Department of Environmental Education and Communications of the Ministry of Environment, several other ministries, non-governmental organizations, academic institutions and provincial authorities. The campaigns often include television spots and radio shows. Specific campaigns are organized around the National and International Environment Day, National Arbor day and other similar occasions. While such education and awareness campaigns focus mainly on students and general public, newsletters targeting decision and policy makers and practitioners are also produced under some project activities (Ministry of Environment 2009).

Capacity building, education and training

Major institutions involved in the management of natural resources and the related training include the Forestry Administration and the Ministry of Environment, the provincial government departments, the Royal University of Phnom Penh, the Royal University of Agriculture, the Prek Leap National School of Agriculture and the Kampong Cham National School of Agriculture. The universities offer master's degree in biodiversity conservation and related fields. In addition, there are approximately 100 non-governmental and international organizations working on research, development and capacity building issues in nature conservation and management in Cambodia (Ministry of Environment 2009).

Because of the numerous programmes and initiatives, especially since the early 2000s, the capacity of government agencies and stakeholders to get involved in and act on the conservation of forest genetic resources has increased significantly in Cambodia (Cambodia National Forest Programme 2008). For example, the Cambodia Tree Seed Programme alone organized over 200 courses and trainings, including specific technical courses on forestry and tree improvement, general methodological courses on project management and informatics, and policy formulation and attitudinal courses. These training events were attended by in total 1850 local and national and over 100 international participants (Forestry Administration and DANIDA 2005).

Capacities need, however, to be further raised among government officials, communes, communities, civil society organizations and the private sector. This was shown for example by an assessment of the capacity needs of the natural resources sector which was conducted under the Cambodia Tree Seed Project (Forestry Administration & DANIDA 2005). The assessment examined capacity issues in a wide sense, including aspects of technical skills, capabilities for research and planning, participation, organizational issues, transparency and accountability. The objectives were to assess the qualification and number of personnel needed for natural resource management, the capabilities of the existing educational and training institutions to meet these needs, and identify the gaps between these two.

The assessment revealed serious needs for capacity development in analytical capacity, institutional knowledge and specific fundamental topics within mainstream natural resource management in the evaluated institutions. It concluded critically that the impact of contemporary development projects on capacities is often very limited, generally because they rarely focus on capacity building but rather see it as an automatic by-product of other

activities. Especially the impact of the prevalent, short training courses was questioned. The assessment also called for the need to critically assess traditional leadership structures and to give way to more dynamic and integrated management approaches (Forestry Administration and DANIDA 2005).

Recently, a national report to the Convention on Biological Diversity (Ministry of Environment 2009) highlighted capacity development needs in the environmental sector. According to the report, the Ministry of Environment is not yet adequately empowered as the lead agency in the conservation and sustainable use of biodiversity. Dissemination of information between the ministry and other relevant agencies should be improved to support planning and decision-making processes. Attention should be paid to adequate human resources, especially at provincial and local levels. Furthermore, traditional knowledge on conservation and sustainable use of biodiversity should be better documented. Limitations of funding restrict the capacity of researchers to provide information on e.g. species and ecosystems, effectiveness and economic valuation of conservation areas.

The role of capacity building is emphasized even more in the future, when responsibilities for the management of natural resources are to be increasingly transferred from the central government organizations to regions, communities and other stakeholders in the process of decentralization. In order to attain international standards in sustainable management of natural resources, financial and technical assistance is still crucial. As one initiative to address the capacity needs, the newly formulated National Forest Programme includes a sub-programme on capacity building. It includes the identification of the needs for capacity development among different stakeholders. The programme considers capacities beyond the traditional activities of training and extension, and evaluates also the aspects of accountability, efficiency, skill development, conflict resolution and information systems (Cambodia National Forest Programme 2008).

Identification of national priorities for future work

A national Consultative Workshop on Forest Genetic Resources Conservation and Management in Cambodia was organized on 12 February 2008. The main objectives of the workshop were to review and develop the conservation and management strategies for Cambodia. The workshop was attended by 32 participants from central and regional forestry administration offices (Chann Sophal 2009).

The workshop participants discussed the research and development needs for the conservation of forest genetic resources, and the required actions for addressing them. Identified needs included basic research and knowledge of the resources; evaluation of the status of the resources; analysis and compilation of existing information; examination and enhancement of linkages between policy, science and technology; extension services; support to activities from stakeholders and local administrative governors; organization of more workshops, seminars and study tours for discussions and dissemination of information; and technical and financial support.

The processes and activities which were identified to support the achievement of these research and development targets included government's commitment; identification of stakeholders; strengthening partnerships between public and private sectors; collaboration at national, regional and international levels; sharing of information and formation of cooperative networks.

Capacity and training needs identified by the workshop participants included training for regional foresters, local administrative governors, communities and private sector; organization of workshops, seminars and extension services at community level; and

inclusion of forest conservation and management issues in the curricula of schools. The specific training needs mentioned by the participants included management of natural stands, selection of mother trees, seed procurement and storage, and tree planting. Moreover, training on the strategies for reducing encroachment of farm land and solving disputes in forest resource management was viewed necessary (Chann Sophal 2009).

National priority species for the conservation of forest genetic resources were identified by a national workshop involving multiple stakeholders during the Cambodia Tree Seed Project (see Table 5).

Conclusion

As demonstrated by the recent policy development, the Royal Government of Cambodia has recognized the fundamental importance of conserving the biological diversity of the country's forest resources. Conservation of forest genetic resources is crucial in ensuring that the rural population and the national economy may benefit from the continuous use of indigenous tree species, whether in meeting the objectives of timber production or livelihood benefits, such as agroforestry, living fences, home gardens and fuel wood. Furthermore, the non-monetary values and environmental services of forest gene conservation, such as watershed protection, erosion control and natural heritage are equally important in meeting the interests of the Cambodian society and its future generations (Sok Srun 2008).

Thanks to the political support by the government and the numerous efforts and initiatives of the recent years, the frameworks of policy, legislation and institutional mechanisms for the forest sector in Cambodia are already fairly comprehensive. Nevertheless, a lot of work is still required for translating this framework to operational policy guidelines. The Action Plan for Forestry and Environment (2007) and the National Forest Programme (2009) represent first such efforts to achieve this end. In addition, the capacities among the government and other public institutions as well as the various stakeholders of the forestry sector should be further enhanced, and the continuity of financial and technical assistance secured also in the coming years. These activities are crucial in order to ensure that the already fairly extensive efforts for the conservation and management of forest genetic resources are not wasted but can be taken full advantage of to further protect the resources of the country and benefit its people in the long term.

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Conservation and management of forest genetic resources in India

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Forest genetic resources (FGR) are one of the most important components for sustainable forestry and food and fodder security. In general, FGR include plant species that do not only provide food, fodder and medicine but also are a source of shelter, energy, environmental protection and other supports to the livelihood. These resources are in imminent danger because of adverse abiotic and biotic stresses resulting from urban expansion, infrastructure development, agriculture and global warming. Conservation and management of forest genetic resources would be essential for sustainable development and adaptation to the changing environment.

India is a distinct geographical entity in the South Asian region. It is situated between latitudes 8°N and 37°N and longitudes 68°7'E and 97°2'E and shares international borders with Pakistan, Afghanistan, China, Nepal, Bhutan, Myanmar and Bangladesh. With its population of over 1.00 milliard (16% of the world's population), it is the second largest nation in terms of population and the largest democratic republic of the world. India is also home to 18% of the world's domestic cattle with the population of about 500 million animals. A land frontier of 15 200 km and a coastline of 6100 km specify India's position as the seventh largest country in terms of area (3.29 million sq. km in 1991). The country accounts for approximately 2.5% of the world's land surface area and 1.8% of the world's forest area. The geographical features and land forms of the country are as varied as its extent: the towering Himalayas; the extensive river plains such as Ganga and Deccan in the north, centre and south; the coastal plains or ghats to the east and west and the numerous islands.

Floristically India is extremely rich. Its botanical wealth consists of over 15 000 species of higher plants, of which approximately 4900 species or 33% are endemic. There are about 141 endemic genera distributed over 47 families (Nayar 1980). The largest proportion of species is localized in the Himalayas (about 2532 species), followed by the peninsular tract (1788 species), and the Andaman and Nicobar Islands (185 species). Floristic richness is estimated to be maximal in the north-eastern region which holds about 50% of India's total species diversity, i.e. more than 7000 species, and is considered as the cradle of flowering plants. Of the 990 species of orchids worldwide, 700 species occur in this region (Nayar 1989).

India is divided into 10 biogeographic regions, namely the Trans-Himalayan, the Himalayan, the Indian desert, the semi-arid zones, the Western Ghats, the Deccan Peninsula, the Gangetic Plain, Northeast India, and the islands and the coasts (Rodgers and Panwar 1988). Based on physiographic, climatic and cultural features, the Indian Council of Agricultural Research (ICAR) recognised 8 agro-climatic regions (Murthy and Pandey 1978), while recently, further micro-climatic considerations pinpoint to 21 such regions (Sehgal *et al.* 1990). Also, the Planning Commission has demarcated the country into 15 agro-climatic zones (Sehgal *et al.* 1990). The land use classification of India is presented in Table 1.

Table 1. Land use in India (Ministry of Agriculture 2003).

Land use	Area (1000 ha)	% of land area
Total geographical area	328 730	
Reporting area for land use	306 050	100
Forests	69 020	22.6
Not available for cultivation	42 410	13.9
Permanent pasture and grazing land	11 040	3.6
Land under miscellaneous tree crops and groves	3 620	1.2
Culturable wasteland	13 480	4.5
Fallow land and other than current fallows	10 110	3.3
Current fallows	14 800	4.8
Net area sown	141 230	46.1

Forestry and agriculture are the two most important land uses in the country, the latter competing with the former under the relentless pressure of an ever-increasing population, which between 1951 and 2001 almost tripled from 361 million to 1028 million. The per capita availability of forests has, thus, declined to a poor 0.08 ha, one of the lowest in the world. The existing land use pattern suggests that there is a good possibility to achieve the goal of the National Forest Policy (1988) of bringing one-third of the area under forest cover through greening culturable wasteland, current fallows and other fallow lands in the coming years.

Status of forest genetic resources in India

India is a country of diversity, with diverse geographical features and varied climates. The diversity in physical and climatic setting produces a markedly diverse fauna and flora. India encompasses a wide spectrum of habitats from tropical rainforests to alpine vegetation and from temperate forests to coastal wetlands. The vegetation ranges from xerophytic in Rajasthan, evergreen in the north-east and the Ghat areas, mangroves of the coastal areas, conifers of the hills and the dry deciduous forests of central India, to alpine pastures in the high reaches of the Himalaya.

India is one of the eight centres of origin of cultivated plants (Vavilov 1951) and one of the 12 mega gene centres of the world, possessing 11.9% of world flora. About 33% of the country's recorded flora is endemic to the region and is concentrated mainly in the Northeast, the Western Ghats, the North West Himalayas, and the Andaman and Nicobar islands. In an identification of biodiversity hotspots carried out in the 1980s, 2 hotspots out of the total 18 worldwide were localized in India, namely the Western Ghats and the Eastern Himalayas (Myers 1988). Recently, Myers *et al.* (2000) brought out an updated list of 25 global biodiversity hotspots, areas featuring exceptional concentration of endemic species and experiencing exceptional loss of habitat. This classification also has two hotspots that extend into India: the Western Ghats – Sri Lanka region and the Indo-Burma region (covering the Eastern Himalayas). They are included amongst the top eight most important hotspots worldwide. In addition, India has 26 recognized endemic centres that are home to nearly one third of all the flowering plants identified and described to date. Katwal *et al.* (2003) have given a brief account of the status of forest genetic resources, their conservation and management in India. This report summarizes the status of conservation of forest genetic resources in 2008.

Forest cover and classification

The forests of India have been grouped into 5 major categories and 16 groups according to biophysical criteria. Among the most important groups are the subtropical dry deciduous, tropical moist deciduous, tropical thorn and tropical wet evergreen forests (Table 2). Other categories include subtropical pine, tropical semi-evergreen forests and other smaller categories. Temperate and alpine areas cover about 10% of the forest area in the Himalayan region. The estimates of forest area by forest type are given in Table 4.

About 60% of forests in India are located in ecologically sensitive zones, e.g. the Himalayas, the Western Ghats, the mountain areas, and the arid and semi-arid tracts. The growing stock and productivity of the country's forests are very low because of heavy biotic pressures of overgrazing, excessive lopping and extensive fire damage. The average growing stock is only 65 m^3/ha and the average annual growth of forests 0.7 m^3/ha. The potential productivity calculated from sample plots exceeds many times the actual production. Most of the forest areas are capable of producing yields significantly higher than their present production.

Table 2. Forest cover in India (FSI 2005).

Class	Area (1000 ha)	% of land area
Very dense forest (canopy density >70% of land area)	5 460	1.7
Moderate dense forest (canopy density 40-70%)	33 260	10.1
Open forests (canopy density 10-40%)	28 990	8.8
Total forest cover	67 710	20.6
Scrub (stunted trees, canopy density <10%)	3 850	1.2
Not forested	257 170	78.2
Total geographical area	**328 730**	**100.0**

Table 3. Mangrove cover in India. Change refers to change in area since the assessment of the year of 2003 (FSI 2005).

State/UT	Mangrove type (ha)			Total (ha)	Change (%)
	Very dense	Moderately dense	Open		
Andhra Pradesh		1 500	31 400	32 900	0
Goa		1 400	200	1 600	0
Gujarat		19 500	74 100	93 600	20
Karnataka		300		300	0
Kerala		300	500	800	0
Maharashtra		5 800	10 000	15 800	0
Orissa		15 600	4 700	20 300	0
Tamil Nadu		1 800	1 700	3 500	0
West Bengal	89 200	89 500	33 100	212 000	-2
Andaman & Nicobar	25 500	27 200	11 000	63 700	-21
Daman & Diu			100	100	0
Pondicherry			100	100	0
Total	**114 700**	**162 900**	**166 900**	**444 500**	**-3**

Mangrove forests

The current assessment shows that mangrove cover in the country is 445 000 ha, which is 0.14% of the country's total geographical area (Table 3). The very dense mangrove covers an area of 115 000 ha (25.8% of total mangrove cover), moderately dense mangrove an area of 163 000 ha (36.6 %), while open mangrove covers and area of 167 000 ha (37.6 %). Compared with the assessment of the year of 2003, there has been a marginal decrease in mangrove cover, mainly because of the tsunami which hit the Andaman and Nicobar Islands on 26 December 2004. Gujarat has also shown an increase in mangrove cover mainly because of plantations and protection measures (FSI 2005).

Table 4. Forest ecosystems in India and their distribution (FSI 1995).

Forest type	Area (1000 ha)	% of forests	Occurrence in states and union territories (UTs)
Tropical wet evergreen forest	4 500	5.8	Arunachal Pradesh, Assam, Karnataka, Kerala, Mizoram, Manipur, Nagaland, Tamil Nadu, Sikkim, Andaman & Nicobar Islands, Goa
Tropical semi-evergreen forest	1 900	2.5	Assam, Karnataka, Kerala, Maharashtra, Nagaland, Orissa, Tamil Nadu, Sikkim, Andaman & Nicobar Islands, Goa
Tropical moist deciduous forest	2 330	30.3	Andhra Pradesh, Bihar, Gujarat, Assam, Karnataka, Kerala, Maharashtra, Nagaland, Mizoram, Tripura, Meghalaya, Uttar Pradesh, West Bengal, Orissa, Tamil Nadu, Sikkim, Andaman & Nicobar Islands, Goa
Littoral and swamp forest	700	0.9	Andhra Pradesh, Gujarat, Maharashtra, Orissa, Tamil Nadu, West Bengal, Andaman & Nicobar Islands
Tropical dry deciduous forest	2 940	38.2	Andhra Pradesh, Bihar, Gujarat, Harayana, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Jammu & Kashmir, Maharashtra, Orissa, Punjab, Rajasthan, Tamil Nadu, Uttar Pradesh
Tropical thorn forest	5 200	6.7	Andhra Pradesh, Bihar, Gujarat, Harayana, Himachal Pradesh, Karnataka, Madhya Pradesh, Maharashtra, Punjab, Rajasthan, Uttar Pradesh
Tropical dry evergreen forest	300	0.3	Himachal Pradesh, Jammu & Kashmir, Andhra Pradesh, Tamil Nadu
Subtropical broad leaved hill forest	300	0.4	Assam, Meghalaya
Subtropical pine forest	3 700	5.0	Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Sikkim, Uttar Pradesh, Haryana, Punjab
Subtropical dry evergreen forest	200	0.2	Himachal Pradesh, Jammu & Kashmir
Montane wet temperate forests	1 600	2.0	Arunachal Pradesh, Karanataka, Manipur, Nagaland, Sikkim, Tamil Nadu
Himalayan moist temperate forests	2 600	3.4	Himachal Pradesh, Jammu & Kashmir, Uttarakhand
Himalayan dry temperate forests	200	0.2	Himachal Pradesh, Jammu & Kashmir
Sub-alpine, moist alpine scrub forests and alpine forests	3 300	4.3	Jammu & Kashmir, Himachal Pradesh and Uttarakhand

Status of non-timber forest products

There is a growing consensus that non-timber forest products (NTFPs) play an important role in the livelihoods of the rural poor as a source of food, medicine, construction materials and income. Estimates indicate that NTFPs contribute to 10-40% of the income of the 50 million tribal households in India, while a further 200-300 million villagers depend on NTFPs to a lesser degree (Shiva 1993). In the dry tropical forest areas of India where there is scarcity of water and the opportunities for farming are limited, NTFPs are in many cases the only means for survival to people. Today, they contribute over 75% of the total forest export revenue in India.

The most important components of the commercial NTFP harvest are plant exudates (resin, oleo-resin, Siam benzoin), medicinal plants, spices and condiments, and plant barks and stems (bamboo, rattan, broom grass). Among the main NTFPs, the most important are the leaves of tendu (*Diospyros melanoxylon*) which are used as wrapper for making bidies (country cigarettes). This enterprise supports about 10 million people in cottage industry of rolling the final product. The other important NTFPs include seeds of sal (*Shorea robusta*), Indian gooseberry, amla (*Emblica officinalis*), myrobelan fruits of *Terminalia bellirica* (baheda) and *T. chebula* (harrad); kernels and seeds of *Buchanania lanzans*; roots of *Asparagus racemosus* (satavar) and *Chlorophytum borivilianum*; gum of *Boswellia serrata* and *Sterculia urens*; and flowers and seeds of *Madhuca longifolia*, *Taxus* sp., *Agalochha* sp., *Celastrus paniculata, Andrographis paniculata* and *Helicteres isora.* These are only some of the most prominent NTFPs for trade. In addition, a number of other NTFPs specific to particular ecosystems are traded (MoEF 2007).

Unsustainable extract of the commercially very important NTFP species is estimated to lead to a loss of germplasm of approximately 50%. Because of lack of appreciation for their ecological role in forest ecosystem and economic value, responsible extraction of these resources is continuously neglected. The bamboo resources are declining due to a lack of investments for revival of gregariously flowered bamboo areas. Similarly, a number of other NTFPs are also being depleted because of unsustainable extraction. Policies and regulations are needed that create a framework for NTFPs conservation, and establish and secure rights for the local people. These rights include not only access to forest to harvest products, but also rights for processing (forming associations for processing and trade) and transporting products without high tariffs and fees.

The important genetic resources of two groups of NTFPs, medicinal plants and bamboos, are described separately in the following.

Status of medicinal plants in India

In India, medicinal plants are widely used by all sections of the population. According to one estimate, over 7500 species of plants are used by several ethnic communities (AICEP 1994; Anthropological survey of India 1994). Presently, medicinal plants play a very important role in the modern economy. NTFPs account for 70% of India's exports in forest products, and the demand for phytochemicals is expected to increase in the future as a new frontier for trade. India has probably the oldest, richest and most diverse cultural traditions in the use of medicinal plants (Table 5).

Exploration of forest-based plant products for new pharmaceuticals and the demand for medicinal plants are increasing in both developing and developed countries, especially among the youth (Farnsworth and Soejarto 1991). Surprisingly, the bulk of the traded material is still from the wild, and only very few species are cultivated. According to the data compiled by the International Trade Centre in Geneva, India is ranked second, after China,

among the exporting countries of medicinal plant products. During 1992-1995, India's annual export in medicinal plants was 326 000 tonnes and valued at 45.95 million Indian rupees (about 1.4 million US$). Recent trends have indicated further increase in this trade with the herbal cosmetic industry playing a major role in fuelling the demand for herbals worldwide. In addition to the international trade, there is a substantial volume of internal trade in medicinal plants in India. One estimate projected the turnover of the herbal industry in India to be 4000 million rupees (about 88 million US$) in 2000 (Ved 1997; Ved *et al.* 2001).

The expanding trade in medicinal plants has serious implications on the survival of several plant species, many of which are under threat of becoming extinct. Today this rich biodiversity of medicinal plants is facing a serious threat because of the rapid loss of natural habitats and overexploitation of plants in the wild. Medicinal plants are being harvested every year from some of 165 000 ha of forests to meet the demands of the Indian herbal industry, which has an annual turnover of about 300 million US$ (FRLHT 1997). The following species of medicinal plants from India have been considered to be endangered and threatened for over a decade (Ayensu 1986): *Acorus calamus, Alpinia galanga, Commiphora wightii, Dendrobium nobile, D. pauciflorum, Dioscorea deltoidea, Diplomeris hirsuta, Gentiana kurroo, Nelumbo nucifera, Paphiopedilum druryi, Podophyllum hexandrum, Rauvolfia serpentina, Santalum album* and *Saussurea lappa*. A very large number of other species of medicinal plants can be added to this list, for example *Saraca asoca, Picrorrhiza kurrooa, Costus speciosus, Berberis aristata*, and *Gloriosa superba*.

Table 5. Medicinal plants: species diversity and representative species of different biogeographic zones of India (Ved *et al.* 2001)

Biogeographic region	No. of species (estimate)	Examples of typical medicinal species
Trans Himalayas	700	*Ephedra gerardiana* Wall., *Hippophae rhamnoides* L., *Arnebia euchroma* (Royle) John.
Himalayan	2500	*Aconitum heterophyllum* Wall. ex Royle, *Ferula jaeshkeana* Vatke and *Saussurea costus* C.B. Clarke, *Nardostachys grandiflora* D.C., *Taxus wallichiana* Zucc., *Rhododendron anthopogon* D.Don, *Panax pseudoginseng* Wall.
Desert	500	*Convolvulus microphyllus* Seib. ex Spreng., *Tecomella undulata* (Sm.) Seem., *Citruleus colocynthis* (L.) Schrader, *Cressa crertica* L.
Semi-Arid	1000	*Commiphora wightii* (Arn.) Bhandari, *Caesalpinia bonduc* (L.) Roxb., *Balanites aegyptiaca* (L.), Delile, *Tribulus rajasthanensis* Bhandari & Sharma.
Western Ghats	2000	*Myristica malabarica* Lam., *Garcinia indica* Choisy, *Utleria salicifolia* Bedd., *Vateria indica* L.
Deccan Peninsula	3000	*Pterocarpus santalinus* L.f., *Decalepis hamiltonii* Wight & Arn., *Terminalia pallida* Brandis, *Shorea tumbuggaia* Roxb.
Gangetic Plain	1000	*Holarrhenaq antidysenterica* Wall., *Mallotus philippensis* (Lam.) Muell. –Arg., *Pluchea lanceolata* C.B. Clarke, *Peganum harmala* L.
North East India	2000	*Aquilaria malaccensis* Lam., *Smilax glabra* Roxb., *Ambroma augusts* (L.) L.f., *Hydnocarpus kurzii* (King) Warb.
Islands	1000	*Calophyllum inophyllum* L., *Adenanthera pavonina* L., *Barringtonia asiatica* (L.), Kurz, *Aisandra butyracea* (Roxb.), Baehni.
Coasts	500	*Rhizophora mucronata* Lam., *Acanthus ilicifolius* L., *Avicennia marina* Vierh., *Sonneratia caseolaris* L. Engl.

Conservation and cultivation strategies for medicinal plants

It is estimated that during the last few decades, approximately half of the earth's mature tropical forests have been destroyed. Experts estimate that only 5-10% of all plants in the world have been systematically investigated for their pharmacological activity. Many of them are threatened in the tropical forest. A strong strategy in terms of conservation through biotechnology and legal matters has to be developed. The research institutes of the Indian Council of Forest Research and Education (ICFRE) have established herbaria and medicinal plant gardens and developed packages for the cultivation of economically important medicinal plants with modern techniques, including tissue culture and genetic engineering. To address the need for conservation of native medicinal plant species, India needs to establish a network of forest sites across its biogeographic regions. However, a network of *in situ* (field) gene banks, the actual forest habitats, is the cost-effective way to manage the intra- and interspecific diversity. Various institutes under ICFRE are working on specific species for the conservation of germplasm.

Rare and threatened medicinal plants

According to the Red Data Book of Indian Plants (Nayar and Sastry 1987; 1988; 1990), several medicinal plant species fall into various IUCN categories of rare and threatened plants. These species listed in the following need to be provided adequate protection in order to conserve them and to bring them out of threatened status.

Extinct (E, 6 species)

- *Carum villosum* Haines: Apiaceae. North Champaran, Bihar. Only known from Haines' collection prior to 1922.
- *Berberis affinis* G. Don: Berberidaceae. Kumaon 2500 m. Endemic. Most of the *Berberis* species are medicinal.
- *Dipcadi reidii* Deb and Dasgupta: Liliaceae. Endemic to Western Himalayas, 2300 m (without precise locality). Not collected for over 100 years.
- *Ligusticum albo-alatum* Haines: Apiaceae. Endemic to Chhotanagpur. Haines' collection is prior to 1919; collected for the last time by Mooney in 1940.
- *Madhuca bourdillonii* (Gamb.) HJ Lam: SW Ghats-Kerala. Known from type specimen collected by Bourdillon in 1894 or 1895.
- *Madhuca insignis* (Radlk.) HJ Lam: SW Ghats-Karnataka. Not collected for over 100 years.

Endangered (E, 8 species)

- *Berberis lambertii* Parker: Berberidaceae. Endemic to Kumaon.
- *Dipcadi maharashtrensis* Deb *et* Dasgupta: Liliaceae. Pachgani, Maharashtra. Last collected in 1955 (the only collection). Potential source of alkaloids. Belongs to the class of alkaloid yielding species such as *Scilla hyacinthina* Macbr. and *Urgenia indica* Kunth.
- *Hydnocarpus macrocarpa* (Bedd.) Worb. ssp. *macrocarpa:* Flacourtiaceae. Endemic to the Southern Western Ghats in Peninsular India.
- *Iphegenia sahyadrica* Ansari et Rolla Rao: Liliaceae. Karnataka. Content of colchicines 1%, of high demand.
- *Kalanchoe roseus* Cl. Crassulaceae. Northeast India: Nagaland and Manipur. Antidote for snake bites.
- *Saussurea costus* Decne: Asteraceae. Jammu &Kashmir, Himachal Pradesh (Chamba), Uttar Pradesh (cultivated), Pakistan. Overexploitation and habitat loss. Used in perfumery and insecticides, possesses alkaloid (sussurine).

- *Scilla viridis* Blatter & Hallberg: Liliaceae. Endemic to Maharashtra. Known from a single gathering.
- *Urgenia congesta* Wt. Liliaceae. South India, Sri Lanka, not collected since 1945. A potential alkaloid-yielding species.

Vulnerable (V, 17 species)

- *Aconitum deinorrhizum* Stapf. Ranunculaceae. Endemic to Himalaya: Jammu & Kashmir, Himachal Pradesh, Nepal, Bhutan. Altitude of 3000-4500 m. The 'Chief Indian Aconite' for export. Excessive collection for medicinal uses.
- *Aconitum falconeri* Stapf. var. *latilobum* Stapf. Ranunculaceae. Endemic to Bashahr Himalayas (Himachal Pradesh). Overexploitation for medical uses. Deadly poisonous of all Aconites 'Bish' or 'Atis'.
- *Aconitum ferox* Wall. ex Seringe: Ranunculaceae. Himachal Pradesh, Sikkim. Endemic. 'Indian Aconite' (a mixture of *Aconitum deinorrhizum* and *Aconitum balfourii*).
- *Capparis polyphylla* Jacobs: Capparaceae. Endemic to Arunachal Pradesh. Potential medicinal species.
- *Coptis teeta* Wall. 'Mishmi teeta'. Ranunculaceae. Endemic to Arunachal Pradesh. Overexploitation for medicinal properties.
- *Cycas beddomei* Dyer: Cycadaceae. Endemic to Cuddapah – Tirupati Range in the Southern Eastern Ghats in Andhra Pradesh. Professed to have medicinal properties.
- *Dioscorea deltoidea* Wall. ex Kunth: Dioscoreaceae. Himalaya: Kashmir to Assam. Overexploitation for medically important tubers.
- *Dipcadi saxorum* Blatter: Liliaceae. Endemic to Maharashtra.
- *Dipcadi ursulae* Blatter: Liliaceae. Endemic to Maharashtra. A potential alkaloid-yielding species.
- *Iphegenia magnifica* Ansari *et* Rolla Rao: Liliaceae. Endemic to the Western Ghats – Maharashtra and Karnataka. Exploited for the high demand of colchicine.
- *Iphegenia stellata* Blatter: Liliaceae. Maharashtra. Rich source of colchicine.
- *Inula racemosa* Hook. f. Asteraceae. Jammu & Kashmir 3000-3500 m. Overexploitation for medicinal purposes and habitat loss. (Vern. 'Mankuth' used as a substitute of 'Kuth' *Saussurea costus*).
- *Nardostachys grandiflora* DC. Valerianaceae. Himalayas: Himachal Pradesh to Bhutan. Overexploitation for medicinal properties.
- *Ochreinauclea missionis* (Wall. ex G. Don) Rids. Rubiaceae. Endemic to Southern Central Western Ghats of Peninsular India: Kerala, Karnataka and Tamil Nadu. 'Jalamdasa'. A potential medicinal species.
- *Panax pseudoginseng* Wall. 'The Himalayan Ginseng' Araliaceae. Himalayas: 2900-4000 m. Much valued for medicinal purposes.
- *Picrorrhiza kurrooa* Royle ex Benth. Scrophulariaceae. Himalaya: Jammu & Kashmir to Sikkim. 3300-5000 m. The plant has become scarce because of over-collection.
- *Toxocarpus palghatensis* Gamb. Asclepiadaceae. Endemic to the Palghat Hills of the Western Ghats. May contain pharmacologically active substances but requires investigations.

Rare (R, 10 species)

- *Anogeissus sericea* Brandis var. *nummularia* King ex Duthie: Combretaceae. Endemic to north-western India (Rajasthan, Gujarat and Punjab). Gum medicinal.
- *Berberis kashmiriana* Ahrendt: Berberidaceae. Endemic to Kashmir. Most of the species of the genus *Berberis* possess medicinal properties.
- *Berberis apiculata* (Ahrendt) Ahrendt: Berberidaceae. Endemic. Himachal Pradesh (Shimla). Potentially important for medicinal properties.
- *Chlorophytum borivilianum* Sant. and Fernand. Liliaceae. Gujarat and Masharashtra. Roots are medicinal and edible.
- *Glycosmis macrocarpa* Wt. Rutaceae. Kerala and Tamil Nadu.
- *Indigofera caerulea* Roxb. var. *monosperma* (Sant.) Sant. Fabaceae. Gujarat and Rajasthan.
- *Kingiodendron pinnatum* (Roxb. ex DC.) Harms: Fabaceae. Endemic to Southern Western Ghats in Karnataka. Resin balsam of medicinal value.
- *Pauia belladonna* Deb and Dutta: Solanaceae. Arunachal Pradesh. Properties similar to Belladonna.
- *Pueraria bella* Prain: Fabaceae. Arunachal Pradesh. Potential species for medicinal and edible purposes.
- *Vanasushava pedata* (Wt.) Mukh. *et* Const. (*Heracleum pedatum* Wt.). Apiaceae. Palni Hills, Hills of South India. After 1836, it was collected for the next time in mature fruiting condition by Mukherjee only in 1972.

Indeterminate (I, 8 species)

- *Angelica nubigena* (Cl.) Mukh. (*Heracleum nubigenum* Cl.). Apiaceae. Not collected since 1849. Endemic to Northeast Sikkim at Chola and Yakla Passes. 3500 m. Roots reported to be used as cardiac stimulant.
- *Asparagus jacquemontii* Baker: Asparagaceae. Known from type collection only. Pune (Maharashtra) and Kerala.
- *Asparagus rottleri* Baker: Asparagaceae. Endemic to Deccan Peninsula.
- *Berberis hugeliana* Schneid. Berberidaceae. Endemic to Kashmir. Known from description only.
- *Cyclea fissicalyx* Dunn: Menispermaceae. Endemic to Southern Western Ghats in Peninsular India.
- *Dioscorea rogersii* Prain *et* Burkill: Dioscoreaceae. Endemic to Andaman Islands. Potential medicinal species.
- *Dipcadi minor* Hk. f. Liliaceae. Deccan Plateau. Not collected after 1957.
- *Pittosporum eriocarpum* Royle: Pittosporaceae. Garhwal-Kumaon Himalayan region. Endemic. Threatened by forest degeneration and habitat loss. Narcotic, used in chronic bronchitis.

Insufficiently known (K)

- *Madhuca diplostemon* (Cl.) van Royen: Sapotaceae. Endemic to Peninsular India. Known only from type collection of Robert Wight.

Bamboo resources

India is very rich in bamboo diversity. There are 124 indigenous and exotic species, under 23 genera, which are found naturally, under cultivation, or both (Naithani 1993). North-east India supports about 50% of the total genetic resources of bamboos (Naithani 2008). It is

followed in diversity by peninsular India, the location of the Eastern and the Western Ghats, which accounts for about 23% of the genetic resources occurring naturally. North-western India, Indo-Gangetic plains and the Andaman and Nicobar Islands account for the remaining diversity. Bamboo resources of Andaman and Nicobar Islands manifest a rich and varied diversity (Garbyal *et al.* 2008). More than 50% of bamboo species occurring in India are endemic, and roughly 19 species are rare and threatened. Clump forming bamboo constitute over 67% of the total growing stock, of which *Dendrocalamus strictus* accounts for 45%, *Bambusa bambos* 13%, *D. hamiltonii* 7%, *B. tulda* 5% and *B. pallida* 4%. All other species account in total for 6%. *Melocanna baccifera*, a non-clump forming bamboo, accounts for 20% of the growing stock and is found in the north-eastern states.

Both *in situ* and *ex situ* conservation measures are being adopted to preserve the genetic resources of bamboos. *In situ* conservation measures include establishment of preservation plots, in every state. Biodiversity on these plots is periodically monitored. In addition, there are 14 biosphere reserves, 97 national parks and 508 wildlife sanctuaries, which include natural habitats of bamboo and rattan as well. The local people in sacred groves also protect these species. However, *in situ* conservation sites with specific emphasis on conservation of bamboo and rattan are yet to be established. The major limitations of *in situ* conservation is that natural stands of bamboo and rattan are scattered in pockets over large areas, which makes it difficult to declare several bamboo or rattan reserves.

Ex-situ conservation activities for preservation of important genetic resources of bamboo and rattan need more emphasis. So far, these activities are limited to the establishment of bambuseta and caneta (rattan garden). The live collections of bamboos are now available in a few centers in India (Subramaniam 1998), including the following:

- Forest Research Institute (FRI), Dehradun: 53 species
- Van Vigyan Kendra, Chessa, Arunachal Pradesh: 35 species
- Arunachal Pradesh Centre Bamborium, Bashar, Siang district: 31 types
- Botanical Garden, Punjab University, Chandigarh: 20 species
- Kerala Forest Research Institute, Peechi, (Sub-centre at Nilambur): 21 species
- Kerala Forest Research Institute, Peechi, (Sub-centre at Palappilly): 51 species
- Kerala Forest Research Institute Campus, Peechi, Kerala: 13 species
- Tropical Botanical Garden and Research Institute, Palode, Kerala: 32 species
- Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore: 26 species
- Forest Department, Begur, Wynaad Division, Kerala: 12 species.

As mentioned earlier, efforts have been initiated at ICFRE, in collaboration with several other research organizations to identify and collect promising genetic resources of the more important bamboo species. Plantations are being established using the genetic resources which are collected under this programme for *ex situ* conservation.

Legal framework

Based on the recommendations of international negotiations, concerned with biodiversity and conservation, India has enacted laws to protect its biological resources. The following acts of the Government of India are intended to guarantee and regulate the access to, and the conservation and regulation of the natural resources:

Forest Acts

- The Indian Forest Act 1927
- The Forest (Conservation) Act 1980
- The Forest (Conservation) Rules 1981

- Biological Diversity Act (BDA) 2002
- The Protection of Plant Varieties and Farmers Rights act (PPVFR) 2001.
- The Seed Bill 2004

Wildlife Protection Acts

- The Wildlife (Protection) Act 1972, as amended up to 1993
- The Wildlife (Transactions and Taxidermy) Rules 1973
- The Wildlife (Stock Declaration) Central Rules 1973
- The Wildlife (Protection) Licensing (Additional matters for consideration) Rules 1983
- The Wildlife (Protection) Rules 1995
- The Wildlife (Specified plants—conditions for possession by License) Rules 1995

These acts are the basis for the protection of the flora and fauna of the country. Within the framework of the legislation, there are national parks and wildlife sanctuaries, wetland reserves and a network of biosphere reserves.

The following are the important acts and bills as approved by the Government of India for the conservation, regulation and access to genetic resources of the country:

Indian Forest Act 1927

Prior to the formulation of a comprehensive Indian Forest Act in 1927, several acts and amendments covering forest administration in British India were enacted – the Indian Forest Act, 1878; the Act of 1890; the amending Acts of 1891; 1901 and 1911; the repealing and amending Act, 1914; the Indian Forest Amendment Act, 1918; and the Devolution Act, 1920.

The act of 1927 provided enabling provisions to make rules and regulations, which makes it quite distinct from other acts of that time. It is this distinct provision that enabled this central act to stay in force when forests were made subject to the provincial governments. The act has 86 sections in 13 chapters which address to reserved forests; village forests; protected forests; control over forest and lands not being the property of the government; duty on timber and other forest produce; control of timber and other forest produce in transit; collection of drift and stranded timber, penalties and procedure; cattle trespass; forest officers; subsidiary rules; and miscellaneous regulations (MoEF 2006).

Forest Conservation Act 1980

This act was enacted to control indiscriminate diversion of forestland. Under this legislation, approval of the Central Government is required before any forestland is diverted for non-forestry purposes. Moreover, the transfer is allowed only with the provision that compensatory plantations or afforestation are raised in an equivalent area of non-forestland or twice the area in degraded forestlands. In 1988, the act was amended to make the existing provisions more stringent. This act is, by far, the most important tool as the Government of India has to regulate and control the change in the land use of recorded forestland. On the positive side, the act has helped reduce diversion of forestland for non-forestry purposes. On the negative side, it is alleged that it has delayed developmental projects in forested districts, where the availability of land other than forestland for roads, bridges, etc., is severely restricted (MoEF 2006)

The Wild Life (Protection) Act 1972

This is an act to provide for the protection of wild animals, birds and plants, and for matters connected therewith or ancillary or incidental thereto, with a view to ensure the ecological and environmental security of the country. The new provisions of the act, following the amendment of 2002, pertain to establishing the Zoo Authority of India to oversee management of all zoos in the country, protection of rare and endangered species of plants and animals, and providing individuals with the power to file complaints against offenders. The act has 11 chapters and 121 sections and categorizes animals, birds, and plants in six schedules (MoEF 2006).

Plant Breeders' Rights

Farmers contribute importantly to conserving, improving and making available plant genetic resources in India. To recognize and protect the rights of the farmers and plant breeders, the Government of India considered it necessary to establish an effective system for the protection of plant varieties and for encouraging the development of new varieties. Securing the rights of plant breeders and thus stimulating investments for research and development for developing new plant varieties was also considered necessary in order to accelerate agricultural development in the country.

The protection of rights by law is likely to facilitate the growth of the seed industry, which will ensure the availability of high quality seeds and planting material to the farmers. India has ratified the Agreement on Trade Related Aspects of the Intellectual Property Rights. To give effect to this agreement, the Protection of Plant Varieties and Farmers' Rights Act (PPVFR) was enacted in 2001. As per the act, plant varieties are defined as groupings of plants (excluding microorganisms) within a single taxon of the lowest rank, which can be defined by the expression of the characteristics resulting from a given genotype of that grouping. A variety must be distinguishable from any other grouping at least by one characteristic trait. A new variety is registered if it conforms to the criteria of novelty, distinctiveness, uniformity and stability.

Biological Diversity Act 2002

The Biological Diversity Act (BDA 2002) of India is a broad policy statement identifying the strategies and actions that need to be taken with regard to access to genetic resources, their conservation, sustainable use, and fair and equitable sharing of benefits, as per the provisions of the Convention on Biological Diversity (CBD). The act envisages the establishment of a National Biodiversity Authority, State Biodiversity Boards and local level Biodiversity Management Committees to provide for regulated access to biological resources and traditional knowledge associated with them. It provides guidelines for undertaking collaborative research involving the use of biological resources and the associated knowledge.

The Seed Bill 2004

The Seed Bill is to provide for regulating the quality of seeds for sale, import and export and to facilitate production and supply of seeds of quality, and for matters connected therewith or incidental thereto.

The idea behind the Seed Bill is that an effective implementation of this new law can be expected to promote private plant breeding in the country in the long term. The major rationale behind the policy is the hope that these developments would provide Indian farmers with multiple choices and an increased access to improved seeds. As such, the bill

also seeks to address the concerns of the seed industry. It aims to regulate the quality of seeds in the market, and it requires registration of all varieties of seeds sold in India. The bill states that it applies to every dealer and every producer of seed, except for when he or she produces the seeds for personal use. Thus, the only exception to the rule is the exemption granted to farmers to use and sell seeds from their own farms, as long as such seeds are sold unbranded. However, even such seeds will have to meet the minimum standards set for registered seeds, a requirement which will obviously be hard to fulfil for a small farmer and probably as hard to detect for the enforcement authorities.

National programmes for the conservation and management of forest genetic resources

Gene pool conservation is necessary for human welfare. Several species have become extinct, and some others are already threatened and may become extinct if appropriate measures for their conservation are not taken. Conservation of habitats and individual species has been practiced in India since times immemorial. Concern for nature conservation is deeply embedded in the multiracial Indian society. India was the pioneer in enacting the world's first recorded conservation measures, as early as 300 BC, when Emperor Ashoka vowed to protect all living creatures. Ancient Indian civilization was cradled in the forests, and the abodes of saints and sages were prime examples of the inherent concern of humans for other forms of life. The groves, pools and ponds that were sanctified at that time are still revered and venerated as religious symbols of the ancient past. The wide prevalence of religious sanctity of trees, animals and birds, practiced by almost all casts and sects of Indians, proves the deep feelings that Indians, in general, have for nature. A well-known manual of administration, dating back to 4th century before current era, advocated establishment and strict protection of forest reserves and specially highlighted the concept of elephant preserves. Many of today's national parks and sanctuaries owe their existence to the hunting reserves established by the rulers of yester-years.

The growing attention to conservation reflects the increasing concern about alterations in the forests and the long-term maintenance of the health and overall productivity of forests and forest ecosystems. The Convention on Biological Diversity, adopted in 1992, affirms that states have sovereign rights over their biological resources and that they are responsible for conserving their biological diversity and for using it in a sustainable manner. The convention relates to the ecological, social, economic and ethical values of diversity. National policies and programmes related to FGR cover a wide range of activities, from conservation measures to protect rare and endangered species and populations, and regulations governing seed collection and transfer in socio-economically important tree species, to comprehensive approaches to the management of landscapes and ecosystems. With these complexities in mind, considerations related to FGR in India have been integrated within broad frameworks, such as national forest programmes and biodiversity action plans (the Biodiversity Bill 2002).

The National Forest Policy 1988 has conservation as one of its basic objectives. It emphasizes the conservation of the natural heritage of the country by preserving the natural forests with a vast variety of flora and fauna, which represent the biological diversity, and genetic resources of the country.

The safest and perhaps the most effective conservation strategy is the one, which combines the two complementary methods, *in situ* and *ex situ*.

In situ conservation

In situ conservation requires planned and systematic management of clearly identified target species in a network of conservation areas aimed at maintaining the intra-specific genetic variability. Examples of such conservation areas are biosphere reserves, preservation plots, sacred tree groves, national parks, sanctuaries and nature reserves. Efforts are being concentrated to maintain the genetic variability of target species within a mosaic of economically and socially acceptable land-use options. These may include protected areas, as well as multiple use reserves, managed forests, and agroecosystems.

Biosphere reserves

Humans have traditionally used the majority of the ecosystems in India, and for nearly 200 years, most of the forested ecosystems have undergone scientific forestry management. This has established a wide gradient of habitats and conserved biodiversity, except at sites where overuse, abuse or change of land use pattern has led to erosion of biodiversity. Following the 'Man and the Biosphere' approach advocated by the UNESCO, 14 sites have been identified as Biosphere Reserves (Table 6) in the country. The purpose of the formation of biosphere reserves is to conserve *in situ* all forms of life, along with its support system, in its totality, so that it could serve as a referral system for monitoring and evaluating changes in natural ecosystems.

Table 6. Biosphere reserves in India (WII, 2008)

Reserve	Year est.	Area (1000 ha)	Location
Achanakamar – Amarkantak	2005	384	Parts of the Anuppur and Dindori districts (Madhya Pradesh), and of Bilaspur district (Chhattishgarh)
Agasthyamalai	2001	183	Neyyar, Peppara and Shendurney Wildlife Sanctuaries and their adjoining areas in Kerala
Dehang-Dibang	1998	511	Part of Siang and Dibang Valley in Arunachal Pradesh
Dibru-Saikhowa	1997	76	Part of Dibrugarh and Tinsukia Districts (Assam)
Great Nicobar	1989	88	Southernmost islands of Andaman and Nicobar (Andaman & Nicobar Islands)
Gulf of Mannar	1989	1 050	Indian part of Gulf of Mannar between India and Sri Lanka (Tamil Nadu)
Khangchendzonga	2000	262	Parts of Khangchendzonga hills and Sikkim
Manas	1989	284	Part of Kokrajhar, Bongaigaon, Barpeta, Nalbari, Kamprup and Darang districts (Assam)
Nanda Devi	1988	586	Part of Chamoli, Pithoragarh and Bageshwar districts (Uttarakhand)
Nilgiri	1986	552	Part of Wayanad, Nagarhole, Bandipur and Madumalai, Nilambur, Silent Valley and Siruvani hills (Tamil Nadu, Kerala and Karnataka)
Nokrek	1988	82	Part of Garo hills (Meghalaya)
Pachmarhi	1999	493	Parts of Betul, Hoshangabad and Chindwara districts of Madhya Pradesh
Simlipal	1994	437	Part of Mayurbhanj district (Orissa)
Sunderbans	1989	963	Part of delta of Ganges and Brahamaputra river system (West Bengal)
Total		**5 951**	

Protected areas

In order to protect critical ecosystems and to preserve the genetic resources of un-quantifiable commercial and non-commercial values, national parks, wildlife sanctuaries and conservation reserves have been created in India over the years. The prime objective for these areas is to preserve them as samples of the interdependent combinations of ecological gene pools and as genebank capital.

There are 97 existing national parks in India, which cover a total area of 3 820 000 ha or 1.2% of the geographical area of the country (Table 7; WII 2008). In addition, 74 national parks covering an area of 1 663 000 ha are proposed in the Protected Area Network Report (Rodgers *et al*. 2002). The network of parks will, thus, increase to 171 in near future.

The number of existing wildlife sanctuaries in India is 508, and they cover an area of 11 824 000 ha, which is 3.6 % of the geographical area of the country (Table 7; WII 2008). Additional 217 sanctuaries, covering an area of 1 667 000 ha, are proposed in the Protected Area Network Report.

In addition to the national parks and wildlife sanctuaries, India has 7 conservation reserves and 2 community reserves (Table 8). Currently, these 614 protected areas together form a network of 15 655 000 ha, approximately 4.8% of the country's total land area.

Tiger reserves

Project Tiger was launched by the Government of India in the year of 1973 to save the endangered species of tiger in the country. Starting from 9 reserves in 1973-1974, the number of reserves increased to 31 in 2008. These Project Tiger areas cover a total area of 3 987 000 ha, which is 1.2% of the country's land area (Table 9). These reserves also act as a way of conservation of valuable gene pool of forest origin.

In addition to the aforementioned reserves and protected areas, a variety of field repositories of genetic resources have been developed within the framework of selection and tree improvement programmes to increase the productivity of forest (Katwal *et al*. 2003). These include nature reserves and other protected areas; private and publicly owned forests; managed and unmanaged forests; natural forests and plantations; trees outside of forests managed in agroforestry systems or growing on homesteads, along rivers and roads; arboreta and botanic gardens; field trials and live collections.

Seed stands and seed production areas

The best natural stands or plantations that are near full stocking are used for the development of seed production areas. Seed stands can be categorized as *in situ* conservation areas, which refer to the conservation of species or provenances as parts of a viable existing ecosystem. Conservation *in situ* is the most desirable method of conserving forest genetic resources, provided the area can be granted full protection and genetic material conserved is made available for use both within and outside the country of origin (FAO 1975). It is particularly important to include extreme environments and marginal populations, in which selection effects may have created varieties or ecotypes of particular potential value. Ashton (1976), working with rain forest species in Borneo, made a theoretical estimation of the area of forest needed for conservation, arbitrarily assuming that 200 mature individuals will form a viable population. Working on tree improvement, Zoble and Talbert (1984) have recommended 125 trees per hectare in a seed stand, depending on tree size and selection intensity. The seed stands are selected for a particular area with regard to its ecological and environmental conditions to fulfil the seed demand of particular species. They are, therefore, certainly working as an aid for *in situ* conservation. A list of seed stands and seed production areas in different states is given in Table 10.

Table 7. National parks and wildlife sanctuaries in India (WII 2008).

Area	Land area (1000 ha)	National parks			Sanctuaries		
		No.	Area (1000 ha)	% of state area	No.	Area (1000 ha)	% of state area
States							
Andhra Pradesh	27 507	4	37	0.1	22	1 260	4.6
Arunachal Pradesh	8 374	2	229	2.7	11	761	9.1
Assam	7 844	5	198	2.5	18	193	2.5
Bihar	9 416	1	34	0.4	12	286	3.0
Chhattisgarh	13 519	3	290	2.1	11	358	2.7
Goa	370	1	11	2.9	6	65	17.5
Gujarat	19 602	4	48	0.2	22	1 645	8.4
Haryana	4 421	2	5	0.1	8	21	0.5
Himachal Pradesh	5 567	2	143	2.6	33	617	11.1
Jammu & Kashmir	22 224	4	393	1.8	15	1 031	4.6
Jharkhand	7 971	1	23	0.3	11	195	2.4
Karnataka	19 179	5	247	1.3	21	389	2.0
Kerala	3 886	6	560	1.4	15	189	4.9
Madhya Pradesh	30 825	9	366	1.2	25	716	2.3
Maharashtra	30 769	6	127	0.4	35	1 415	4.6
Manipur	2 233	1	4	0.2	1	18	0.8
Meghalaya	2 243	2	27	1.2	3	3	0.2
Mizoram	2 108	2	15	0.7	7	68	3.2
Nagaland	1 658	1	20	1.2	3	2	0.1
Orissa	15 571	2	99	0.6	18	697	4.5
Punjab	5 036				12	32	0.6
Rajasthan	34 224	5	412	1.2	23	545	1.6
Sikkim	710	1	178	25.1	7	40	5.6
Tamil Nadu	13 006	5	31	0.2	20	300	2.3
Tripura	1 049	2	20	1.9	3	40	3.8
Uttar Pradesh	24 093	1	49	0.2	23	522	2.2
Uttarakhand	5 349	6	473	8.9	6	242	4.5
West Bengal	8 875	5	169	1.9	15	120	1.4
Union territories							
Andaman & Nicobar	825	9	116	14	96	39	4.7
Chandigarh	11				2	3	22.9
Dadra & Nagar Haveli	49				1	9	18.8
Daman & Diu	11				1		1.9
Delhi	148				1	3	1.8
Lakshadweep	3				1		0.03
Pondicherry	49						
Total	**328 726**	**97**	**3 820**	**1.2**	**508**	**11 824**	**3.6**

Table 8. Conservation and community reserves in India (WII 2008).

Name	Type of reserve	Year est.	Area (ha)	District and state
Asan Wetland	Conservation	2005	440	Dehradun, Uttarakhand
Jhilmil Jheel	Conservation	2005	3780	Haridwar, Uttarakhand
Thiruppudai-Maruthur	Conservation	2005	3	Tirunelveli, Tamil Nadu
Kadalundi	Conservation	2007	150	Malappuram, Kerala
Saraswati Plantation	Conservation	2007	4450	Kurukshetra, Kaithal, Haryana
Bir Bara Ban	Conservation	2007	420	Jind, Haryana
Bhorkada (Bhorgad)	Conservation	2008	350	Nashik, Maharashtra
Keshopur Chhamb	Community	2007	340	Gurdaspur, Punjab
Lalwan	Community	2007	1280	Hoshiarpur, Punjab

Table 9. Tiger reserves in India.

State	Tiger reserves	Year est.	Area (1000 ha)
Assam	Kaziranga	2006	86
	Manas	1973-1974	284
	Nameri	1999-2000	34
Arunachal Pradesh	Namdapha	1982-1983	198
	Pakhui	1999-2000	86
Andhra Pradesh	Nagarjunsagar-Srisailam	1982-1983	357
Bihar	Valmiki	1989-1990	84
Chhattishgarh	Indravati	1982-1983	280
Jharkhand	Palamau	1973-1974	103
Karnataka	Bandipur Nagarhole	1973-1974	87
	(extension)	1999-2000	64
	Bhadra	1998-1999	49
Kerala	Periyar	1978-1979	78
Madhya Pradesh	Bandhavgarh	1993-1994	116
	Bori-Satpura	1999-2000	149
	Kanha	1973-1974	195
	Panna	1994-1995	54
	Pench	1992-1993	76
Maharashtra	Melghat	1973-1974	168
	Pench	1992-1993	26
	Tadoba-Andhari	1993-1994	62
Mizoram	Dampa	1994-1995	50
Orissa	Simlipal	1973-1974	275
Rajasthan	Ranthambhore	1973-1974	133
	Sariska	1978-1979	87
Tamil Nadu	Kalakad-Mundathurai	1988-1989	80
	Muduumalai tiger reserve	2007	34
	Annamalai Tiger Reserve, Pollachi	2007	91
Uttar Pradesh	Dudhwa Katerniaghat	1987-1988	81
	(extension)	1999-2000	55
Uttarakhand	Corbett	1973-1974	132
West Bengal	Buxa	1982-1983	76
	Sunderbans	1973-1974	259
Total			**3 987**

Table 10. Seed stands and seed production areas (ICFRE 2003).

State	Species (ha)
Arunachal Prades	*Bombax ceiba* (1), *Dalbergia sissoo* (975), *Duabanga grandiflora* (1), *Terminalia myriocarpa* (1)
Andhra Pradesh	*Eucalyptus* hybrid (30), *Tectona grandis* (6410)
Chhatishgarh	Bamboo (35), *Emblica officinalis* (10), *Eucalyptus* (5), *Gmelina arborea* (18), *Tectona grandis* (301), *Terminalia tomentosa* (100)
Gujrat	58 different species (4970)
Haryana	*Eucalyptus* (2)
Himachal Pradesh	*Abies pindrow* (3615), *Cedrus deodara* (1380), *Pinus roxburghii* (2830), *P. wallichiana* (969)
Jammu and Kashmir	*Pinus wallichiana* and *Abies pindrow* (total 239), *Dalbergia sissoo*, *Gmelina arborea*, *Tectona grandis* and Bamboo (250)
Karnataka	*Acacia amara* (10), *A. catechu* (10), *Casuarina equisetifolia* (10), *Grevillea robusta* (10), *Hardwickia pinnata* (10), *Santalum album* (7), *Sterculia campanulata* (10), *Swietenia mahagoni* (1), *Tectona grandis* (317), *Terminalia tomentosa* (1), *Trewia nudiflora* (1), *Xylia xylocarpa* (14)
Kerala	*Acacia auriculiformis* (2), *Bombax ceiba* (12), *Casuarina equisetifolia* (5), *Dalbergia latifolia* (46), *Eucalyptus grandis* (7), *Eucalyptus* hybrid (5), *Gmelina arborea* (4), *Tectona grandis* (1100), *Santalum album* (23)
Madhya Pradesh	*Dalbergia latifolia* (5), *Hardwickia binata* (5), *Tectona grandis* (400),
Maharashtra	*Tectona grandis* (677)
Manipur	*Tectona grandis* (1)
Orissa	*Casuarina equisetifolia* and *Tectona grandis* (total 500)
Rajasthan	*Bombax ceiba* (8) *Dalbergia sissoo* (58), *Tectona grandis* (15)
Tamil Nadu	*Acacia ferruginea* (3), *A. mearnsii* (10), *A. melanoxylon* (0.5), *A. nilotica* (2), *Albizia falcataria* (7), *Anacardium occidentale* (21), *Eucalyptus citriodora* (0.5). *E. globulus* (10), *E. grandis* (30), *E. tereticornis* (13), *Hardwickia binata* (5), *Pinus patula* (9), *Pterocarpus santalinus* (21), *Tectona grandis* (93)
Uttarakhand	Different species (total 6020)
Uttar Pradesh	*Acacia catechu* (146), *Adina cordifolia* (98), *Albizia lebbeck* (4), *Bombax ceiba* (56), *Cedrus deodara* (20), *Dalbergia sissoo* (146), *Eucalyptus* hybrid (3), *Haplophragma adenophyllum* (1), *Jacaranda ovalifolia* (1), *Kydia calycina* (10), *Lagerstroemia flos-reginae* (3), *Morus alba* (56), *Parkinsonia aculeata* (0.5), *Pinus roxburghii* (100), *P. wallichiana* (15), *Poinciana regia* (4), *Prosopis juliflora* (1), *Tectona grandis* (240), *Terminalia arjuna* (3), *Toona ciliata* (9)

Plus trees

Plus tree selection is one of the methods to conserve diversity at species level. Plus tree is a phenotypically superior tree. In forestry, it is easy to see that trees of a particular species vary in growth, form and wood character. In some cases much of the variation may be genetic and in others environmental. It is when the conserved genes are used that individual selection and breeding within locally adapted provenances will provide additional improvement in selected characteristics. Superior phenotypes of species (Emmanual et al. 1990) selected in different states are listed in Table 11.

Ex situ conservation

Ex situ conservation refers to the conservation of genetic material or biological diversity outside of the natural habitats of the species. Generally, the conservation takes place in

Table 11. Plus trees in different states.

State	Species (no. of trees)
Andhra Pradesh	*Tectona grandis* (75)
Arunachal Pradesh	*Acrocarpus fraxinifolius* (16), *Ailanthus grandis* (18), *Altingia excelsa* (27), *Anthocephalus cadamba* (8), *Bombax ceiba* (21), *Canarium resiniferum* (7), *Cinnamomum cecidodaphne* (4), *Chukrasia tabularis* (5), *Dipterocarpus macrocarpus* (39), *Gmelina arborea* (20), *Mesua ferrea* (8), *Michelia champaca* (30), *Phoebe goalparensis* (21), *Pinus roxburghii* (4), *Shorea assamica* (27), *Terminalia myriocarpa* (28), *Tectona grandis* (2)
Himachal Pradesh	*Pinus roxburghii* (47 for high resin yielder, 59 for timber production).
Karnataka	*Artocarpus heterophyllus* (31), *Emblica officinalis* (11), *Feronia elephantum* (40), *Syzygium cumini* (1) *Tectona grandis* (50), *Ziziphus jujuba* (3)
Kerala	*Azadirachta indica* (300) *Bombax ceiba* (11), *Casuarina* sp. (150), *Santalum album* (3), *Tectona grandis* (29)
Madhya Pradesh	*Albizia procera* (55), *Azadirachta indica* (200), *Tectona grandis* (360)
Maharashtra	*Acacia catechu* (23), *Bombax ceiba* (1), *Dalbergia sissoo* (12), *Tectona grandis* (33)
Manipur	*Tectona grandis* (25)
Tamil Nadu	*Acacia mearnsii* (354), *Casuarina equisetifolia* (male 36, female 115), *Eucalyptus tereticornis* (42), *E. globulus* (40), *Pinus patula* (56), *Tectona grandis* (24)
Tripura	*Gmelina arborea* (50), *Shorea robusta* (50), *Tectona grandis* (50).
Tamil Nadu	*Eucalyptus* (100)
Uttar Pradesh & Uttarakhand	*Dalbergia sissoo* (302), *Eucalyptus tereticornis* (85), *Pinus roxburghii* (54 for tree form, *39* for high resin yield)
Rajasthan	*Azadirachta indica* (350), *Dalbergia sissoo* (50)
Gujrat	*Acacia mangium* (50), *Tectona grandis* (63)
North eastern states	*Gmelina arborea* (119), *Tectona grandis* (46), Dipterocarps (93)

facilities which support either storage or the continuity of the conditions suited to maintain the viability and genetic constitution of the genetic material or diversity. *Ex situ* conservation virtually safeguards and provides a required supply of germplasm for research and breeding. The various possible approaches in *ex situ* conservation of FGR are listed in the following.

Botanical gardens

India has more than 100 botanical gardens under different management systems and located in different bio-geographical regions. Most botanical gardens are being used for recreational purposes. Central and state governments manage 33 botanical gardens that maintain the diversity in the form of plants or plant populations (MoEF 1998). A study of 61 botanical gardens showed that 14 are purely botanical, 21 have a mixture of botanical, horticultural and agricultural species, and 26 are purely horticultural gardens (MoEF 1998). However, the efforts to acquire and conserve rare native species and their genetic diversity are rather inadequate.

Arboreta

An arboretum generally refers to an area established for the conservation of tree species. Forest Research Institute in Dehradun has established an arboretum with 130 forest tree species and a bambusetum of 53 species. Similarly, the Regional Plant Resources Centre of the National Bureau of Plant Genetic Resources (NBPGR) at Bhubaneswar has established an arboretum with 1430 species of trees, a palmatum of 100 different types of palms, a bambusetum with 61 collections of bamboo, and an orchidarium housing 220 species of orchids. At the national level the interest in establishing arboreta is very weak, probably

because of the costs involved. Nevertheless, there is a need for additional arboreta for tropical tree species whose behaviour for seed storage is in most cases either unknown or poorly known. Establishment of arboreta for such species may be the first step towards their conservation (Singh *et al.* 2004).

Herbal gardens

Herbal gardens generally refer to the gardens that predominantly conserve herbs, shrubs that are of medicinal and aromatic value. The concept of herbal gardens has been picked up by the non-governmental organizations (NGOs) in India. Several NGOs in different parts of the country, particularly in tribal areas in Gujarat, Karnataka, Maharashtra, Madhya Pradesh, Chhattisargh and Uttarakhand, have established herbal gardens with the objective of conserving local biodiversity of medicinal and aromatic plants and other economically important species (Singh *et al.* 2004).

Clonal repositories

Most institutions dealing with perennial or vegetatively propagated domesticated plants have field repositories for the conservation of FGR. Therefore, most of the institutes dealing with horticultural crops, agroforestry species and medicinal and aromatic plants have field repositories. ICFRE has established field repositories in the form of Vegetative Multiplication Gardens (VMGs), clonal banks and germplasm banks at its regional institutes in Dehradun, Jabalpur, Coimbatore, Jorhat, Jabalpur, Bangalore, Ranchi and Shimla. Such repositories have also been established in the jurisdiction of the state forest departments for their use. Similarly, the National Bureau of Plant Genetic Resources has established field repositories of certain perennial and tree species at various regional stations at Shimla, Bhowali, Jodhpur, Thrissur, Akola, Amravati and Hyderabad.

Herbaria

Plant diversity has also been preserved in herbaria. The Botanical Survey of India has the largest holding of 1 500 000 specimens. The Forest Research Institute in Dehradun has a collection of more than 300 000 specimens. There are many more herbaria, such as the one at Presidency College Madras (100 000 specimen), the Blater Herbarium at St. Xavier's College in Bombay (100 000) and St. Joseph College in Tiruchirapally (60 000).

Provenance trials

Provenance trials help in the exploration of gene resources called genecological exploration. Through genecological exploration, patterns of ecological and phenotypic variation within the natural range of species are studied, which then lead to and can be applied for provenance seed collection and provenance evaluation (FAO 1975). Provenance trials can be categorized under *ex situ* conservation. Knowledge of the breeding system and biology of the species, and methodology for growing them in plantation condition or storing their seeds are pre-requisites of *ex situ* conservation. *Ex situ* conservation is, therefore, especially useful when dealing with species or a combination of biological characteristics for which this information is available. More than 90 species provenance trials have been laid out in different parts of India to screen out the best provenances for raising new plantations with increased productivity. Since these provenances are collected from different geographical, ecological and environmental conditions, such traits play an important role in gene conservation. (Emmanual *et al.* 1990).

The first provenance trials for two important native species, *Tectona grandis* (teak) and *Pinus roxburghii* (chir pine), were initiated by Professor M.L. Laurie and Sir Harry Champion, respectively, during the time when they were silviculturists at the Forest Research Institute

in Dehradun. Provenance trials of teak were established between 1928 and 1930 in a number of locations in India. The tests on teak and chir pine have yielded useful information. International provenance trials of *Tectona grandis* and *Gmelina arborea* have been established in different states in collaboration with the Danida Forest Seed Centre (DFSC). ICFRE has initiated national level provenance experiments on *Tectona grandis*, *Pinus roxburghii* and *Bombax ceiba*. ICFRE has also collaborated in international provenance testing of eucalypts, particularly *Eucalyptus tereticornis*, *E. camaldulensis* and *E. grandis*. Trials have also been laid for acacias and tropical pines, such as *Pinus oocarpa*, *P. caribaea* and *P. kesiya*. Technical inputs have been extended to state forest departments for provenance tests for species of interest such as *Eucalyptus grandis* and *E. globulus*. The provenance trials have been further systematized by ICFRE during the last five years. Several institutes have conducted both national and international provenance trials in collaboration with the state forest departments and international agencies.

Seed orchards

Seed orchards contribute greatly to the production of quality planting stock of the desired species. These are plantations established primarily for the production of seed of proven genetic quality. Seed orchards are of two types: clonal seed orchards and seedling seed orchards. These orchards can be categorized under selective conservation, as one of the objectives in *ex situ* conservation. Establishment of seed orchards is part of a long-term conservation management programme and also a long-term breeding programme (Table 12).

Table 12. Seed orchards developed in different states (ICFRE 2003).

State	Species (area in ha)
Arunachal Pradesh	*Bombax ceiba* (4), *Chukrasia tabularis* (1), *Duabanga grandiflora* (1), *Gmelina arborea* (3), *Michelia champaca* (1), *Phoebe goalparensis* (1), *Tectona grandis* (17), *Terminalia myriocarpa* (2)
Bihar	*Dalbergia sissoo* (2), *Tectona grandis* (134)
Chhattisgarh	*Emblica officinalis* (20), *Eucalyptus* (15), *Gmelina arborea* (39), *Tectona grandis* (98)
Haryana	*Dalbergia sissoo, Tectona grandis, Azadirachta indica, Ficus benghalensis, F. religiosa, Eucalyptus* spp., *Populus deltoides, Acacia nilotica* and *Melia azedarach* (total area 43), *E. tereticornis* (12)
Jharkhand	*Acacia catechu, Cassia siamea, Tectona grandis, Dalbergia sissoo* (total 60)
Karnataka	*Eucalyptus* (18), *Tectona grandis* (110)
kerala	*Tectona grandis* (51)
Madhya pradesh	*Tectona grandis* (113)
Marashtra	*Dalbergia sissoo* (1), *Tectona grandis* (235)
Manipur	*Pinus kesiya* (0.5), *Tectona grandis* (0.3)
Orissa	*Tectona grandis* (12)
Punjab	*Dalbergia sissoo* (4)
Tamil Nadu	*Anacardium occidentale* (12), *Casuarina equisetifolia* (5), *Eucalyptus tereticornis* (2), *Pterocarpus marsupium* (2), *Santalum album* (2), *Tectona grandis* (19), *Terminalia* sp. (6)
Tripura	*Gmelina arborea* (5), *Tectona grandis* (5),
Uttarakhand	*Cedrus deodara, Pinus roxburghii, P. wallichiana, Ficus micrantha, Juglans regia* and *Abies pindrow* (total 216)
Uttar Pradesh	*Acacia nilotica* (6), *Bombax ceiba* (7), *D. sissoo* (95), *Tectona grandis* (3)
West Bengal	Various species, total area 54 ha

Cryogenebank and DNA bank

Cryopreservation is the storage of biological samples in viable conditions at an ultra-low temperature of liquid nitrogen (-196^0 to -150^0 C). As an alternative complementary method, attempts are also being made to cryopreserve pollen of forest tree species at National Bureau of Plant Genetic Resources (NBPGR). Conservation in the form of DNA is a challenge. Research in the area was initiated just recently, and further research is required.

Role of the Indian Council of Forestry Research and Education in the conservation of forest genetic resources

The Indian Council of Forestry Research and Education (ICFRE) is an autonomous body under the Ministry of Environment and Forests, Government of India, with eight research institutes and three advanced centres in various parts of the country. It caters to the needs of different biogeographic regions of the nation to increase the productivity through genetic and silvicultural improvement and conservation of forest ecosystems. To reach the desired goals, the following priority areas for research have been identified for FGR conservation (NFRP 2001):

- Research on upland watershed management (integrated soil and water conservation to reduce siltation and water scarcity and to support afforestation)
- Research on reforestation of degraded lands and problematic soils (e.g. barren, mined, waste, water-logged and salt-affected lands)
- Research on conservation, protection and sustainable development of existing forests to conserve biodiversity
- Increasing productivity of existing forests and future plantations through production of high quality seeds
- Production and multiplication of planting stocks which match site-specific needs
- Improvement of species and varieties using traditional breeding methods and biotechnology
- Biological rejuvenation of lands using mycorrhizal fungi and other useful microorganisms
- Research on multipurpose trees in farming systems
- Research on non-timber forest products (NFTP), which provide sustenance to people and supply raw materials to a large number of forest-based industries

Research on policy strategies and the combinations of measures desired for enlarging the area under forest cover has included studies on property rights and land tenure, culture and gender issues related to conservation, non-timber products, effects of tariff and non-tariff trade barriers, legal and regulatory settings for forestry, and other laws regulating tree felling, transportation and sales.

Research and development of forest genetic resources

With a view to improve the productivity and profitability of planting forest species and to offer an attractive land use option, many state forest departments have established seed production areas (SPA), clonal seed orchards (CSO), seedling seed orchards (SSO), vegetative multiplication gardens (VMG) and modern nurseries in consultation with ICFRE for the production of quality planting. The importance of production forestry has been realized and strategic activities for tree improvement are in progress in the ICFRE institutes. In this approach,

the emphasis is on species-oriented tree improvement programme in collaboration with the state forest departments. During the last fifteen years ICFRE has developed comprehensive strategies for tree improvement programme for species like teak, neem, acacias, pines, eucalypts, bamboos, poplars, *Dalbergia* spp., *Casuarina* spp., *Cedrus deodara*, *Jatropha* spp., *Albizia* spp. and *Gmelina* spp. The approach involves the development of seed production areas, clonal and seedling seed orchards to select germplasm for progenitors and clonal accessions of high value. Several hundred trees have been identified as candidate plus trees, which are propagated vegetatively and established as a germplasm bank.

The following ICFRE institutes have also assembled populations of various species: Forest Research Institute (FRI, Dehradun), Tropical Forest Research Institute (TFRI, Jabalpur), Arid Forest Research Institute (AFRI, Jodhpur), Rain Forest Research Institute (RFRI, Jorhat) and Institute of Forest Genetics and Tree Breeding (IFGTB, Coimbatore). In addition, international provenances of neem, *Casuarina* spp., eucalypts and acacias have been assembled. Provenance trials at a national level for various species like *Dalbergia sissoo*, pines and acacias have also been conducted. Improved seeds from clonal seed orchards and seedling seed orchards of some species are made available for planting to user agencies.

ICFRE has also implemented a major research and development programme to improve the productivity of *Casuarina*, poplar, *Tectona grandis*, *Dalbergia sissoo*, acacias and eucalypts in a short time span through the application of vegetative propagation and cloning techniques. In order to develop better clones than presently available and to widen the genetic base of clonal plantations, research and development priorities have been identified and are being carried out in various institutions of ICFRE with significant achievements.

ICFRE institutes follow appropriate methods in the strategy of long-term tree improvement. Steps involved in developing the genetic resources are exploration, collection, evaluation, breeding, multiplication and conservation. In this process, ICFRE has developed and assembled germplasm and executed tree improvement programmes for different species for the states which it interacts with and provides services to (Table 13).

Table 13. Species in focus for the development and improvement of forest genetic resources in ICFRE institutes.

Institute	Species focus
Forest Research Institute (FRI), Dehradun	*Eucalyptus* spp., *Shorea robusta, Dalbergia sissoo, Acacia* sp., poplars, *Leucaena leucocephala*, Himalayan pines, tropical pines
Arid Forest Research Institute (AFRI), Jodhpur	*Eucalyptus* spp., *Tectona grandis*, *Acacia* sp., *Azadirachta indica*, *Ailanthus excelsa*, *Tecomella undulata*
Rain Forest Research Institute (RFRI), Jorhat	*Gmelina arborea*, *Tectona grandis*, Bamboos, *Acacia* spp., *Dipterocarpus* sp.
Tropical Forest Research Institute (TFRI), Jabalpur	*Tectona grandis*, Bamboos, *Acacia nilotica*, *Dalbergia sissoo*, *Albizia procera*, *Azadirachta indica*, *Gmelina arborea*
Institute of Wood Science and Technology (IWST), Bangalore	*Santalum album, Pterocarpus santalinus*, Eucalypts, *Casuarina* sp., *Tectona grandis*, Bamboos, *Dalbergia latifolia*
Institute of Forest Genetics and Tree Breeding (IFGTB), Coimbatore	Eucalyptus, *Casuarina* sp., *Tectona grandis, Acacia* spp., Bamboos, *Azadirachta indica*
Institute of Forest Productivity (IFP), Ranchi	Eucalyptus, *Acacia catechu*, *Adina cordifolia*, tropical pines, *Leucaena leucocephala*, *Gmelina arborea*
Himalayan Forest Research Institute (HFRI), Shimla.	*Pinus roxburghii, Picea smithiana, Abies pindrow, Dalbergia sissoo, Salix* sp., *Populus* sp., *Cedrus deodara*

Training

To provide up-to-date training and educational exposure on the management and conservation of forest genetic resources, visits are arranged abroad for short and long-term training, such as courses, meetings, symposia and workshops. In the past, the World Bank, the United Nations Development Programme (UNDP), the British Council, the International Development Research Centre (IDRC), the Food and Agriculture Organization (FAO), the International Network for Bamboo and Rattan (INBAR), and the United States Department for Agriculture (USDA) have provided financial assistance under various programmes to support forestry research and education. Recently, programmes by the Japan International Cooperation Agency (JICA), the Asia Forest Partnership (AFP) and the Asia Pacific Forest Genetic Resources Programme (APFORGEN) also supported workshops and training programmes on FGR conservation and management issues, in which scientists of ICFRE participated. In order to strengthen programmes on genetic resources, ICFRE provides technical support to state forest departments, farmers and industries on *ex situ* and *in situ* conservation methods and management of forest and NTFP genetic resources. Many students, industry representatives, teachers and various user groups, including farmers, are trained on advanced technologies developed by the ICFRE institutes in the form of short-term training courses.

Conclusion

Increased use of forest resources and shrinking forest areas threaten the sustainability of forest genetic resources and highlight the importance of conservation and sustainable management of these resources. Several species have become extinct and some others are already threatened and may become extinct if appropriate measures for their conservation are not taken. India is bestowed with very rich and diverse flora and fauna. Proper utilization of biodiversity can very substantially contribute to the economic progress of the nation. Areas of rich and diverse biological resources need to be identified and conserved. As a priority, areas with rare endemic species with very limited distribution need to be conserved before they are lost.

Indian forests have been under severe pressure to meet the growing demand for alternative land uses, fuel, fodder, grazing, timber, pulp wood and non-timber forest products by an ever-growing human and livestock populations, industrial development and infrastructural needs. These resources are also facing multiple threats related to habitat loss, forest fires, climate change and the invasion of exotic species. Forest resources are a biological basis for world security and directly or indirectly support the livelihoods of every person on earth by providing food, feed for domestic animals, fibres, clothing, shelter, wood, timber, medicine, energy and numerous other benefits. These resources are also the raw material used in the production of new plant varieties through traditional plant breeding or through biotechnology. Silvicultural practices such as selective felling of superior genotypes may lead to loss of genetic diversity. Thus, appropriate approaches for management of forests for biodiversity conservation will have to be evolved and followed and reflected in the management or working plans. There is an urgent need to conserve and use genetic resources as a safeguard for future.

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Current status and recent progress in the conservation and management of forest genetic resources in Indonesia

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Forest management in Indonesia has a long history. Initially, the country's forest area was divided into two forest types, tropical rain forest and teak plantation forest. The teak plantation forests are mainly found in Java Island, whereas the tropical rain forest occupies the outer islands of Java. Total forest area in Indonesia is 120 300 000 ha covering more than 60% of the country's land area. From an ecosystem point of view, Indonesia can be classified into seven vegetation zones ranging from beach forest, peat forest, mangroves, low land tropical rain forest and savanna to mountain and alpine forest.

Tropical rain forests have suffered from an increasing disturbance and have been largely destroyed. Reforestation has been carried out by developing plantation forests, using mainly fast growing species. The objective of plantation forestry is not only forest rehabilitation but also to substitute for wood extraction from natural forests. This development encourages tree improvement efforts for increasing wood production. The concern of tree improvement for plantation forests dates back to the 1980s. On the other hand, the genetic resources for establishing plantation forests are limited because of decreasing natural forests. Forest is also a resource on which many Indonesian people depend for their subsistence and customary activities. Forests generate employment and business opportunities. It is estimated that 36 million people out of the total population of about 213 million rely on the forestry sector for their livelihoods either formally (e.g. industry) or informally (e.g. forest-fringe communities; Ministry of Forestry 2002).

Forest genetic resources are considerably important in Indonesia, as shown by the designation of conservation forests. These forests account for approximately 17% of the country's total forest area. Together with protection forests they occupy a protected area of 54 000 000 ha, or roughly 45% of the total forest area. Considering the inherent characteristics of conservation forests, the government has taken various measures to secure them by law. Several legal instruments have been put into effect, and various planning frameworks have been developed through national initiatives and cooperation with international partners. The government has also recognized the value of a number of Indonesia's protected areas which are of particular global importance, as shown by the support it has given in the designation of biosphere reserves by the United Nations Educational, Scientific, and Cultural Organisation (UNESCO).

Legal framework

Some legislation in Indonesia related to forestry and biodiversity has been enacted, although most of the legislation does not directly concern genetic resources. Regulations which affect the policy on forest genetic resources in Indonesia can be described as follows:

- Act No. 5/1990 on Conservation of Living Resources and Their Ecosystems
- This act emphasizes protection efforts including the protection of buffer zones and biodiversity preservation. There are no specific statements related to forest genetic resources conservation and management. Under this act, conservation areas were divided into two: sanctuary reserve and nature conservation. The sanctuary reserves

consist of nature reserves and wildlife sanctuaries, whereas the nature conservation areas comprise national parks, grand forest parks and nature recreation parks.

- Act No. 5/1994 on Ratification of Convention on Biological Diversity (CBD): approves the application of the convention and related agreements in Indonesia.
- Act No 23/1997 on Environment: regulates policy aspects and environmental management of natural and man-made resources including genetic resources.
- Act No 41/1999 on Forestry
- Conservation forest is defined as a forest area with specified characteristics and having as a main function the conservation of biological diversity (flora and fauna) and the ecosystems. Conservation forests are divided into three different categories: sanctuary reserve, nature conservation area and hunting area. The act includes a specific statement on the conservation of flora and fauna, but there are no statements directly related to genetic resources.
- Act No 29/2000 on Protection of New Variety of Plants.
- The act regulates the property rights and benefit sharing of genetic resources and related products. It also relates with international agreements such as the CBD, the International Convention for the Protection of New Variety of Plants (the UPOV Convention), and the agreements of World Trade Organization (WTO).
- Minister of Forestry Decree No. 67/2004 on Distribution and Utilization of Teak Planting materials: regulates the use of teak genetic materials in the country including the need to use planting materials for which the origin is known
- Minister of Forestry Decree on Forest Tree Seeding No. P 10/2007
- This decree regulates the conservation and management of forest genetic resources, certification of forest seed source, tree improvement activities, and provision and distribution of seeds of forest trees. This is the only regulation directly related to FGR conservation in Indonesia. Several Directorate General Regulations were also set up following the decree in order to implement the regulation.

Currently Indonesia is in the process of formulating an act which will directly regulate utilization, management, and conservation of genetic resources, including forest genetic resources. The draft of the act is being finalized since several years.

Strategies and practices for the conservation of genetic resources

National strategies

Indonesian Biodiversity Strategy and Action Plan (IBSAP) covers the years 2003-2020. Eight points of policy direction for its implementation were determined (BAPPENAS 2003) as follows:

- Enhance the capacity of communities in managing biodiversity
- Enhance assessment and development of knowledge and technology in sustainable management of biodiversity
- Increase the sustainability of functions and ecosystem balance at the local, regional and national levels
- Improve national economy through the development of environmentally and socially sound, biodiversity-based technology
- Improve management systems (conservation, rehabilitation, utilization) of biodiversity on a fair and sustainable basis

- Develop institutional framework, local and national policy and an effective law enforcement in a synergic management of biodiversity
- Encourage deconcentration and decentralization of central government authority on managing biodiversity to local governments and communities on a gradual and selective manner
- Develop mechanisms for the resolution of conflicts on natural resources and biodiversity at the local, regional, national and international levels

These eight points are expected to be followed up by the relevant ministries and other government institutions, organizations and other stakeholders. However, as each ministry and organization has also set up a priority policy and actions, progress in the implementation of the strategy varies among them.

The Ministry of Environment of Indonesia coordinates a National Commission and Working Group on Germ Plasm. The commission consists of representatives of related ministries and other government institutions as well as experts from various universities and institutes of research and development. The task force is, however, focused on agrobiodiversity. Its objective is to coordinate programmes and activities related to genetic resources (agriculture and forestry), especially in translating the Article 15 of the CBD at the national level to suit national development objectives. By June 2008, commissions had been established in 19 provinces.

Conservation and management practices of forest genetic resources

As mentioned previously, IBSAP has been applied as a guide in the conservation of natural resources, including forest genetic resources. Examples of the conservation efforts include *in situ* conservation in terrestrial parks and protected areas, *in situ* conservation outside the networks of protected areas, coastal and marine conservation, and *ex situ* conservation.

In situ conservation

Indonesia has a system of protected areas which includes *in situ* conservation. Classification of conservation areas in Indonesia is shown in Table 1.

In situ conservation is also practiced by forest concession companies by implementing 'genetic resources areas'. This practice is compulsory for the companies in order to provide

Table 1. Conservation areas in Indonesia in 2002 and 2006 (area in 1000 ha; Ministry of Forestry 2002; 2007).

Type of conservation area	Terrestrial conservation				Marine conservation			
	2002		2006		2002		2006	
	Units	Area	Units	Area	Units	Area	Units	Area
Nature Reserve	175	2 354	241	4 525	8	211	8	404
Wildlife Sanctuary	47	3 517	71	5 005	3	65	5	338
Nature Recreation Park	81	281	104	269	14	668	19	770
National Park	34	11 069	43	12 330	6	3 681	7	4 045
Grand Forest Park	16	332	21	347				
Hunting Park	15	247	15	226				
Total	**368**	**178 00**	**395**	**22 702**	**31**	**4 625**	**39**	**5 557**

seed supply for the establishment of plantation forests and the purposes of enrichment planting. Each company has to allocate 100 ha as seed stands in their each 5-year operation plan. In addition to the genetic resources areas, the companies must also allocate an area of 100-300 ha for germplasm conservation. The practice must meet three criteria of species target: (1) tree species from endangered population, (2) tree species with low regeneration capacity, and (3) tree species which are scarce in their natural habitats. This practice was, however, found ineffective. The companies did not fully understand the strategy, there was no further strategy following the implementation, and monitoring and evaluation of the practice were also lacking.

Ex situ conservation

Ex situ conservation in Indonesia is practiced for two purposes: conservation practices and tree improvement. The form of *ex situ* conservation is usually botanical gardens. The 17 botanical gardens of the country include the Bogor botanical garden (87 ha) in West Java which has species collection of mainly tropical rain forest species, the Purwodadi botanical garden in East Java with deciduous forest species as major species, and the Bali botanical garden which has a collection of 936 species from 156 families.

Various research institutes have also established some arboreta. Most of the 15 research institutes under the Forestry Research and Development Agency (FORDA) have established arboreta or conservation plots. As part of a long-term research in tree improvement, the Centre for Forest Biotechnology and Tree Improvement (CFBTI) has established *ex situ* conservation plots for *Santalum album* and *Artocarpus altilis*.

Ex situ conservation for *Shorea leprosula* and *Lopophetalum multinervium* was established by the Gadjah Mada University in collaboration with several states and private-owned companies. As to teak, the state-owned forestry enterprise Perhutani established *ex situ* conservation areas in 1999 by collecting plus trees from different origins throughout Indonesia.

Tree improvement

The CFBTI conducts tree improvement research focusing on 11 species: *Acacia mangium, Eucalyptus pellita, Melaleuca cajuputi, Santalum album, Paraserianthes falcataria, Tectona grandis, Araucaria cunninghamii, Morus* spp., *Artocarpus altilis, Eusideroxylon zwageri, Alstonia* spp.. and *Intsia* spp. *In situ* conservation and *ex situ* conservation activities developed as part of tree improvement research are shown in Table 2.

Priority species

Indonesia does not have national lists of priority species for the conservation of forest genetic resources or tree improvement. As there is a large variation among regions in terms of biodiversity, species characteristics, social and cultural values, each region has its own priority species to promote. As a result there is no formal document listing priority species at the national level. The existing list of priority species (Appendix 1) was compiled from various institutions as included in a previous country report (Nur Masripatin *et al.* 2004).

National movement on forest and land rehabilitation

There is a national movement on forest and land rehabilitation (GERHAN), where genetic conservation has been given more attention especially in species selection for the target regions. Matching of sites and species has been an important consideration in selecting species for all target regions. In particular, species used for rehabilitation programmes of degraded conservation forests must be endemic to the targeted conservation areas.

National coordination on the conservation of forest genetic resources

National APFORGEN Secretariat

Indonesia is a member of the Asia Pacific Forest Genetic Resources Programme (APFORGEN). The Centre for Plantation Forest Research and Development (CPFRD) in its capacity as the National Coordinator for APFORGEN has carried out activities under the terms of reference of the National Coordinators as stated in the joint letter of assignment from Bioversity (former IPGRI) and Asia Pacific Association of Forestry Research Institutions (APAFRI). A National APFORGEN Secretariat has been established at the CPFRD in 2004 with annual activities in line with national forestry policies and the APFORGEN Action Plan 2005-2007. The Secretariat issues publications such as leaflets, flyers, workshop proceedings, and the bi-monthly Newsletter on APFORGEN activities at the national level.

A national workshop on FGR conservation and management has been organized by the CPFRD annually since 2004. The first workshop was intended for identifying stakeholders, sharing information on the status of research and development on FGR, and gathering relevant inputs for FGR conservation and management. The outputs of the workshop were brought to the meeting of National Coordinators of the South East Asia region in Kuala Lumpur in 2004 as inputs from Indonesia for the draft of APFORGEN Action Plan 2005- 2007.

The second national workshop was conducted in 2005. It focused on reviewing the policy on FGR and introduction of a concept on village level FGR conservation and management (in Indonesian, *Konservasi Sumberdaya Genetik Tanaman Hutan Tingkat Desa,* KSDGTH-TD*)*, and identified stakeholders to carry out the relevant tasks. The concept was introduced with the consideration that the enormous challenges faced by Indonesia in the conservation and management of FGR in a large scale, both *in situ* and *ex situ* conservation activities needed to be complemented with smaller-scale activities as models for implementation.

The third workshop was held in November 2006, to discuss scientific considerations related to the KSDGTH-TD programme, formulate its technical details, and assess institutional aspects to enable early actions in the field. It was clearly stated in the opening speech of the Minister of Forestry that an effective follow up after the workshop would be critical for the KSDGTH-TD. Furthermore, the recent workshop recommended a number of immediate follow-up actions which needed to be discussed further with key stakeholders.

The latest workshop was held in March 2007 in Bogor, Indonesia. About 50 participants attended the workshop, representing the key stakeholders, government institutions, research institutions, universities, local government, NGOs and individuals working on the conservation and management of FGR.

Task Force Team for the APFORGEN National Coordinator

In 2007, a Task Force for FGR conservation was established by the Forest Research and Development Agency (FORDA) to support the Indonesian National Coordinator of APFORGEN. One of the underlying reasons for the establishment of the Task Force is its importance in facilitating, monitoring and evaluating the implementation of FGR conservation by cross-sector stakeholders. The other rationale is that the Task Force is needed to give direction towards the implementation of the APFORGEN Secretariat programme (e.g. Centre for Plantation Forest Research and Development). The roles and responsibilities of the Task Force are to

- Give direction for the APFORGEN National Focal Point through providing information and direction on technical aspects for the implementation of FGR conservation activities according to procedure
- Determine an action programme for FGR conservation and coordinate the dissemination of related information to related parties at the national level
- Monitor and evaluate the implementation of FGR conservation
- Review the action programme of FGR conservation (along with the APFORGEN Secretariat)

In 2008, the Task Force met four times. It was concluded that the work plan of the Task Force is created for a time period of five years, and it will be reviewed annually. The work plan should be realistic and avoid redundancy and duplication of actions among the institutions. The team's task is to gain information on the programmes and activities related to genetic resources conservation from stakeholders. The main focus of attention is, however, still on the demonstration plots supported by the APFORGEN Secretariat (plots located in Java in Cilacap, Gunungkidul, Blitar, Cicurug and Tasikmalaya) to keep the programme sustainable. The Task Force programme to be followed-up by the APFORGEN Secretariat includes the integration of conservation activities, use and management of FGR locally (in villages), determination of conserved priority species with consideration of social conditions, and the active involvement of community in conservation activities. The team also promotes the dissemination of the APFORGEN programme by the Indonesian National Coordinator of APFORGEN through varied meetings, within the Ministry of Forestry, and in television programmes. Another plan requiring an immediate follow-up is the identification of stakeholders who will be partners in APFORGEN programmes in order to establish synergy and integration of conservation activities in the field.

National Partners' meetings and information sharing

Meetings of National Partners of APFORGEN are held twice a year. The first meeting was held in Bogor in June 2008. In total 38 institutions related to the forest genetic resources (FGR) in Indonesia were invited to the meeting, and 26 participants from 22 institutions attended the meeting. The participants represented governmental organizations, enterprises and companies, non-governmental organizations and universities. The objectives of the meeting were to (1) disseminate information on the work and practices of APFORGEN; (2) develop networking across the involved institutions, (3) consolidate the management programme of forest genetic resources across the institutions, and (4) agree on follow-up actions. The important results of the meeting included the following proposals:

Development of networking across the involved institutions and stakeholders

- In order to identify the areas of work and the potential of each institution relevant to FGR conservation, a database is needed which describes the related activities of the institutions. This will also assist the National Coordinator of APFORGEN in establishing an integrated work plan for FGR conservation.
- A mailing list is needed to facilitate exchange of information related to FGR conservation.
- Regular meetings are necessary between the National Coordinator of APFORGEN and the institutions and organizations who conduct activities related to FGR conservation in order to strengthen networking across the stakeholders.

Table 2. Priority species for research and development determined by the Forestry Research and Development Agency (FORDA), Ministry of Forestry (Nur Masripatin *et al.* 2004). SSO = seedling seed orchards, CSO = clonal seed orchards.

Species	Research area	Research organizations
Santalum album	Microbiology, e*x situ* gene conservation, genetic tests (molecular biology), establishment and evaluation of SSO, vegetative propagation, forest protection (pest and disease), reproduction biology, silviculture, chemistry (oil content test)	Centre for Plantation Forest Research and Development (CPFRD), Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Kupang Forest Research Institute, CFP
Eusideroxylon zwageri	*Ex situ* gene conservation, genetic test (molecular biology), vegetative propagation, silviculture	CPFRD, Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Samarinda Dipterocarp Research Office, Pelambang Forest Research Institute, Banjarbaru Forest Research Institute
Araucaria cunninghamii	*Ex situ* gene conservation, genetic test (molecular biology), establishment of CSO, progeny test, silviculture, chemistry (oil content test)	CPFRD, Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Papua Forest Research Institute
Melaleuca cajuputi subsp. *cajuputi*	Establishment and evaluation of SSO/CSO, reproduction biology, hydrology	CPFRD, Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Kupang Forest Research Institute, Makasar Forest Research Institute
Acacia mangium and Eucalyptus spp.	Forest protection (Pest and Disease), multi- site test, silviculture, evaluation of SSO-F2, reproduction biology, wood technology, hydrology	CPFRD, Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Palembang Forest Research Institute, Banjarbaru Forest Research Institute, Makasar Forest Research Institute
Alstonia spp.	Microbiology, vegetative and generative propagation, e*x situ* gene conservation, establishment of propagation population and SSO, silviculture	CPFRD, Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Palembang Forest Research Institute, Banjarbaru Forest Research Institute, Kupang Forest Research Institute
Intsia spp.	*Ex situ* and i*n situ g*ene conservation, genetic test (molecular biology), vegetative and generative propagation, progeny test, silviculture	CPFRD, Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Palembang Forest Research Institute, Banjarbaru Forest Research Institute
Tectona grandis	Clonal test, intensive silviculture, establishment and evaluation of SSO/CSO, genetic tests (molecular biology), wood technology	CPFRD, Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Kupang Forest Research Institute, Makasar Forest Research Institute, Palembang Forest Research Institute, Banjarbaru Forest Research Institute, Centre for Forest Product Research and Development (CFP)

Species	Research area	Research organizations
Paraserianthes falcataria	Progeny test, silviculture, establishment of CSO, resistant tree breeding	CPFRD, Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Ciamis Forest Research Institute
Artocarpus altilis	*Ex situ g*ene conservation, establishment and evaluation of CSO and hedge orchard, establishment of propagation population	Yogyakarta Forest Biotechnology and Tree Improvement Research Office, Makasar Forest Research Institute
Dyospyros celebica	Silviculture, distribution, growth requirements, microbiology	Centre for Forest and Nature Conservation Research and Development (CFNC), CPFRD, Makasar Forest Research Institute
Dyera costulata	Silviculture, distribution, growth requirements, microbiology	Palembang Forest Research Institute
Shorea johorensis	Silviculture, distribution, growth requirements, microbiology, forest protection (pest and disease)	Samarinda Dipterocarp Research Office, Palembang Forest Research Institute, Banjarbaru Forest Research Institute
Shorea stenoptera	Silviculture, growth requirements, forest protection (pest and disease)	CFNC, Samarinda Dipterocarp Research Office, Banjarbaru Forest Research Institute, Aek Nauli Forest Research Institute
Swietenia macrophylla	Silviculture, distribution, growth requirement, forest protection (pest and disease)	CFNC
Morus spp.	Evaluation of CSO and hedge orchard, establishment of propagation population	CFNC, Makasar Forest Research Institute

Consolidation of a management programme for forest genetic resources across the involved institutions

- Criteria of prioritized species for conservation should be more clearly determined (e.g. rarity or economic aspects). The emerging issues such as climate change and demand for energy should also be considered.
- Activities related to FGR conservation have been carried out by different institutions with varied levels and purposes. These include (i) self-supporting nurseries, maintained by the Directorate of Forest Tree Seed under the Ministry of Forestry, (ii) the Conservation Village Model maintained by the Gunung Halimun National Park, and (iii) conservation village by the KEHATI Foundation and Conservation International.
- Other recent or current efforts carried out by varied stakeholders include community-based FGR conservation (by the KEHATI Foundation); the development of Biodiversity Garden (Ministry of Environment); training on FGR conservation (Directorate of Forest Seed, Ministry of Forestry); *ex situ* conservation of tropical species, reintroduction of plant collection to community and establishment of new Botanical Gardens in each province (Centre for Plant Conservation, Bogor Botanical Garden), and varied research and development activities by some other R&D institutions.
- There is a need for a Genetic Conservation Programme which is well-integrated, within the Ministry of Forestry as well as in the national level.
- The involvement of communities in FGR conservation activities should be directly beneficial in order to maintain the continuity of the programme
- Databases on conservation activities and priority species are urgently needed.

- Self-supporting implementation of FGR conservation plots should be encouraged. For instance, the Forestry Service of Blitar is preparing an area of 55 ha intended to the conservation of the Island of Wadang, following the 5-ha demonstration plots provided by the Secretariat of APFORGEN.
- Mechanisms for the exchange of germplasm of selected forest tree species should be clear, transparent, equitable and mutually-beneficial as it is associated to the intellectual property rights.
- Governmental and private enterprises should commit to involve in providing area for conservation activities.
- The following steps of conservation programme activities should be reviewed: (i) studies to gain technology, (ii) networking to identify existing potential, and (iii) actualization and actions in the field.
- Dissemination of programme and FGR conservation guidelines need to be included in short-term programmes.
- Other suggestions presented in the meeting included organizing the National Partners' Meeting two or three times a year; a funding proposal for a possible climate change programme; the establishment of coordinator at regional level; and an award for FGR conserver.

Follow-up steps to be taken

- Improvement of communication intensity through mailing list, by publishing newsletters and flyers and by organizing periodical meeting.
- Information exchange on FGR conservation programme

Recent activities related to the implementation of national policy on forest genetic resources

Database on priority species for genetic resources and tree improvement

Forest resources were seriously affected by economic and social crises for some years in late 1990s. Based on the data of the Ministry of Forestry, forest degradation reached 2 830 000 ha yearly. Of the 120 300 000 ha of forest areas, at least 59 700 000 ha are degraded and need to be rehabilitated. Illegal logging and trade, forest fires and forest encroachment are among the causes of forest degradation, and may consequently threaten genetic diversity of species or even lead to species extinction. Conservation activities and tree improvement are needed to save the genetic resources and ecosystems, to preserve the production values of forests and to increase the usage value of their genetic resources. Because of the wide variety of forest genetic resources species, prioritization of species is necessary. It can be based on determining the existing benefit values, future potential values and the status of conservation of species. For this reason, the CPFRD has compiled a database on 60 priority species for genetic resources and tree improvement, including the taxonomy, spreading, ecological characteristics, reproduction biology, usefulness, genetic variation and status of conservation. These priority species include dipterocarp species, *Eusideroxylon zwageri* (ulin), *Gonystylus bancanus* (ramin), *Dalbergia latifolia* (sonokeling), *Agathis borneensis* (damar), *Duabanga moluccana* (benuang) and *Pinus merkusii* (dammar batu).

Conservation of forest genetic resources at village level

The concept on FGR conservation at village level is developed as a basis for conservation

activities. It takes into account the availability of farm land, crop species and the potential to directly benefit local communities. Villages, which number over 70 000 in Indonesia, are adopted as conservation units. If each village could conserve one species, Indonesia would be able to conserve at least 4 000 species, assuming that not all villages would be involved in this activity. Some institutions have initiated efforts related to the conservation of genetic resources in forest plantations at village level. Examples of these include the following:

Government institutions

- The Directorate General of Forest Protection and Conservation, Ministry of Forestry, has 132 model villages surrounding national parks. They are involved mostly in conservation of fauna.
- The Directorate General of Rehabilitation and Social Forestry, Ministry of Forestry, has demonstration plots on seedlings managed by villages or groups of farmers
- The CPFRD under the Forest Research and Development Agency (FORDA) has demonstration plots on the conservation and management of FGR at village level in Gunungkidul (Yogyakarta), Cilacap (Central Java), Blitar (East Java), Cicurug and Ciawi Tasikmalaya (West Java).

Local governments

- Cilacap has permanent seed orchard
- Banyumas has a 20-ha demonstration plot

Non-governmental organizations

- LATIN has a model villages of conservation situated in East Java (Jember, 7 ha) and West Java (Halimun and Ciremai)
- KEHATI in Yapen Papua is involved in pandan conservation;
- DAS Barito is involved in the development of rattan and non-timber forest products
- Mt Murai has plantations of local herbs.

Private sector

- PT Wira Karya Sakti provided an area of 9000 ha in the forest production area for the exploitation of jernang, gaharu and petai species in collaboration with a local NGO and the local government.

Guidelines for conservation activities at village level

The Task Force team for APFORGEN has compiled and published a book on the guidelines for FGR conservation at village level. The publication is intended as a guidance and reference to all stakeholders (government, NGOs, private sector, individuals) who initiate to implement FGR conservation and management activities at the village level. The book contains all steps of the necessary activities, starting from the description of conservation and management types for FGR, and planning, executing and managing demonstration plots for FGR conservation.

Demonstration plots for the conservation and management of forest genetic resources

The CPFRD has established demonstration plots on FGR conservation and management in order to conserve endangered species and to demonstrate to local communities how to realize activities for FGR conservation at a village level. Thereby, the local communities are expected to initiate FGR conservation activities. Examples of these demonstration plots are presented in Table 3.

Table 3. Conservation and management of forest genetic resources at village level

Plot (location)	Ownership	Implementing group	Area (ha)	Species
Gunungkidul (Wonosari, Gunungkidul)	Under the local government related with forestry	Farmer group of Podang Ngisep	3	15 species: *Stelechocarpus burahol, Santalum album,Manilkara kauki, Kleinhovia hospital, Aleurites moluccana*, *Acacia mangium*, *Alstonia* sp., *Pterocarpus indicus*, *Swietenia* sp., *Pongamia pinnata*, *Ficus glomerata, F. cerifera, Calophyllum inophyllum*, *Adenanthera* sp., *Parkia speciosa*
Cilacap (Cilacap, Central Java)	Under institutions of natural resources conservation	Farmer group Wana Terpadu	5	6 species: *Artocarpus elastica*, *Parkia* sp., *Pinus roxburghii*, *Eugenia polyantha*, *Ceiba pentandra*, *Pithecellobium* sp.
Blitar, (Blitar, East Java)	Village property	Farmer group	5	1 species: *Pterospermum javanicum*
Cicurug (Sukabumi, West Java)	Village property	Local communities of Nangerang village	5	20 species: *Baccaurea lanceolata, Eusideroxylon zwageri, Eugenia cumini, Anthocephalus cadamba, Hibiscus macrophyllus, Dysoxylum caulostachium, Alstonia scholaris, Sandoricum koetjape, Schima wallichii, Syzygium polyantum, Castanopsis argentea, Altingia excelsa, Pricopsis mooniana, Shorea stenoptera, Gonystylus bancanus, Artocarpus rigidus, Praserianthes falcataria, Toona sureni, Diospyros celebica, Michelia champaca*
Ciawi (Tasikmalaya, West Java)	Village property	Local communities of Bugel village	5	16 species: *Paraserianthes falcataria, Toona sureni, Swietenia macrophylla, Syzygium polyantum, Peronema canescens, Pometia pinnata, Dalbergia latifolia, Alstonia scholaris, Syzygium* sp., *Altingia excelsa, Schima wallichii, Magnolia blumei, Diospyros celebica, Shorea platyclados, Artocarpus heterophyllus, Mangifera odorata*

Challenges and conclusions

Challenges in the conservation and management of forest genetic resources

Major challenges for the conservation and management of FGR in Indonesia include

- the lack of specific regulations related to conservation and management of the resources
- the lack of funds, facilities and qualified human resources
- awareness of the importance of conservation and management of FGR is relatively low
- mobilization of alternative funding is still difficult.

The first and third challenges require more national efforts, while the remaining two require collaborative activities at regional and international levels.

Conclusions

1. Setting of priority species which are approved by stakeholders in each participating country should be prioritized as the main programme.
2. Conservation and management of FGR should be supported by many institutions. In order to gain support, conservation and management of FGR should provide benefits for stakeholders. Participation of the people is crucial for the success of the programme.
3. Government facilitation is needed in the programmes of conservationa and management of FGR in order to provide direction, technical assistance and other stimulation for participation
4. Conservation and management of FGR at village level is an alternative form of participation of the people in the programme
5. Future policy in Indonesia would emphasize rehabilitation of degraded forests and lands, and conservation of the remaining natural forests. Advances in research and information exchange are needed in terms of species domestication, tree improvement and genetic conservation.
6. Research on environmental management of plantation forests, particularly in monoculture plantations, is important for a sustainable management of genetic resources.

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Appendix 1.

Priority species for the conservation and management of forest genetic resources in Indonesia (Nur Masripatin *et al.* 2004).

No.	Species	Product type		Source*
		Timber	Non-timber	
1	*Acacia auriculiformis*	x		CFBTI
2	*Acacia crassicarpa*	x	x	CFBTI
3	*Acacia mangium*	x		CFBTI
4	*Agathis borneensis*	x		Perhutani
5	*Agathis loranthifolia*	x		
6	*Aleurites moluccanus*	x	x	
7	*Alstonia palembanica*	x		
8	*Alstonia scholaris*	x		CFBTI
9	*Altingia excelsa*	x	x	
10	*Anthocephalus chinensis*	x		
11	*Aquilaria malaccensis*		x	FORDA
12	*Araucaria cunninghamii*	x		CFBTI
13	*Arenga pinnata*		x	
14	*Artocarpus altilis*		x	CFBTI
15	*Artocarpus heterophyllus*	x	x	
16	*Azadirachta excelsa*	x	x	
17	*Calamus manan*		x	FORDA
18	*Calophyllum inophyllum*	x	x	
19	*Canarium asperum*	x	x	
20	*Cassia siamea*	x		
21	*Cassia vera*		x	
22	*Casuarina equisetifolia*		x	
23	*Casuarina junghuhniana*	x		
24	*Ceiba pentandra*		x	
25	*Cinnamomum* sp.	x	x	FORDA
26	*Cynometra ramiflora*		x	CFBTI
27	*Dalbergia latifolia*	x		Perhutani
28	*Diospyros celebica*	x		
29	*Dipterocarpus* spp.	x		
30	*Dryobalanops aromatica*	x	x	
31	*Duabanga moluccana*	x		
32	*Durio zibethinus*	x	x	
33	*Dyera costulata*	x	x	
34	*Dysoxylum mollissimum*	x		
35	*Elmerrillia ovalis*	x		
36	*Eucalyptus deglupta*	x		
37	*Eucalyptus pellita*	x		CFBTI
38	*Eucalyptus urophylla*	x		
39	*Eusideroxylon zwageri*	x		CFBTI
40	*Fagraea fragrans*	x		
41	*Gmelina moluccana*	x		
42	*Gnetum gnemon*		x	
43	*Gonystylus bancanus*	x		Appendix III CITES, CFBTI, CFNC
44	*Hopea mengarawan*	x		
45	*Intsia bijuga*	x		CFBTI
46	*Koompassia malaccensis*	x		
47	*Lophopetalum multinervium*	x		UGM, FORDA
48	*Manilkara kauki*	x	x	CFBTI
49	*Melaleuca cajuputi var.cajuputi*	x	x	CFBTI
50	*Melaleuca leucadendra*	x		FORDA
51	*Mesua ferrea*		x	CFBTI
52	*Metroxylon sagu*		x	

No.	Species	Product type		Source*
		Timber	Non-timber	
53	*Mimusops elengi*		x	
54	*Myristica fragans*		x	
55	*Ochras zapota*	x		
56	*Octomeles moluccana*	x		
57	*Palaquium amboinense*	x		
58	*Palaquium rostratum*	x	x	
59	*Paraserianthes falcataria*	x	x	CFBTI
60	*Parkia speciosa*		x	
61	*Pericopsis mooniana*	x		
62	*Peronema canescens*	x		
63	*Pinus merkusii*	x	x	Perhutani, UGM
64	*Pithecellobium jiringa*		x	
65	*Pometia pinnata*	x	x	
66	*Pterocarpus indicus*	x	x	
67	*Rhizophora* spp.	x		
68	*Samanea saman*		x	
69	*Santalum album*	x	x	CFBTI
70	*Schima wallichii*	x	x	
71	*Schleichera oleosa*	x	x	
72	*Shorea javanica*	x	x	
73	*Shorea johorensis*	x		
74	*Shorea laevis*	x		
75	*Shorea leprosula*	x		UGM, FORDA
76	*Shorea macrophylla*		x	
77	*Shorea ovalis*	x		
78	*Shorea parvifolia*	x		
79	*Shorea pinanga*		x	CFBTI
80	*Shorea polyandra*	x		
81	*Shorea selanica*	x		
82	*Shorea stenoptera*	x	x	
83	*Styrax benzoin*		x	
84	*Swietenia mahagoni*	x		Perhutani, FORDA
85	*Tamarindus indica*		x	CFBTI
86	*Tarrietia* spp.	x		
87	*Tectona grandis*	x		CFBTI, Perhutani
88	*Toona sureni*	x		
89	*Vitex pubescens*	x		

* Data sources:
CFBTI: Centre for Forest Biotechnology and Tree Improvements
FORDA: Forestry Research and Development Agency
UGM: University of Gadjah Mada
Perhutani: a state-owned forestry enterprise

Status of Malaysia's forest genetic resources – their conservation and management practices

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Forest genetic resources are defined as genetic diversity in trees and other organisms of potential or present benefit to human. It refers to diversity of genetic origin (DNA) and diversity of genes at different levels: between species, between populations within species, and between individuals within a population (FAO 2007). Genetic diversity provides the fundamental basis for the evolution of forest tree species and for their adaptation to environmental changes, including climate change. Genetic diversity is also essential for selection and breeding to meet the present and future human needs. Conserving forest genetic resources is therefore vital, as they are a unique and irreplaceable resource for the future.

Forest genetic resources are a component of forest biodiversity, which denotes the variability among forest living organisms and the ecological processes of which they are part. The overall goal in the conservation and management of forest genetic resources is to help ensure that forest biodiversity, at all levels, is conserved, managed and sustainably used in support of local and national development, including food security, poverty alleviation, environmental conservation, economic and social advancement and the maintenance of cultural and spiritual values.

Malaysia is located between latitudes 1°N to 7°N and longitudes 100°E to 119°E. It comprises two distinct regions separated by about 650 km of the South China Sea: Peninsular Malaysia and East Malaysia which consists of Sarawak and Sabah. Peninsular Malaysia comprises 11 states and two federal territories, Kuala Lumpur and Putrajaya. It occupies the southern half of the Malay Peninsula, bordered on the north by Thailand, on the south by Singapore, on the west by the Strait of Malacca, and on the east by the South China Sea. The states of Sabah and Sarawak, and the federal territory of Labuan, occupy the northern third of the island of Borneo. The land area of the country is approximately 329 750 sq. km, of which 40% is on the Peninsula and 60% Sabah and Sarawak.

Topographically, Peninsular Malaysia is characterized by extensive coastal plains in the east and west, hilly and mountainous region with steep slopes in central areas, and undulating terrain in other parts of the peninsula. Sabah is characterized by the western lowlands, the Crocker Range, the central uplands and the eastern lowlands. Sarawak, in turn, is characterized by the coastal region made up of low-lying flat lands with a large extent of swamps and other wet environments, the hill region, a mountain region along the border, and the highlands in the north.

Malaysia is fortunate to have extensive areas of valuable natural tropical rainforests. The combination of warm equatorial climate and the variation of geographical, edaphic and climatic features have resulted in the extremely rich forest biodiversity of Malaysia. Indeed, Malaysia is considered one of the 12 mega-diverse countries in the world. The country has undergone rapid economic development since its independence in 1957. This was possible because of the use of the rich natural resources, and also development of human capital. Inevitably, some of the original forests were converted to agriculture, plantation and urban development. In addition, it is foreseen that extensive tracts of the existing forests may be degraded to various degrees through damage from pests, diseases, fire, atmospheric pollution, and climatic variation and fluctuations.

This paper provides an assessment of the conservation and management of forest

genetic resources in Malaysia as a whole, focusing mainly on plant forest genetic resources. The information was collected from varied literature and through consultations with the government departments and non-governmental organisations.

Forest resources

Data on the forest cover in Malaysia differ somewhat between sources. According to the Ministry of Primary Industries, the total forested area in Malaysia in 2001 was 20 200 000 ha, or 62% of the country's land area (Ministry of Primary Industries 2002). Distribution and extent of natural forest by major forest types is detailed in Table 1. If one considers also the 4 800 000 ha planted under fast-growing agricultural tree crops, notably rubber and oil palm, the total area under permanent tree cover in Malaysia is estimated to be 25 000 000 ha (Ministry of Primary Industries 2002), amounting to about 76% of the total land area.

Of the total forested area in 2001, 14 450 000 ha or about 44% of the total land area is designed as Permanent Forest Estate (PFE) to be managed sustainably for the benefit of present and future generations. Of the total PFE, approximately 3 810 000 ha are classified as Protection Forest with the remaining 10 640 000 ha being classified as Production Forest. The function of the Protection Forest is to ensure climatic stability, protection of water resources, soil fertility, environmental quality, conservation of biological diversity and the minimization of damage by floods and erosion to rivers and agricultural lands. The role of the Production Forests is to provide a sustainable supply of forest and timber products for agricultural and industrial purposes and for export (Ministry of Primary Industries 2001).

Table 1. Distribution and extent of natural forest by major forest types in Malaysia in 2001 (Ministry of Primary Industries 2001; 2002).

Land classification	Region (1000 ha)			Total
	Peninsular Malaysia	Sabah	Sarawak	
Land area	13 150	7 370	12 300	32 820
Inland forest (Dipterocarp)	5 460	3 810	8 640	17 910
Swamp forest	300	120	1 040	1 460
Mangrove forest	110	340	130	580
Plantation forest	70	150	30	250
Total forested land	**5 940**	**4 420**	**9 840**	**20 200**
% of land forested	**45.2**	**60.0**	**80.0**	**62.0**

Legal framework

Malaysia has a federal system of government. Under the Article 74(2) of the Malaysian Constitution, land (including forested land) is defined as a state responsibility and each state is empowered to enact laws and to formulate their policy independently. Hence, the reservation and revocation of the PFE and conservation areas are effected by state legislation. The executive authority of the federal government only extends to the provision of advice and technical assistance to the states and the conduction of research. Such a distinct division of powers poses a challenge to ensure that national policies relating to forestry and formulated at the federal level will be implemented in a coordinated manner at the state

level. To facilitate the coordination between the federal and state governments, the establishment of a National Forestry Council (NFC) was accepted in 1971 and endorsed on 19 April 1978 by the National Land Council. The National Forestry Council is chaired by the Deputy Prime Minister and its aim is to serve as a forum for the federal and state governments to discuss forestry issues, such as planning, management and development of the forest resources. The Council also plays a major role in encouraging the adoption of federal acts at state level. Members of the NFC include the chief ministers from all states and the ministers responsible for forestry, agriculture, environment and trade.

The key to responsible forest management in Malaysia has been a policy of ensuring the continuity of product flow while conserving complex ecosystems rich and varied in flora and fauna. In this context, the National Forestry Policy 1978 and the National Forestry Act 1984 (amended 1993) provide the basis for systematic management, development and conservation of the forest resources. The National Forestry Act stipulates the preparation of forest management plans and the classification of forest for various functional classes.

The revised National Forestry Policy of 1992 and the amended National Forestry Act of 1993 manifest a vital change in the philosophy of forest management: from simply ensuring sustainable timber yields to sustainable management of the multiple functions of the forests. The effectiveness of forest management is based not just on forests' capacity to produce wood in perpetuity, but more on how forests are managed to balance ecological, social and environmental functions with their economic importance.

A number of other federal legislations complement and support the National Forestry Act. These include

- Water Enactment 1920 which provides guidelines for the maintenance of riparian strips of river reserves
- Land Conservation Act 1960
- National Land Code 1965
- Protection of Wildlife Act 1972 (amended in 1976 and 1988) which provides a legal framework for the protection of threatened and endangered species
- Malaysian Timber Industry Board Act 1973
- Environmental Quality Act 1974 (amended 1985) which prescribes the assessment of environmental impacts for activities involving forest land
- National Parks Act 1980 (amended 1983) which provides a legal framework for the conservation of national and state parks
- Malaysian Forestry Research and Development Board Act 1985
- Biosafety Act 2007.

Apart from the National Forestry Policy, however, various state governments have their own forest policies. In the case of Sarawak, the forest policy adopted in 1954 provides the framework for forest management. In addition, Sarawak has also amended its forest laws and enacted new laws in order to strengthen its role and responsibilities in facing the challenges related to the implementation of sustainable forest management (SFM). The Forest Ordinance of 1958 was amended in 1996. The following legislations provide the legal basis for implementing the State's Forest Policy: Sarawak Public Parks and Greens Ordinance 1993; Sarawak Forest (Amendment) Ordinance 1996; Sarawak Biodiversity Centre Ordinance 1997; Sarawak Forests (Planted Forests) Rules 1997; Sarawak Biodiversity (Access, Collection and Research) Regulations 1998; Sarawak National Parks and Nature Reserves (Amendment) Ordinance 1998; Sarawak Wildlife Protection Ordinance 1998; Sarawak Wildlife Protection Rules 1998; Sarawak Land Code (Amendment) Ordinance 1998; and Sarawak Natural Resources and Environment (Amendment) Ordinance 2001.

Similarly, Sabah has formulated its own Forest Policy in 1948 and implemented it since 1954. Sabah also has enacted the Forest Enactment 1968 and the Forest Rules 1969. To

accommodate current challenges in the forestry sector, the Forest Enactment 1968 has been amended accordingly. Other state laws governing forestry include the Sabah Park Enactment 1984; Sabah Culture Heritage (Conservation) Enactment 1997; Sabah Wildlife Conservation Enactment 1997; Sabah State Water Resources Enactment 1998; Sabah Environment and Conservation Enactment 1999; and Sabah Biodiversity Enactment 2000.

In 1998, the National Biodiversity Policy was formulated to enhance the conservation of Malaysia's plant and animal life and creating a safe, healthy and productive environment (Ministry of Science, Technology and the Environment 1998). It is the first policy which has documented multisectoral involvement, including the Ministry of Primary Industries, the Ministry of Agriculture, and the Department of Wildlife and National Parks and Fisheries. This policy, among others, includes strategies to conserve biological diversity and the sustainable use of biological resources. It also outlines an action programme for each strategy geared towards achieving an adequate protection of the country's resources. The policy underscores the importance of managing the country's natural resources to ensure long-term economic benefits, food security and environmental stability.

On April 2005, the National Biotechnology Policy was unveiled. It outlines nine major initiatives to realise the country's potential in the biotechnology sector. One of the initiatives is to capitalize on the strengths of biodiversity in Malaysia to commercialize discoveries in natural products as well as position Malaysia in the bio-generics market. This policy is related, amongst others, to the utilisation of forest genetic resources (especially medicinal plants) through modern biotechnology tools towards economic development in the country.

Characterization of forest genetic resources

Having evolved over millions of years, Malaysia's rich and diverse tropical rainforests have been recognized internationally as a depository of megadiversity of both flora and fauna, and they act as a large storehouse of untapped genetic resources. The species diversity and the pattern of geographical distribution of present-day Malaysian flora and fauna have their roots in the geographical history of the region. Fossil records indicate that many species of Malaysian flora first appeared as long as 60–70 million years ago (Soepadmo 1998a). The incredible biodiversity found in the tropical forest of Malaysia is because of the amazing range and variety of habitats and local conditions found within even a small area of the rainforest, which allows many new variants of plant species to evolve, specialize and survive.

The characterisation of forest genetic resources depends critically on the contributions of three scientific disciplines. Taxonomy provides the reference system and depicts the pattern or tree of diversity for all organisms. Genetics give a direct knowledge of the genetic variation found within and between species. Ecology provides knowledge of the varied ecological systems in which taxonomic and genetic diversity is located and of which it provides the functional components.

Taxonomy

The exact number of plant species in Malaysian forests is not known. According to a recent assessment of biological diversity, the number of recorded plant species is about 15 000 (Ministry of Science, Technology and the Environment 1997). Turner (1997) listed in total 8198 vascular plants in Peninsular Malaysia. Some plant groups are better known than others. The Tree Flora of Malaya (Whitmore 1972, 1973; Ng 1978, 1989) covers every tree species of Peninsular Malaysia, except dipterocarps, which were covered by Symington

(1943) and Ashton (1982). The four volumes of the Tree Flora of Malaya describe nearly 2830 species of woody plants. Of these species 746 are endemic and 511 endangered because they are rare, hyper-endemic or their habitats are threatened (Ng 1991). The ongoing project of Tree Flora of Sabah and Sarawak (Soepadmo and Wong 1995; Soepadmo *et al.* 1996; Soepadmo and Saw 2000; Soepadmo *et al.* 2002, 2004, 2007) documents the tree species of Sabah and Sarawak.

In addition to trees, documented plant species in Peninsular Malaysia are ferns (Holttum 1954), orchids (Holttum 1964; Seidenfader and Wood 1992), grasses (Gilliland 1971), rattans (Dransfield 1979), bamboos (Wong 1995), gingers (Larsen *et al.* 1999) and *Nepenthes* (Clarke 2001). Furthermore, over 1300 plant species and 76 species of ferns have been documented to have potential pharmaceutical properties, and traditionally some of them are being used as herbal medicine (Burkill 1966). In general, herbaceous plants have been somewhat neglected in the study of taxonomy. For Peninsular Malaysia about 2600 species of herbaceous plants have been recorded, including 850 species belonging to the orchid family, and 650 species of ferns and fern allies. In Sabah and Sarawak at least 2500 herbaceous species are expected (Ministry of Science, Technology and the Environment 1997).

Endemic plants are confined in their occurrence to a specific area or habitat. Various estimates of endemism have been made for flowering plants. In Peninsular Malaysia 26% of tree species (Ng *et al.* 1990) and 24% of orchids (Kiew 1998a) are endemic. The highest levels for trees are 57% for the tea family (Theaceae) and 60% for the holly family (Aquifoliaceae; Kiew 1998a). For many groups of herbaceous plants, the level of endemism is even much higher; for example, 97% for *Begonia* species (Bignoniaceae) and 100% for *Didissandra* species (Gesneriaceae) in Peninsular Malaysia (Kiew 1998a).

Ecology

Much of the Malaysian forest genetic resources await investigation, understanding and documentation, but a complete inventory of all fauna and flora may never really be possible. The best way to evaluate the status of forest genetic resources in the country is to determine the status of the various ecosystems that harbour species diversity. Malaysia has a wide range of distinct ecological formation. The forests have been classified into several schemes, which vary according to substrate (i.e., dry or wet soil type), floristic composition, altitude and other features. Examples of widely used forest classification systems applicable to Peninsular Malaysia are given by Wyatt-Smith (1963), Symington (1943) and Whitmore (1990). A description of the forest profile in Sabah and Sarawak in comparison to that of Peninsular Malaysia is given by Ashton (1995).

In general, the forested area of Malaysia can be categorized into 16 habitat and vegetation types (Table 2). Lowland, hill and upper hill dipterocarp forests occur from sea level to an altitude of approximately 1200 m. They are the most complex and species-rich forest that flourish on the well-drained soils of the plains, undulating lands and foothills of Malaysia. These are world centre of species diversity for a number of tropical tree families, such as the Dipterocarpaceae, Bombacaceae, Clusiaceae, Euphorbiaceae, Myristicaceae and Myrtaceae.

At an altitude of about 1200–1500 m, upper hill dipterocarp forest merges into lower montane forest, which in turn become upper montane forests, and on Mount Kinabalu, subalpine and alpine vegetation. Limestone, quartzite and ultramafic vegetation include many endemic species which are adapted to nutrient-poor conditions, and to periodic drought in the case of limestone and quartzite vegetation, or tolerate heavy metal toxicity under ultramafic conditions. Because of their high species endemism, the flora of limestone, quartzite and ultramafic soils are of great importance for conservation.

Freshwater and peat swamp forests which occur on the coastal or riverine plains on different soil types are the home to a unique flora dominated by high-quality timber tree species. Conservation of these forest types is extremely important as they play a significant role in hydrological and carbon cycles. Sandwiched between land and the sea or river, mangrove forests are subjected to tidal flooding at least once a day. They consist mainly of plant species with unique adaptive features such as pneumatophores or breathing roots.

Heath forests develop on highly acidic soil that is poor in base minerals. The Malaysian name given to heath forest, *kerangas*, is an Iban word meaning land on which rice will not grow. Sandy beach and rocky shore vegetation are the habitats that predominate along the 4800 km coastline of Malaysia. Plants inhabiting these coastal areas show remarkable adaptive morphological and physiological features that enable them to withstand strong winds and solar radiation, constant salt spray, a shortage of fresh water and nutrient-deficient substrates.

Table 2. Habitat and vegetation types of forested land in Malaysia (Ministry of Primary Industries 1998).

Climatic climax forest	Edaphic forest
Lowland dipterocarp forest	Limestone vegetation
Hill dipterocarp forest	Quartzite vegetation
Upper hill dipterocarp forest	Ultramafic vegetation
Low montane forest	Freshwater forest
Upper montane forest	Peatswamp forest
Subalpine vegetation	Mangrove forest
Alpine vegetation	Heath forest (kerangas)
	Sandy beach vegetation
	Rocky shore vegetation

Genetics

Conservation of genetic resources of timber species require a robust understanding of the processes by which species organize genetic diversity in local populations and the patterns of this diversity among populations. Maintaining a broad genetic base through the conservation of a range of provenance of target species is likely to be the safest available option until more adequate data are available. Information on the genetic diversity of Malaysian timber species is still lacking. At the time of writing, information is available for the following species: *Aquilaria malaccensis* (Norwati 2000); *Dryobalanops aromatica* (Lee 2000; Lee *et al.* 2000b); *Dyera costulata* (Norwati 1994); *Hopea odorata* (Wickneswari *et al.* 1994); *Intsia palembanica* (Lee *et al.* 2002a); *Koompassia malaccensis* (Lee *et al.* 2007; 2008); *Scaphium macropodum* (Lee *et al.* 2002b); *Shorea curtisii* (Ng *et al.* 2006); *S. leprosula* (Lee *et al.* 2000a; Ng *et al.* 2004; 2006; 2009); *S. macroptera* (Ng *et al.* 2006); and *S. ovalis* ssp. *sericea* (Ng *et al.* 2004, 2009).

Conservation of forest genetic resources

In situ conservation

Malaysia has adopted several measures to protect and conserve the biodiversity of forests. These include the creation of a network of totally protected areas including national and state parks, wildlife sanctuaries, wildlife reserves, wildlife rehabilitation centres, bird reserves, bird sanctuaries, terrapin centres, permanent forest estates (PFE), conservation areas and marine parks. Some of these areas have been designated as World Heritage Sites by the United Nations Educational, Scientific, and Cultural Organisation (UNESCO), heritage sites

of the Association of Southeast Asian Nations (ASEAN), or Ramsar sites (the Convention on Wetlands).

Currently, Malaysia has 2 150 000 ha of protected areas, which have been gazetted or proposed as national parks and wildlife and bird sanctuaries (Table 3). Of this area, 320 000 ha are located within the PFE (Ministry of Primary Industries 2001). With the 3 810 000 ha of protected forests of the PFE, which also serve similar functions, the total area designated for protection amounts to 5 960 000 ha or 29.5% of the country's total forested land (Ministry of Primary Industries 2001).

Table 3. National parks, wildlife and bird sanctuaries in Malaysia (in 1000 ha; Ministry of Primary Industries 2001).

Region	National park	Wildlife and bird sanctuary	Total
Peninsular Malaysia[a]	430	310	740
Sabah	250	160	410
Sarawak	700[b]	300[c]	1 000
Malaysia	1 380	770[d]	2 150

[a] Estimate; [b] Include 570 000 ha of proposed national parks; [c] Include 140 000 ha of proposed wildlife sanctuaries; [d] A total of 190 000 ha and 130 000 ha is located in the PFE of Peninsular Malaysia and Sabah, respectively.

Peninsular Malaysia has altogether 40 Totally Protected Areas (TPAs) in all 11 states with a total area of approximately 751 400 ha[5]. The Taman Negara National Park is the largest of all TPAs in Peninsular Malaysia with 434 400 ha, located in three states Pahang, Kelantan and Terengganu (Table 4). It was gazetted separately by each state under the states' enactment in 1938–1939. It represents the flora of central Peninsular Malaysia together with the Krau, Sungkai and Sungai Dusun Wildlife Reserves. The Endau-Rompin (Johor) National Park and Endau-Rompin (Pahang) Wildlife Reserves represent the southern flora while the Perlis and the proposed Belum State Parks form a continuous link with the monsoon forests of Thailand and Myanmar. Sarawak currently has 15 national parks, three wildlife sanctuaries, two wildlife rehabilitation centres and three nature reserves[6]. In Sabah, the protected area network consists of six natural parks, two wildlife reserves and two conservation areas.

Conservation strategy of forest habitats was initiated in 1950 (Wyatt-Smith 1950) through the establishment of a network of small protected patches of natural forests, Virgin Jungle Reserves, particularly for study purposes. These areas are largely located within commercially productive forests throughout the country and represent ecological types of original conditions. The usefulness and importance of the Virgin Jungle Reserve system in the conservation of forest patches has received positive reviews by the Food and Agriculture Organisation (FAO 1984). As of 2009, in total 120 Virgin Jungle Reserves have been established. They cover an area of 111 800 ha and represent several forest types, including mangrove swamp forest, beach forest, heath forest, peat swamp forest, lowland dipterocarp forest, hill and upper hill dipterocarp forests, and montane forest.

Malaysia has also established two Genetic Resources Areas (GRAs), one of 4800 ha in the Ulu Sedili Forest Reserve in Johor and the other one in the Semengoh Forest Reserve in Sarawak. The GRAs in Johor and Sarawak have initially targeted 8 and 14 commercial species for genetic conservation, respectively. These species are by no means exclusive and research is in progress to identify additional species for genetic conservation.

[5] For details, see the website of the Department of Wildlife and National Parks, Peninsular Malaysia, http://www.wildlife.gov.my/webpagev4_en/bhg_PA.html.

[6] For details, see http://www.forestry.sarawak.gov.my.

Table 4. Examples of totally protected areas in Malaysia.

Totally protected area	Area (ha)	Year est.	State
Taman Negara National Park	434 400	1939	Kelantan, Pahang, Terengganu
Endau-Rompin (Johor) National Park	48 900		Johor
Tanjung Piai[b]	500	2003	Johor
Pulau Kukup[b]	600	2003	Johor
Sungai Pulai[b]	9 100	2003	Johor
Gunung Ledang National Park	8 600	2005	Johor
Perlis State Park	5 100	1996	Perlis
Penang National Park	2 600	2003	Penang
Endau-Rompin (Pahang) Wildlife Reserve	40 200		Pahang
Krau Wildlife Reserve	62 400		Pahang
Tioman Island Wildlife Reserve	9 500	1984	Pahang
Tasik Bera[b]	38 400	1994	Pahang
Sungai Dusun Wildlife Reserve	4 300	1964	Selangor
Selangor State Park	113 000	2007	Selangor
Sungkai Wildlife Reserve	2 500	1928	Perak
Royal Belum State Park	117 500	2003	Perak
Bako National Park	2 700	1957	Sarawak
Mulu National Park[a]	52 900	1974	Sarawak
Niah National Park	3 100	1975	Sarawak
Lambir National Park	6 900	1975	Sarawak
Similajau National Park	7 100	1978	Sarawak
Gunung Gading National Park	4 100	1983	Sarawak
Kubah National Park	2 200	1989	Sarawak
Batang Ai National Park	24 000	1991	Sarawak
Loagan Bunut National Park	10 700	1991	Sarawak
Tanjung Datu National Park	1 400	1994	Sarawak
Talang-Satang National Park	19 400	1999	Sarawak
Bukit Tiban National Park	8 000	2000	Sarawak
Maludam National Park	43 100	2000	Sarawak
Rajang Mangroves National Park	9 400	2000	Sarawak
Gunung Buda National Park	6 200	2001	Sarawak
Semengoh Wildlife Rehabilitation Centre		1975	Sarawak
Matang Wildlife Centre	200		Sarawak
Lanjak-Entimau Wildlife Sanctuaries	168 800	1983	Sarawak
Pulau Tukong Ara-Banun Wildlife Sanctuaries	1	1985	Sarawak
Samunsam Wildlife Sanctuaries	6 100	1979	Sarawak
Wind Cave Nature Reserve			Sarawak
Sama Jaya Nature Reserve	18		Sarawak
Semenggoh Nature Reserve	700	2000	Sarawak
Bukit Sembiling Nature Reserve			Sarawak
Bukit Hitam Nature Reserve			Sarawak
Kuching Wetlands[b]	6 600	2005	Sarawak
Crocker Range Park	139 900	1984	Sabah
Kinabalu Park[a]	73 400	1964	Sabah
Pulau Tiga Park	600	1978	Sabah
Tawau Hills Park	27 800	1979	Sabah
Tunku Abdul Rahman Park	1 300	1974	Sabah
Turtle Island Park	15	1977	Sabah
Kulamba Wildlife Reserve	20 700		Sabah
Tabin Wildlife Reserve	120 500		Sabah

Totally protected area	Area (ha)	Year est.	State
Maliau Basin Conservation Area	58 800	1984	Sabah
Danum Valley Conservation Area	43 800	1980	Sabah
Lower Kinabatangan-Segama Wetlands[b]	78 800	2008	Sabah

[a] UNESCO World Heritage Site (Natural List) and ASEAN Heritage Sites; [b] Ramsar sites

Ex situ conservation

Ex situ conservation refers to the maintenance of species outside their original habitats in botanical gardens, arboreta, seed genebanks, or in vitro genebanks. It is an important technique for long-term storage of genetic material for future breeding programmes or for reintroducing species to the wild. In Malaysia, most research efforts have concentrated on the improvement and sustainable development of agricultural crop species. Little work has been carried out on conserving the genetic resources of forest plant species. The largest groups of forest plant species under *ex situ* conservation are orchids (1639 species), followed by fruit trees (434 species), timber species (364 species) and medicinal plants (115 species). Saw and Raja Barizan (1991) provide a detailed list of *ex situ* conserved species.

At present, Malaysia has 26 *ex situ* conservation areas, and examples of these in various states are given in Table 5. Collections are conserved mainly in arboreta of research institutions, universities and government agencies. The universities include University of Malaya (UM), Universiti Putra Malaysia (UPM) and Universiti Kebangsaan Malaysia (UKM), and the government-funded research centres include those at Semengoh in Sarawak and at Sepilok and Poring in Sabah. Of the research institutions, the Forest Research Institute Malaysia (FRIM), the Malaysia Palm Oil Board (MPOB), the Malaysia Rubber Board, and the

Table 5. Examples of *ex situ* conservation areas in various states in Malaysia (Ministry of Primary Industries 1998).

State	Area
Johor	Research Station, Palm Oil Research Institute Malaysia, Kluang
Melaka	Zoo, Air Keroh
Penang	Botanic Garden, Penang Island
	Rice Genebank, Malaysia Agriculture Research & Development Institute, Seberang Perai
Perak	Terrapin Hatchery, Bota Kanan
Sabah	Agriculture Research Station, Ulu Dusun
	Arboretum, Forest Research Centre, Sepilok
	Orang-Utan Rehabilitation Centre, Sepilok
	Orchid Centre and Agriculture Research Station, Tenom
	Sabah Parks Orchid Garden, Poring
Sarawak	Botanical Research Centre, Semengoh
	Sungai Sebiew Agriculture Park, Bintulu
	Wildlife Rehabilitation Centre, Semengoh
Selangor	Arboreta, Forest Research Institute Malaysia, Kepong
	Etnobotany Garden, Forest Research Institute Malaysia, Kepong
	Bukit Cahaya Agricultural Park, Shah Alam
	Captive Breeding Station, Sungai Dusun
	Experiment Station, Rubber Research Institute Malaysia, Sungai Buloh
	Medicinal Plant Garden, Universiti Putra Malaysia, Serdang
	Rimba Ilmu, University of Malaya, Kuala Lumpur
	Fern Garden, Universiti Kebangsaan Malaysia, Bangi
	Taman Pantun, Universiti Kebangsaan Malaysia, Bangi

Malaysia Agricultural Research and Development Institute (MARDI) have arboreta for various groups of wild species. For example, the arboreta of FRIM have a collection of more than 500 forest plant species, including 150 dipterocarp species.

Malaysia lost its most valuable botanical garden when Singapore left the Federation in 1965. The Singapore Botanical Gardens was a centre of botanical research and had large plant collections. It also played an important role in describing and documenting Malayan flora. The Penang Botanical Garden, established during the British rule, is currently the oldest *ex situ* conservation area in Malaysia. However, the garden has carried out little research in recent years. Its major functions are education, recreation and as tourism. For these reasons, FRIM has begun to develop the Kepong Botanical Garden, a national botanical garden, with support from the federal government and private institutions. The garden is still at an early stage of development. Planning for two other botanical gardens at Putrajaya and Sungai Buluh is also underway.

Seed genebanks for forest species are not appropriate as most of the plants produce recalcitrant seeds which cannot be stored for long. Various institutes in the country are conducting research to explore the possibilities of using cryogenic and *in vitro* techniques for long-term gene conservation of tree species. Some of the species that have been successfully cryopreserved for *ex situ* conservation are *Dipterocarpus alatus, D. intricatus, Swietenia macrophylla, Pterocarpus indicus, Thyrosostachys siamenis, Bambusa arundinacea, Dendrocalamus membranaceus* and *D. brandissi*. Tissue culture through *in vitro* techniques has been widely studied in *Swietenia macrophylla, S. leprosula, S. ovalis, S. parvifolia, S. macrophylla, Hopea odorata,* and *Calamus manan*.

Policies and management practices related to forest genetic resources

Forest management and harvesting

Management of forested land in Malaysia falls, broadly, into three categories: (1) Totally Protected Areas (TPAs) under the control of the Federal Government (Department of Wildlife and National Parks); (2) Permanent forest estates (PFEs, comprised of Forest Reserves) under the control of the Forestry Department and (3) Stateland, which is forested land owned by the State Government and is essentially viewed as a land reserve for development. It should be stressed here, however, that the term PFE may be misleading, since the permanency of these areas as forest is currently not guaranteed. The Executive Council within the state government can degazette any area of the PFE for infrastructure development, agriculture, housing or other purposes.

Under the National Forestry Policy 1978 (revised 1992), the PFEs have to be strategically located throughout the country and to be managed as Protection Forest, Production Forest, Amenity Forest and Research and Education Forest. Under the National Forestry Act 1984 (amended 1993), the PFEs are further classified into functional classes as follows: timber production forests under sustained yield, soil protection forests, soil reclamation forests, flood control forests, water catchment forests, forest sanctuaries for wildlife, virgin jungle reserve forests, amenity forests, education forests, research forests, and forests for federal purposes.

In Peninsular Malaysia, the timber production forests of the PFE are managed under two systems: the Malayan Uniform System (MUS) based on a 55-year cutting cycle and the Selective Management System (SMS) based on a 30-year cutting cycle. In brief, the MUS consists of removing the mature crop in one single felling of all trees down to 45 cm diameter at breast height (dbh) for all species (Wyatt-Smith 1963; Thang 1988). The SMS entails the

selection of optimum management (felling) regimes based on pre-felling forest inventory data (Thang 1987; 1988).

Under MUS, all large timber trees are harvested in one operation in the logging area. Following this, the remaining large trees which have a low market value are removed by poison girdling. The next crop, therefore, has to develop from seedlings, and would, consequently, be of uniform age and contain a greater proportion of commercial species. According to Wyatt-Smith (1988), the MUS is certainly not environmentally degrading, although admittedly it is not oriented towards genetic conservation.

As the MUS relies primarily on seedlings and saplings to form the next crop, silvicultural treatments are designed to favour these groups, often at the expense of the biggest trees. Such treatments tend to lead to a much more intense poison girdling than necessary and in some cases, opening the canopy too drastically. Hence, over the years, the emphasis has shifted from the seedlings and saplings to advanced growth. This has led to a more restricted use of the poison-girdling technique and a more conservative approach in silvicultural treatments, thus conserving forest genetic resources (Hashim 1997).

After the modification, the MUS has been applied successfully to lowland dipterocarp forests. However, it has been found to be unsuitable in hill dipterocarp forests because of the comparatively more difficult terrain, uneven stocking, lack of natural regeneration, erosion risk on steep slopes, and the incidence of other secondary growth favoured by a drastic opening of the canopy.

Subsequently, in 1978, the SMS system was introduced for hill dipterocarp forests. It is based on selective removal of the mature crop in a single operation. This approach allows more flexible timber harvesting regimes; emphasis is on retaining the advanced growth of trees of a diameter of 15–45 cm as the next crop. It discourages poison girdling of the presently noncommercial timber species, thus conserving the existing forest genetic resources. Tree felling is selective: the cutting limit should not be less than 50 cm dbh for dipterocarp species, except for *Neobalanocarpus heimii* (Dipterocarpaceae) for which it should be above 60 cm dbh. For non-dipterocarp species the cutting limit should not be less than 45 cm dbh. In addition, the cutting limit prescribed for dipterocarp species should be at least 5 cm higher than for non-dipterocarp species in order to conserve a higher percentage of dipterocarps in the next crop (Thang 1988).

Views on the suitability of SMS for managing dipterocarp forests vary and are sometimes even opposing. While Cheah (1978), Thang (1987) and FAO (1989) viewed that the SMS was most suitable for hill dipterocarp forests, Wyatt-Smith (1987; 1988) and Chin (1989) perceived that selective felling on a short felling cycle under high lead logging was unsuitable for managing dipterocarp forests, especially hill forests. Nonetheless, the SMS is the principal management system for hill dipterocarp forests in Peninsular Malaysia, although some lowland dipterocarp forests are still being managed under the MUS.

In pursuance of sound management objectives, forest harvesting in the state of Sabah is undertaken in accordance with the prescribed silvicultural practices of promoting the development of natural regeneration. In this context, the Dipterocarp Forest in the state of Sabah is selectively harvested on a 50-year cutting cycle, and only trees of 60 cm at dbh and above are removed. In the state of Sarawak, the cutting cycle prescribed for the Dipterocarp Forest is 25 years, where the prescribed cutting limits for the dipterocarp and non-dipterocarp species are 60 cm and 45 cm at dbh, respectively (Thang 1997a).

Currently, the peat swamp forests in Peninsular Malaysia are managed under a 'modified' SMS system where higher cutting limits are prescribed due to a lower stocking of natural regeneration on the ground. Research and development efforts are currently being taken to formulate more effective management systems for this forest type. In this regard, the cutting cycle adopted for the peat swamp forest in the state of Sarawak is 45 years, with the prescribed cutting limits being 40 cm dbh and above for *Gonystylus bancanus* (ramin) and

other species (Thang 1997b).

The mangrove forests, in general, are managed with cutting cycles of 20–30 years. In Peninsular Malaysia, mature trees are clear-felled but seven mother trees per hectare are retained and three meter wide strips along river banks or the coast are left uncut for ensuring adequate natural regeneration and protecting the environment (Thang 1997b).

Several regulations and guidelines with special emphasis on environmental measures, including Forest Harvesting Guidelines, Forest Engineering Plan and Forest Road Specifications, have also been adopted to supplement the forest management and harvesting plans. Helicopters have been deployed to assist in surveillance operations to check on illegal logging and for more effective monitoring of the country's forest. To reduce the damage to the surrounding environment, helicopter logging is also being experimented. In addition, a number of practices aimed at reducing logging damage on forest stands have been introduced. These include tree marking for felling, timber tagging for identification and log removal and directional felling to reduce the negative impact of logging on the residual stand.

A Continuous Forest Resources Monitoring System, operational since 1993, has been developed for Peninsular Malaysia. It applies an integrated system of remote sensing, Geographical Information System (GIS) and field data. In Sarawak, GIS coupled with the commissioning of the Forest Management Information System Sarawak (FOMISS) has enhanced the technological capability for managing the state's forest resources more effectively[7].

In recent years, research on reduced impact logging (RIL) and low-impact logging (LIL) harvesting technologies has been intensified. Sabah has already formulated standards and guidelines for RIL operations[8]. A number of collaborative projects have been undertaken to explore the feasibility of these technologies. In Sarawak, field studies of improved tractor logging practices, namely 'Path Logging', were carried out as a part of the development programmes of the International Tropical Timber Organization (ITTO). Experiences in felling blocks with Path Logging from 1997 indicate a considerable reduction in damages as compared with conventional working practices[9]. As to the harvesting of hill forests in the remote regions of difficult terrains of Sarawak, the Forest Department encourages the timber operators to adopt helicopter harvesting.

Malaysian criteria and indicators for sustainable forest management

Malaysia is a member of the ITTO and has adopted ITTO's guidelines and criteria for the implementation and monitoring of sustainable forest management (SFM) in natural tropical forests. A national committee on SFM was established in 1994 under the Ministry of Primary Industries to ensure that the ITTO criteria and indicators for SFM are fully implemented. The national committee has formulated the Malaysian criteria and indicators (MC&I) for SFM at the national and forest management unit (FMU) levels. Since their first formulation in 1994, the MC&I have undergone numerous refinements both through internal and external consultations, to take into account the latest developments in forestry.

At the national level, the MC&I comprise 7 criteria, 64 indicators, 201 activities and 170 standards of performance. At the FMU level, the MC&I consist of 7 criteria, 56 indicators, 172 activities and 150 standards of performance (Chan 2002). These activities will be tested on the ground to establish their applicability. Institutional plans and capacity building are currently

[7] For details, see the Sarawak Forest Department website, http://www. forestry.sarawak.gov.my.

[8] For details, see the Sabah Forest Department website, http://www.sabah.gov.my/htan.

[9] For details, see the Sarawak Forest Department website, http://www. forestry.sarawak.gov.my.

being undertaken to monitor the implementation of all these activities which are to be carried out at the state and the FMU level. A technical monitoring committee has been established by the Forest Department of Peninsular Malaysia to monitor the implementation of all the activities undertaken by each state forestry department in Peninsular Malaysia.

In Sabah, the state government has developed a concession model at the Deramakot Forest Reserve to implement SFM[10]. Based on the success of the Deramakot model, the state government has extended the model to other FMUs. In 2000, 15 organizations from the private sector signed SFM license agreements (SFMLAs) to manage the forest in accordance with SFM principles for the next 100 years. Under this concept, the SFMLA holders need to manage the forest areas sustainably, prepare long-term forest management plans, employ ecological harvesting plans and undertake enrichment planting, forest rehabilitation and silviculture.

Timber certification

To strengthen the measures towards SFM, the federal government established Malaysian Timber Certification Council (MTCC) in 1998. The MTCC operates as a non-profit organization and independent national certifying and accrediting body. In October 2001, the MTCC certification scheme commenced operations in a phased manner. The standard currently used for assessing the FMUs is the MC&I developed by the Forestry Department of Peninsular Malaysia. As of March 2003, the MTCC had certified three FMUs (Pahang, Selangor and Terengganu) and issued certificates of Chain-of-Custody to 29 companies in Malaysia[11].

The MTCC is currently in the process of developing a set of standards which are compatible with the Principles and Criteria (P&C) of the Forest Stewardship Council (FSC). In addition, a multi-stakeholder National Steering Committee (NSC) is currently revising the MC&I to make them compatible with the principles and criteria of the FSC. A National Working Group (NWG) has been established to formulate a national standard for submission to the FSC for endorsement (Chew 2002).

As a recent development, the MTCC has been admitted as a member in the Council of the Programme for the Endorsement of Forest Certification (PEFC). The MTCC intends to submit its scheme to the PEFC Council for endorsement in near future. In the ASEAN front, Malaysia is pushing for a Pan-ASEAN forest certification scheme. A working group has been established to look into the matter.

Forest plantations

To supplement the future wood supply and to relieve the pressure on the natural forests, forest plantations that are capable of yielding a high volume of timber with short rotations have been established. By the end of 2000, Malaysia had a total area of 240 000 ha of forest plantations, of which 70 000 ha in Peninsular Malaysia, 140 000 ha in Sabah and 23 000 ha in Sarawak (Ministry of Primary Industries 2001). In the 9th Malaysia Plan (2006–2010), the government pledged through the Ministry of Plantation, Industries and Commodities to establish additional 193 000 ha of forest plantation areas in the Peninsular Malaysia, Sabah and Sarawak. The species planted include tropical pines such as *Pinus caribaea*, *P. merkusii* and *Araucaria* species as well as fast-growing hardwood species such as *Acacia mangium*, *Acacia* hybrid, *Khaya* sp., *Gmelina arborea* and *Paraserianthes falcataria*. Other species planted

[10] For details, see the Sabah Forest Department website, http://www.sabah.gov.my/htan.

[11] For details, see the website of the Malaysian Timber Certification Council, http://www.mtcc.com.my/documents/index.html)

include *Tectona grandis*, *Swietenia macrophylla*, *Durio zibethinus*, *Neolamarckia cadamba*, *Octomeles sumatrana*, *Dyera costulata* and *Azadirachta excelsa*.

Establishment of forest plantations will be accelerated, particularly in Sarawak and Sabah, while those already established by the Forest Department in Peninsular Malaysia will be privatized. The State Government of Sarawak has planned for 1 000 000 ha of forest land degraded by shifting cultivation to be planted with fast-growing species during the next 15 to 20 years. To that effect, the government has enacted the Forest (Planted Forest) Rules 1997, which set out the procedures and condition for the orderly establishment of forest plantations in Sarawak[12]. Incentives in the form of low land premium and long leases have been provided to encourage investments. In Sabah, a total of 745 000 ha have been identified as suitable for forest plantations.

Forest plantations are capable of yielding higher volume of timber per unit area, which relieves the pressure of overharvesting natural forests by supplementing the future wood supply for the country. Consequently, to encourage investments by the private sector in the development of forest plantations, the government of Malaysia has reviewed the existing fiscal incentives and granted full tax exemptions under the pioneer status for ten years and under the Investment Tax Allowance (ITA) for five years.

Non-timber forest products

Besides the production of timber products, policies are now geared towards the development of non-timber forest products (NTFPs) and forest services as well as agroforestry. This is to maximize the returns to investors and to diversify the forestry sector, which is an important aspect of SFM. In recent years, NTFPs, including rattan, bamboo and herbal and medicinal plants, have been developed in a more integrated manner. Agroforestry has been promoted throughout the country to address the decreasing availability of land and raw materials. This will allow for a wider range of agricultural crops to be planted with forest tree species, optimizing land use and returns to the sector. In addition, various incentives have been designed to promote the development of biotechnology products, the extraction of natural chemicals from forest biological resources, the utilization of forest biomass for clean fuel production, and the development of genetically engineered products from flora. The establishment of Malaysian Biovalley in 2003 was one of these incentives. The diversification of forestry products will make SFM a more viable option since the forests will yield greater revenues that can be reinvested into the sector to ensure its sustainability.

Research and national activities related to forest genetic resources

Since 2000, many research activities have been conducted in FRIM through various funding sources in order to establish conservation strategies for rare and threatened dipterocarps in Peninsular Malaysia. The overall objective of this initiative is to generate biological information of rare and threatened dipterocarps towards conservation management. Multi-disciplinary research approach was adopted, which involves botanists, geneticists and ecologists.

The objective for conservation of a rare timber species differs from that of a common species. For a common timber species, the conservation strategies are to prevent the species from becoming an endangered species. In contrast, for a rare species, the final race against extinction is being fought. Malaysian forests are rich in plant species diversity. An area of 50 ha in the Pasoh Forest Reserve was reported to contain 814 different tree species (Kochummen 1997). For the majority of these species, adequate knowledge to set

[12] For details, see http://www.forestry.sarawak.gov.my/forweb/ homepage.htm.

conservation strategies will never be obtained. It is suggested that for the conservation of timber species, the species are grouped according to life history traits. The information generated for one species then can be adapted to other species that have similar types of life history traits.

Accordingly, to date, comprehensive conservation strategies were developed for a rare and predominantly outcrossed dipterocarp (*Shorea lumutensis*; Lee *et al.* 2006), a rare and predominantly selfing dipterocarp (*Hopea bilitonensis*; Lee 2008), and a widespread endemic and predominantly outcrossed dipterocarp (*Neobalanocarpus heimii*; Lee 2007) to set conservation strategies in order to prevent the common species from becoming endangered and to protect the rare species against extinction. The comprehensive conservation strategies (*in situ* and *ex situ*) for these three model species are currently available for implementations.

Public awareness

Several institutions in Malaysia are engaged in organizing seminars and conferences, including international conferences, to exchange knowledge and expertise on research and management of biodiversity. The institutions involved include the Ministry of Natural Resources and Environment (NRE); the Ministry of Agriculture and Agro-based Industry (MOA); the Ministry of Science, Technology and Innovation (MOSTI); the Economic Planning Unit; and the institutions of higher learning such as Universiti Kebangsaan Malaysia *(*UKM*)*, Universiti Malaya *(*UM*),* MARDI and FRIM, to name a few. Media coverage on biodiversity issues is also enhanced, and management of environment and biodiversity are part of the daily coverage by the national television channels. The importance of biodiversity is also regularly contemplated in major national newspapers.

Identification of national priorities with regard to forest genetic resources

Identification of priority species

Plant species which according to varied literature can be considered as priority species for Malaysia are listed in Table 6. They consist mainly of currently popular timber species for forest plantation (e.g. *Azadirachta excelsa*, *Khaya ivorensis, Tectona grandis* and *Dyera costulata*), currently popular medicinal plants (e.g., *Eurycoma longifolia* and *Labisia pumila*) and valuable timber species (e.g. *Neobalanocarpus heimii* and *Eusideroxylon zwageri*). Some of these popular timber species are exotic and were introduced to Malaysia for forest plantation (e.g. *Tectona grandis*, *Khaya ivorensis* and *Melaleuca cajuputi*). Species listing in Appendix 1 also includes other indigenous timber species which are not popular for forest plantation at the moment (e.g. *Shorea glauca*, *S. curtisii* and *S. platyclados*), medicinal plants with clear potential or future value (e.g., *Calophyllum lanigerum* var. *austrocoriaceum*, *Andrographis paniculata* and *Goniothalamus velutinus*), species for agroforestry (e.g. *Calamus* sp.), ornamental plants (e.g. *Cycas* sp., *Nepenthes* sp. and *Johannesteijsmannia* sp.), fruit trees (e.g. *Nephelium* sp. and *Durio* sp.) and mangrove species (e.g. *Avicennia alba* and *Sonneratia alba*). The following species are protected by law in Sarawak: *Antiaris toxicaria*, *Aquilaria malaccensis*, *Avicennia alba*, *Casuarina equisetifolia*, *Dipterocarpus oblongifolius*, *Eurycoma longifolia*, *Goniothalamus velutinus*, *Koompassia malaccensis*, *Nepenthes* sp., *Paphiopedilum* sp., *Rafflesia* sp., *Shorea hemsleyana*, *S. macrophylla*, *S. splendida*, *S. stenoptera* and *Sonneratia alba* (Forest Department Sarawak 1999).

Table 6. Priority species in Malaysia. (Ng and Tang 1974; Patrick and Muhammad 1980; Ministry of Primary Industries 1991; Saw and Raja Barizan 1991; Appanah and Weinland 1993; Dransfield and Manokaran 1993; Soerianegara and Lemmens 1994; Dransfield and Widjaja 1995; Saw 1998; Teo 1998; and de Padua *et al.* 1999).

Species (family)	Conservation		Production		Field trial
	In situ	*Ex situ*	Natural forest	Plant-ation	
Agathis borneensis (Araucariaceae)	+	(+)	+	K	+
Azadirachta excelsa (Meliaceae)	K	(+)		+	+
Calamus manan (Palmae)	+	(+)	+	+	+
Chukrasia tabularis (Meliaceae)	K	K	+	+	+
Dryobalanops aromatica (Dipterocarpaceae)	+	+	+	+	+
Dyera costulata (Apocynaceae)	K	+	+	+	+
Eurycoma longifolia (Simaroubaceae) [a]	K	(+)	+	+	+
Eusideroxylon zwageri (Lauraceae)	K	+	+		+
Fagraea fragrans (Loganiaceae)	K	(+)	+	K	+
Gonystylus bancanus (Thymelaeaceae)	K	(+)	+	K	
Hopea odorata (Diptreocarpaceae)	K	+		+	+
Intsia palembanica (Leguminosae)	K	+	+	K	+
Khaya ivorensis (Meliaceae) [b]				+	+
Koompassia malaccensis (Leguminosae) [a]	K	(+)	+	K	+
Labisia pumila (Myrsinaceae)	K	K	+	+	+
Melaleuca cajuputi (Myrtaceae) [b]				+	+
Neobalanocarpus heimii (Dipterocarpaceae)	+	+	+	K	+
Palaquium rostratum (Sapotaceae)	K	(+)	+	K	+
Pterocarpus indicus (Leguminosae)	K	(+)		K	+
Shorea leprosula (Dipterocarpaceae)	K	(+)	+	K	+
Shorea macrophylla (Dipterocarpaceae) [a]	+	+	+	+	+
Shorea ovalis (Dipterocarpaceae)	K	(+)	+	K	+
Shorea parvifolia (Dipterocarpaceae)	K	(+)	+	K	+
Shorea roxburghii (Dipterocarpaceae)	K	(+)	+	K	
Tectona grandis (Verbenaceae) [b]				+	+

+ = existing
(+) = less than 10 accessions
K = insufficiently known
[a] Protected species by law in Sarawak; [b] Exotics species

In situ conservation stands are present for *Agathis borneensis*, *Aquilaria malaccensis*, *Calamus manan*, *Dryobalanops aromatica*, *Neobalanocarpus heimii*, *Nepenthes hamulatum*, *Rafflesia* sp., *Shorea curtisii*, *S. macrophylla*, *S. glauca*, *S. hemsleyana*, *S. splendida* and *S. stenoptera*. Data on area of these stands are not currently available. *Ex situ* conservation of most species is limited to fewer than ten accessions, with the exception of only *Anisoptera costata*, *Casuarina equisetifolia*, *Dryobalanops aromatica*, *D. oblongifolia*, *Durio* sp., *Dyera costulata*, *Eusideroxylon zwageri*, *Garcinia* sp., *Hopea odorata*, *Intsia palembanica*, *Metroxylon rumphii*, *Neobalanocarpus heimii*, *Nepenthes* sp., *Nephelium* sp., *Rafflesia* sp., *S. macrophylla*, *S. pauciflora*, *S. splendida* and *S. stenoptera*. Majority of the indigenous species can be found in natural forest and in forests managed for production.

The Table 7 lists 85 endemic and rare plant species in Malaysia. A species is said to be endemic when it is found naturally in only a single geographical area. A species is said to be rare when its population is small and can be found only in one or very few places. It is also considered rare if it is only represented by a few individuals over a large area. Endemic and rare species are automatically endangered because of their narrow distribution ranges or small population size, and they should, therefore, receive special attention.

Table 7. Endemic and rare species in Malaysia. Circumscribed to the species that were listed in IUCN categories (1998), and species that have been reported by Chin and Kiew (1985), Kiew *et al*. (1985), Jacobsen (1987), Weber (1988), Kiew (1989), Abdul Latiff and Mat-Salleh (1991), Kiew (1991a; 1991b), Kiew and Pearce (1991), Abdul Latiff (1998a; 1998b), Kiew (1998b; 1998c; 1998d), Soepadmo (1998b), and Wong (1998).

Species (family)	Species (family)
Acrymia ajugiflora (Labiatae)	*Johannesteijsmannia magnifica* (Palmae)
Actinodaphne cuspidata (Lauraceae)	*Justicia subalternans* (Acanthaceae)
Aglaia densitricha (Meliaceae)	*Kibatalia borneensis* (Apocynaceae)
Alphonsea kingii (Annonaceae)	*Koilodepas ferrugineum* (Euphorbiaceae)
Ardisia langkawiensis (Myrsinaceae)	*Kostermanthus malayus* (Chrysobalanaceae)
Begonia eiromischa (Begoniaceae)	*Lagerstroemia langkawiensis* (Lythraceae)
Begonia rajah (Begoniaceae)	*Litsea scortechinii* (Lauraceae)
Beilschmiedia penangiana (Lauraceae)	*Maclurochloa montana* (Gramineae)
Browniowia velutina (Tiliaceae)	*Madhuca calcicola* (Sapotaceae)
Calamus balingensis (Palmae)	*Mallotus smilaciformis* (Euphorbiaceae)
Calamus viminalis (Palmae)	*Mangifera superba* (Anacardiaceae)
Castanopsis catappaefolia (Fagaceae)	*Mezzettia herveyana* (Annonaceae)
Cleistanthus major (Euphorbiaceae)	*Nepenthes gracillima* (Nepenthaceae)
Croton macrocarpus (Euphorbiaceae)	*Nepenthes northiana* (Nepenthaceae)
Cryptocoryne elliptica (Araceae)	*Oberonia calcicola* (Orchidaceae)
Cycas pectinata (Cycadaceae)	*Paphiopedilum niveum* (Orchidaceae)
Dendrobium langkawiense (Orchidaceae)	*Paphiopedilum phillippinense* (Orchidaceae)
Didymocarpus pumilus (Gesneriaceae)	*Peperomia maxwelliana* (Piperaceae)
Diplodiscus hookerianus (Tiliaceae)	*Phyllagathis stonei* (Melastomataceae)
Dipterocarpus lamellatus (Dipterocarpaceae)	*Polyalthia glabra* (Annonaceae)
Dipterocarpus perakensis (Dipterocarpaceae)	*Polyalthia hirtifolia* (Annonaceae)
Dipterocarpus rotundifolius (Dipterocarpaceae)	*Popowia pauciflora* (Annonaceae)
Eugenia camptophylla (Myrtaceae)	*Popowia velutina* (Annonaceae)
Eugenia gageana (Myrtaceae)	*Pseudoeugenia tenuifolia* (Myrtaceae)
Eugenia johorensis (Myrtaceae)	*Rafflesia kerrii* (Rafflesiaceae)
Eugenia klossii (Myrtaceae)	*Sauropus elegantissimus* (Euphorbiaceae)
Eugenia scalarinervis (Myrtaceae)	*Schefflera cephalotes* (Araliaceae)
Eugenia taipingensis (Myrtaceae)	*Schefflera kuchingensis* (Araliaceae)
Glycosmis crassifolia (Rutaceae)	*Schoutenia cornerii* (Tiliaceae)
Glycosmis monticola (Rutaceae)	*Shorea bentongensis* (Dipterocarpaceae)
Glycosmis tomentella (Rutaceae)	*Shorea kuantanensis* (Dipterocarpaceae)
Goniothalamus subevenius (Annonaceae)	*Shorea kudatensis* (Dipterocarpaceae)
Hexapora curtisii (Lauraceae)	*Shorea lumutensis* (Dipterocarpaceae)
Homalium spathulatum (Flacourtiaceae)	*Shorea maxima* (Dipterocarpaceae)
Hopea auriculata (Dipterocarpaceae)	*Shorea palembanica* (Dipterocarpaceae)
Hopea depressinerva (Dipterocarpaceae)	*Shorea singkawang* ssp. *scabrosa*
Hopea johorensis (Dipterocarpaceae)	(Dipterocarpaceae)
Hopea polyalthioides (Dipterocarpaceae)	*Strobilanthes pachyphyllus* (Acanthaceae)
Hopea subalata (Dipterocarpaceae)	*Symplocos nivea* (Symplocaceae)
Horsfieldia sessilifolia (Myristicaceae)	*Tristania pontianensis* (Myrtaceae)
Hydnocarpus scortechinii (Flacourtiaceae)	*Vaccinium whitmorei* (Ericaceae)
Ilex pauciflora (Aquifoliaceae)	*Vatica flavida* (Dipterocarpaceae)
Johannesteijsmannia lanceolata (Palmae)	*Zollingeria borneensis* (Sapindaceae)

In 2008, a national consultative workshop was organized with the aim to identify priority species and actions for the conservation of forest genetic resources in Malaysia. The workshop further identified 30 plant species as priority species using the criteria of economic importance and endemic or rare distribution (Table 8). The workshop involved participants from the Ministry of Natural Resources and Environment, the Forest Department of Peninsular Malaysia, various state forest departments, FRIM, Bioversity International, the Asia Pacific Association of Forestry Research Institutions (APAFRI), Universiti Malaysia

Sarawak (UNIMAS), the Sarawak Forestry Corporation, the Malaysia Furniture Industry Council, the Institute for Environment and Development at UKM, the World Wide Fund for Nature (WWF) Malaysia, and Perak ITC Sdn. Bhd.

Table 8. The plant species identified as priority species for the conservation of forest genetic resources in Malaysia. Criteria: (1) economic importance, (2) endemic or rare distribution.

No	Species	Criteria	No	Species	Criteria
1	*Agathis borneensis*	1	16	*Shorea singkawang*	1
2	*Calamus manna*	1	17	*Begonia eiromischa*	2
3	*Calophyllum lanigerum*	1	18	*Begonia rajah*	2
4	*Canarium pseudosumatranum*	1	19	*Dactylocladus stenostachys*	2
5	*Dyera costulata*	1	20	*Dipterocarpus oblongifolius*	2
6	*Eusideroxylon zwageri*	1	21	*Dipterocarpus perakensis*	2
7	*Ganua motleyana*	1	22	*Dipterocarpus sarawakensis*	2
8	*Gonystylus bancanus*	1	23	*Dryobalanops beccarii*	2
9	*Intsia palembanica*	1	24	*Dryobalanops rappa*	2
10	*Koompassia excelsa*	1	25	*Eugenia johorensis*	2
11	*Neesia altissima*	1	26	*Johannesteijsmannia perakensis*	2
12	*Neobalanocarpus heimii*	1	27	*Mangifera pajang*	2
13	*Protoxylon melagangai*	1	28	*Nepenthes rajah*	2
14	*Shorea albida*	1	29	*Shorea bentongensis*	2
15	*Shorea macrophylla*	1	30	*Shorea kudatensis*	2

Malaysian strategy on the conservation of forest genetic resources

At its sixth meeting in 2002, the Conference of the Parties (COP) to the Convention on Biological Diversity (CBD) adopted the decision VI/9 on the Global Strategy for Plant Conservation. The focus of the Global Strategy is to reduce the rate of loss of plant species drastically by the year 2010 worldwide. It is part of the global agenda of the World Summit in Johannesburg (2002) to significantly reduce the rate of biodiversity loss within that time frame. Using the framework established by the Global Strategy for Plant Conservation under the CBD, a Malaysian National Strategy for Plant Conservation was recently initiated to consolidate past and existing efforts towards the conservation of biological diversity. The strategy emphasizes ecosystem approach, outlines 5 objectives and has 17 targets designed specifically to address how Malaysia could progress forward in plant conservation, taking cognizance of the rationale behind each target and the current situation. Conservation of genetic diversity was emphasized in Target 10, according to which 70% of the genetic diversity of crops and other major socio-economically valuable plant species should be conserved and associated indigenous and local knowledge protected.

As an extension, the national consultative workshop of 2008 formulated a Malaysian strategy on plant forest genetic resources conservation. This strategy, emphasized on genetic diversity, outlined four objectives and has nine targets designed specifically to address the concern of conservation of genetic resources of forest plants in Malaysia (Table 9).

Table 9. Malaysian strategies on the conservation of the genetic resources of forest plants.

Objective 1: Understanding the genetic diversity of forest plant species		**Duration**
Target 1	Development of research methodologies to understand genetic diversity and other biological information of forest plant species	2008–2011
Target 2	Development of models with protocols for gene conservation of forest plant species	2008–2013
Target 3	Development of models with protocols for sustainable utilization of forest plant species	2008–2013
Target 4	Development of models with protocols for forest rehabilitation	2008–2013
Target 5	Development of models with protocols for species reintroduction of critically endangered forest plant species	2008–2013
Objective 2: Conserving forest plant species *in situ* and *ex situ*		
Target 6	Application of models and protocols developed from Target 2 to conserve *in situ* and *ex situ* of 30 forest plant species of socioeconomic importance or endemic or rare distribution	2013–2020
Objective 3: Using forest plant species sustainably		
Target 7	Application of models and protocols developed from Target 3 to use forest plant species from natural sources that are sustainably managed	2013–2020
Objective 4: Rehabilitating forest and species reintroduction		
Target 8	Application of models and protocols developed from Target 4 to rehabilitate at least 10 000 ha of heavily disturbed forests with consideration of genetic diversity	2013–2020
Target 9	Application of models and protocols developed from Target 5 to reintroduce at least two critically endangered forest plant species into natural habitats	2013–2020

Capacity building activities, education and training

Undertaking activities to achieve the targets of Malaysian strategy on the conservation of the genetic resources of forest plants requires that the existing national capacity in the relevant fields be increased manifold and that the infrastructure to support this increased capacity is developed fairly rapidly. Capacity building in the area of the conservation of forest genetic resources covers training of workforce in various biological and management disciplines, at different levels and in the use of various technologies. It requires training of various stakeholders – government personnel, non-governmental organizations (NGOs) and communities. Adequate funding is a prerequisite for the building of capacity for the conservation of forest genetic resources.

The Malaysian government encourages collaboration with other countries and international organizations to enhance its capacity and capability in managing its biodiversity. Malaysia established collaboration and cooperation with several developed countries in many aspects of biodiversity research and management, such as the Borneon Biodiversity and Ecosystem Conservation (BBEC) project with the Japanese government and many biodiversity projects with the Danish government (DANIDA) which amount to millions of US dollars. Malaysia collaborates with international organizations such as the Global Environment Facility (GEF), the ITTO and the International Treaty Plant Genetic Resources for Food and Agriculture (ITPGRFA) to further strengthen its capacity. The Heart of Borneo conservation project is also an initiative to strengthen collaboration of three countries, namely Malaysia, Indonesia and Brunei, in biodiversity conservation.

Identification of current gaps on capacity building needs for the conservation of forest

genetic resources in Malaysia are given in Figure 1. Overall, seven questions can be used to guide the identification of gaps: (1) How to conduct conservation research? (2) How to acquire funding to conduct conservation research? (3) How to translate conservation research into conservation strategies? (4) How to implement conservation strategies? (5) How to create public awareness on forest genetic resources conservation? (6) How to create networks for conservation activities? (7) How to acquire funding to implement conservation strategies?

During the national consultative workshop of 2008, strategies on capacity building needs were formulated as shown in Table 10.

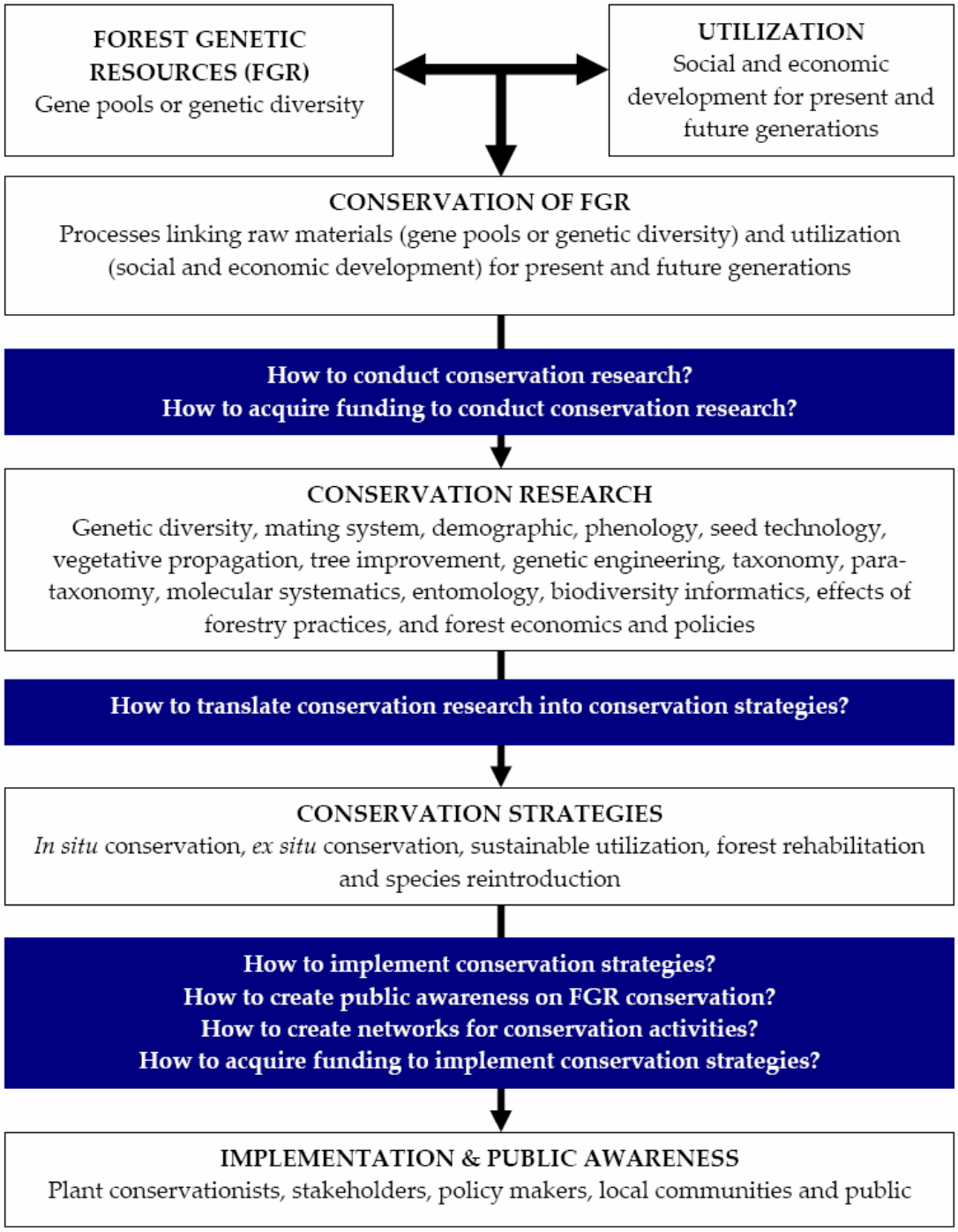

Figure 1. Identification of current gaps in the capacity building needs for the conservation of forest genetic resources in Malaysia.

Table 10. Malaysian strategies on the capacity building needs for the conservation of forest genetic resources (FGR).

Capacity building needs	Gap	Strategies
(i) Human resources and infrastructure development		
▪ How to conduct conservation research? ▪ How to translate conservation research into conservation strategies? ▪ How to implement conservation strategies?	▪ Lack of trained population geneticists, molecular biologists and conservation biologists ▪ Lack of trained and dedicated field managers to implement forest genetic resources conservation strategies ▪ Lack of molecular biology facilities in research institutions and universities ▪ Lack of policy makers who fully understand the importance of FGR conservation.	▪ Encourage institutes of higher learning to train population geneticists, molecular biologists and conservation biologists ▪ Recruitment of trained and dedicated field managers for the implementation of strategies of FGR conservation ▪ Equip the molecular biology facilities in research institutions and universities, especially in Sabah and Sarawak ▪ Policy makers should be enlightened on the importance of the conservation of FGR towards environmental protection and for the used of future generations.
(ii) Communication		
▪ How to create public awareness on forest genetic resources conservation? ▪ How to create networks for conservation activities?	▪ Lack of publications related to FGR conservation for the public ▪ Lack of coordination, communication and networking among institutions, scientists and policy makers on issues related to FGR conservation ▪ Lack of coordination and commitment among policy makers to issues related to FGR conservation ▪ Lack of regional and international networking and communication on FGR conservation.	▪ Encourage scientists to participate in the production of articles, commentaries and films related to FGR conservation ▪ Establish rapport with mainstream journalists and media agencies ▪ Encourage local scientists to publish in international journals to increase their exposure and networking ▪ Incentives and recognition for scientists to be prolific in production of popular media ▪ Suggest to institutions to offer courses to combine FGR conservation and journalism. ▪ Support from government to ensure commitment among policy makers on issues related to FGR conservation. ▪ Set up a coordinating body to coordinate activities among institutions and/or scientists ▪ Encourage more exchange of students and staff within and among countries.
(iii) Funding mechanism		
▪ How to acquire funding to conduct conservation research? ▪ How to acquire funding to implement conservation strategies?	▪ Severe lack of funding for fundamental conservation research ▪ Lack of funding to implement strategies for FGR conservation ▪ Unbalanced funding and coordination for biodiversity programmes ▪ Lack of funding for training in postgraduate programmes ▪ Lack of funds to participate in international events on FGR conservation.	▪ Governmental research funding should proportionally cover both biotechnology and conservation activities ▪ The spending of 'timber cess and levy' income should be extended to support fundamental conservation research and implement conservation strategies ▪ Local scientists should be encouraged to tap international funds available for fundamental research ▪ Scholarship and financial assistance should be made available to postgraduates to pursue degrees in population genetics, molecular biology and conservation biology ▪ Dedicated fund should be made available for local scientists to participate in important international symposia and congress.

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Appendix 1

Important tree species in Malaysia (additional to priority species). Sources: Ng and Tang (1974), Patrick and Muhammad (1980), Ministry of Primary Industries (1991), Saw and Raja Barizan (1991), Appanah and Weinland (1993), Dransfield and Manokaran (1993), Soerianegara and Lemmens (1994), Dransfield and Widjaja (1995), Saw (1998), Teo (1998), and de Padua *et al.* (1999).

Species (family)	Conservation		Production		Field trial
	In situ	*Ex situ*	Natural forest	Plant-ation	
Acalypha hispada (Euphorbiaceae)	K	(+)	+		
Acorus calamus (Araceae)	K	(+)	+		
Alangium serraca (Alangiaceae)	K	(+)	+		
Alstonia scholaris (Apocynaceae)	K		+		
Andrographis paniculata (Acanthaceae)	K	(+)	+		
Anisoptera costata (Dipterocarpaceae)	K	+	+		
Anisoptera curtisi (Dipterocarpaceae)	K		+		
Antiaris toxicaria (Moraceae)[a]	K	(+)	+		
Aquilaria malaccensis (Thymelaeaceae)[a]	+	(+)	+		+
Artocarpus elasticus (Moraceae)	K	(+)	+		+
Artocarpus lanceifolius (Moraceae)	K	(+)	+		
Avicennia alba (Verbenaceae)[a]	K		+		
Brucea javanica (Simaroubaceae)	K		+		
Calamus subinermis (Palmae)	K		+		
Calophylum lanigerum var. *austrocoriaceum* (Guttiferae)	K		+		
Cantella assiatica (Umbelliferae)	K		+		+
Casuarina equisetifolia (Casuarinaceae)[a]	K	+	+		+
Cotylelobium lanceolatum (Dipterocarpaceae)	K	(+)	+		
Cycas sp. (Cycadaceae)	K	(+)	+		
Dipterocarpus baudii (Dipterocarpaceae)	K	(+)	+		+
Dipterocarpus cornutus (Dipterocarpaceae)	K	(+)	+		+
Dipterocarpus costulatus (Dipterocarpaceae)	K	(+)	+		+
Dipterocarpus crinitus (Dipterocarpaceae)	K	(+)	+		+
Dipterocarpus grandiflorus (Dipterocarpaceae)	K	(+)	+		+
*Dillenia grandifolia (*Dilleniaceae*)*	K	(+)	+		
Dipterocarpus oblongifolius (Dipterocarpaceae)[a]	K	(+)	+		+
Dryobalanops oblongifolia (Dipterocarpaceae)	K	+	+		+
Durio sp. (Bombacaceae)	K	+	+		+
Endospermum diadenum (Euphorbiaceae)	K	(+)	+	K	+
Ficus deltoidea (Moraceae)	K		+		
Garcinia sp. (Guttiferae)	K	+	+		
Gigantochloa scortechinii (Gramineae)	K		+		
Gmelina arborea (Verbenaceae)[b]					+
Goniothalamus velutinus (Anonaceae)[a]	K		+		
Heritiera javanica (Sterculiaceae)	K	(+)	+		
Hopea nervosa (Dipterocarpaceae)	K	(+)	+		+
Hopea nutans (Dipterocarpaceae)	K	(+)	+		+
Johannesteijsmannia sp. (Palmae)	K		+		
Metroxylon rumphii (Palmae)	K	+	+		
Metroxylon sagu (Palmae)	K	(+)	+		
Nepenthes sp. (Nepenthaceae)[a]	+[c]	+	+		
Nephelium sp. (Sapindaceae)	K	+	+		
Oncosperma tigillarium (Palmae)	K	(+)	+		

Species (family)	Conservation		Production		Field trial
	In situ	*Ex situ*	Natural forest	Plant-ation	
Orthosiphon grandiflorus (Labiatae)	K	(+)	+		
Palaquium maingayi (Sapotaceae)	K	(+)	+		+
Paphiopedilum sp. (Orchidaceae) [a]	K	(+)	+		
Parashorea lucida (Dipterocarpaceae)	K		+		
Parashorea stellata (Dipterocarpaceae)	K		+		
Parkia javanica (Leguminosae)	K	(+)	+		
Parkia speciosa (Leguminosae)	K	(+)	+		+
Phalaenopsis sp. (Orchidaceae)	K	(+)	+		
Rafflesia sp. (Rafflesiaceae) [a]	+	+	+		
Santiria laevigata (Burseraceae)	K	(+)	+		
Schima wallichii (Theaceae)	K		+		
Senna alata (Leguminosae)	K		+		
Shorea acuminata (Dipterocarpaceae)	K	(+)	+		+
Shorea bracteolata (Dipterocarpaceae)	K	(+)	+		
Shorea curtisii (Dipterocarpaceae)	+	(+)	+		+
Shorea glauca (Dipterocarpaceae)	+	(+)	+		+
Shorea hemsleyana (Dipterocarpaceae) [a]	+	(+)	+		+
Shorea kunstleri (Dipterocarpaceae)	K	(+)	+		+
Shorea laevis (Dipterocarpaceae)	K	(+)	+		+
Shorea lepidota (Dipterocarpaceae)	K	(+)	+		+
Shorea longisperma (Dipterocarpaceae)	K	(+)	+		
Shorea macroptera (Dipterocarpaceae)	K	(+)	+		+
Shorea maxwelliana (Dipterocarpaceae)	K	(+)	+		+
Shorea multiflora (Dipterocarpaceae)	K	(+)	+		+
Shorea pauciflora (Dipterocarpaceae)	K	+	+		+
Shorea platyclados (Dipterocarpaceae)	K	(+)	+		+
Shorea resinosa (Dipterocarpaceae)	K	(+)	+		+
Shorea splendida (Dipterocarpaceae) [a]	+	+	+		
Shorea stenoptera (Dipterocarpaceae) [a]	+	+	+		
Sindora coriacea (Leguminosae)	K	(+)	+		
Sonneratia alba (Sonneratiaceae) [a]	K		+		
Swietenia macrophylla (Meliaceae) [b]				+	+
Tinospora crispa (Menispermaceae)	K		+		
Toona sinensis (Meliaceae)	K		+		
Toona sureni (Meliaceae)	K		+		
Vatica maingayi (Dipterocarpaceae)	K		+		
Vatica pauciflora (Dipterocarpaceae)	K	(+)	+		

+ = existing
(+) = less than 10 accessions
K = insufficiently known
[a] Protected species by law in Sarawak; [b] Exotics species; [c] Nepenthes hamulatum

Status of Myanmar's forest genetic resources - Their conservation and management practices

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Myanmar is richly endowed with diverse habitat types and natural resources, culture and traditions. The country's total land area is 676 580 sq. km, more than 50% of which is still forested. Myanmar is best known as the natural home to teak (*Tectona grandis* L. f.), which is regarded worldwide as one of the most valuable premier wood. Myanmar is situated between latitudes 9°58′ and 28°29′ north and longitudes 92°10′ to 101°10′ east, geographically located in the South-east Asia.

Myanmar possesses a broad ecological spectrum, ranging from the snow-capped mountains through tropical rain forests to coastal and marine ecosystems. There is no denying the fact that the forests in Myanmar are socially and economically significant. The country's population in 2004 was approximately 53 million, with an annual growth rate of 1.84%. Over 70% of the population is rural and depend on forest resources for their basic needs and livelihoods. The forestry sector contributed about 30% of the country's total export earnings in 1990s.

Timber export constitutes a major source of earnings of foreign exchange for the country's economy. As a result, extraction of teak and other commercial hardwood species is inevitable, and the natural forests and forest genetic resources are affected to some extent. According to the forest resource assessment conducted in 1990, forest cover decreased between 1975 and 1989 at an annual rate of 220 000 ha or 0.64% of forest area. FAO (1999) estimated that 387 000 ha or 1.4% of forest area of Myanmar was destroyed annually between 1990 and 1995. The continued degradation of the country's forests will not only reduce earnings of foreign exchange, it will also significantly affect environmental quality with serious consequences for watershed protection and hence agricultural production and living conditions. Therefore, strong measures must be taken to conserve and maintain the existing natural forests to avoid further loss of forest resources.

The Forest Department (FD) of the Ministry of Forestry (MOF) is responsible for the protection and conservation of biodiversity and sustainable management of the forest resources of the country. Conservation of forest genetic resources (FGR), including teak, was started in 1984. Since then, the major conservation activities with regard to forest genetic resources have been the conversion of teak plantations and full-stocked teak natural forests into seed production areas (SPA), and the establishment of teak hedge gardens (THGs), teak seed orchards and the protected area system (PAS).

Forest resources

The forest flora of Myanmar is diverse, varying from sub-alpine, dry forest and moist deciduous forests, to tropical rain forests and mangrove forests. The forest types vary depending on topographic, edaphic and climatic conditions. They are classified as mangroves and estuarine forests in the delta region, deciduous and dipterocarp forests in the regions with pronounced dry season, evergreen forest in areas of high moisture regime and rainfall, hill evergreen and sub-alpine forest at high altitudes and subtropical regions, and dry thorn forests in places with scanty rainfall (Tables 1 and 2).

Reserved forests, protected public forests, and protected areas system constitute permanent forest estate (PFE). The status of PFE of Myanmar in 2006 is provided in Table 3.

Natural forests in Myanmar have been managed and conserved on a sustainable basis including biodiversity conservation. Myanmar still possesses diverse flora and fauna in terms of species richness. At present, 11 800 plant species belonging to 2 371 genera and 273 families have already been identified (Table 4). Among plant species, only 85 species are being used as commercial timber species because of their prominent high quality (Forest Department 2000). The properties and end-uses of other plant species need to be investigated in order to increase commercial timber production and to release the pressure on a few commercial timber species.

Table 1. Forest cover by forest types in Myanmar in 2004. (FAO 2006)

Category	Area (1000 ha)	% of land area
Closed forest	24 705	36.5
Open or degraded forest	9 427	13.7
Other wooded land	11 950	17.7
Others (including water bodies)	21 741	32.1
Total	**67 658**	**100.0**

Table 2. Major forest types in Myanmar, 2004. (Source: Planning & Statistics Division, Forest Department)

Forest type	Area (1000 ha)	% of forests
Tidal forest		
Beach and dune forest	1 375	3.9
Swamp forest		
Evergreen forest	5 500	15.5
Tropical wet-evergreen		
Tropical semi-evergreen		
Mixed deciduous forest	13 407	37.9
Moist upper mixed		
Lower mixed		
Dry upper mixed		
Dry forest	3 438	9.7
Than-dahat		
Thorn		
Deciduous indaing (Dipterocarp) forest	1 719	4.9
Hill and temperate evergreen forest	8 938	25.2
Sub-tropical wet hill		
Sub-tropical hill		
Alpine		
Fallow Land	998	2.8
Total	**35 375**	**100.0**

Table 3. Permanent forest estates (PFE) in Myanmar in 2006. (Source: Planning & Statistics Division, Forest Department)

Forest area by legal status	Area (1000 ha)	% of land area
Reserved forests and protected public forests	15 806	23.4
Protected area system (PAS)	5 330	8.0
Other forests	20 510	30.3

Table 4. Plant species diversity in Myanmar (Forest Department 2003).

Category	No. of species
Plants	11 800
Bamboo	102
Rattan	50
Shrubs	1 696
Orchids	841

Legal Framework

Myanmar has adopted the following policy and legislative measures which are concerned with conservation, protection and proper utilization of the country's natural resources:

- The Forest Law 1992
- The Forest Rule 1995
- The Protection of Wildlife and Wild Plant and Conservation of Natural Areas Law 1994
- The Protection of Wildlife and Wild Plant and Conservation of Natural Areas Rule 2002
- The Myanmar Forest Policy 1995
- The Mines Law 1994

The Myanmar Forest Policy was formulated in 1995, aligning it with the forestry principles adopted at the United Nations Conference on Environment and Development (UNCED, 1992). The policy identifies six imperatives:

- *Protection* of soil, water, wildlife, biodiversity and the entire environment
- *Sustainability* of forest resources to ensure perpetual supply of both tangible and intangible benefits accrued from the forests for the present and future generations
- *Basic needs* of the people for fuel, shelter, food and recreation
- *Efficiency* to harness, in a socio-environmentally friendly manner, the full economic potential of the forest resources
- *Participation* of the people in the conservation and utilization of forests
- *Public awareness* about the vital role of forests in the well-being and socio-economic development of the nation.

The Forest Policy seeks to extend the protected area system (PAS) from the present 8.0% to 10.0% of the land area in long-term by gazetting an additional 5.0% of the total land of the country as protected areas. It also includes a system of environmental pricing based on the 'polluter pays' principle to compensate for environmental and ecological degradation.

The new Forest Law focuses on the balance approach towards conservation and development issues implicit in the concept of sustainable forestry. Highlighting environmental and biodiversity conservation, the law encourages community forestry and people's participation in environmental and forest management.

Legislation to protect the wildlife began with Burma Game Rules and the Elephant Protection Act, the heritage of the Indian legislation which has been in force for near a century. A separate legislation for Myanmar was promulgated only in 1936 in the Burma Wildlife Act. This old wildlife act did not, however, reflect the present concept of wildlife and biodiversity conservation. Therefore, the new legislation, the Protection of Wildlife and Wild plants and Conservation of Natural Areas Law, was promulgated in 1994. The new law

highlights maintenance and restoration of habitats, protection of endangered and rare species of both fauna and flora, establishment of new parks and protected area systems, and buffer zone management. It is the basis for the protection of the flora and fauna of the country. Within the framework of the legislation, 6 national parks and 32 wildlife sanctuaries and wetlands have already been established throughout the country.

Myanmar has actively participated in international cooperation programme concerning with the environmental affairs, and it has made commitments to several international agreements on forestry and other environmental issues.

Characterization of forest genetic resources

The forests in Myanmar could be categorized based on species composition as follows:

- Sub-alpine forests (hill and temperate evergreen forest)
- Dry forests
- Mixed deciduous forests
- Tropical evergreen forests
- Indaing (Dipterocarpus) forests
- Mangrove forests.

These forest types are described in more detail in the following.

Sub-alpine forests

The Sub-alpine or hill evergreen forest type is characteristic of high rainfall and resembles typical evergreen forest in many ways. The species are, however, usually distinct. Species of evergreen *Quercus* and *Castanopsis*, *Schima wallichii* (laukya) and species of the orders Magnoliaceae and Lauraceae are characteristic of this subtype. The forest usually contains a large number of climbers and dense undergrowth.

Dry hill forest usually occurs on drier localities where rainfall is not so heavy. Characteristic species are *Quercus serrata* with several other deciduous or semi-evergreen species of *Quercus* and *Castanopsis, Schima wallichii* (laukya), *Alnus nepalensis* (maibau) and occasionally *Pentacme siamensis* (ingyin). Pine forests of this forest type are usually pure or almost pure forests of *Pinus kesyia* and *P. merkusii*.

Dry forest

Dry forest is usually found in areas where annual rainfall is less than 1250 mm. It is often difficult to determine where dry forest ends and the drier types of mixed deciduous begin as the two merge gradually into each other. Dry forests are further divided to three subtypes: (i) Than-dahat forest characterized by the predominance of two species, *Terminalia oliveri* (than) and *Tectona hamiltoniana* (dahat). (ii) in areas with an annual rainfall of less than 1000 mm, the than-dahat-type is displaced by Thorn forest. It is an open forest type of low growth, characterized by the presence of a number of thorny species such as *Acacia catechu* (sha), *A. leucophloea* (tanaung) and *Ziziphus jujuba* (zi). (iii) Aukchinsa-thinwin forest is a some-what rare type. The forest consists of scattered *Diospyros ehretiodes* (aukchinsa), *Acacia catechu* (sha) and *Millettia pendula* (thinwin) with an undergrowth of grass or stunted *Dendrocalamus strictus* (hmyinwa).

Mixed deciduous forests

Mixed deciduous forests are by far the most important forest in Myanmar. They are further divided into three types described in the following.

Moist upper mixed deciduous forest

Moist upper mixed deciduous forest (MUMD) are characterized in Lower Myanmar by the presence of the bamboo species *Bambusa polymorpha* (kyathaungwa) and *Cephalostachyum pergracile* (tinwa). In Upper Myanmar, north of the dry zone, *B. polymorpha* is replaced by *Dendrocalamus hamiltonii* (wabo-myet-sangye) or *Dendrocalamus membranaceus* (wabyu). Thus, *C. pergracile* thus becomes the most typical bamboo of this forest type. The forest contains the finest teak, usually associated by *Xylia xylocarpa* (pyinkado). It occurs on well drained slopes and usually indicates a good quality of soil. On ridge tops and hot slopes it is often replaced by dry upper mixed deciduous type.

A peculiar type of forest which may best be included under the moist upper mixed deciduous is found in Rakhine and over wide stretches of the Rakhine Yomas. In this type the bamboo species *Melocanna baccifera* (kayinwa) is intrusive and has undoubtedly spread over a considerable area. Typically it is found on shallow clay. However, it has displaced evergreen forests on other soil types, too, because its dense growth precludes the natural regeneration of most other species. As the regrowth of other species is reduced, these areas, thus, tend to convert to pure stands of *M. baccifera*.

Dry upper mixed deciduous forest

This dry subtype of mixed deciduous forest (DUMD) is usually characterized by the presence of *Dendrocalamus strictus* (hmyinwa). In many places, *Thrysostachys oliveri* (thanutwa) is also characteristic of this type, and in Upper Myanmar it may predominate over large areas. *Cephalostachyum pergracile* (tinwa), and even *Bambusa polymorpha* (kyathaungwa) may occur in this type of forest, but the latter is usually of smaller growth than in moist forest and cannot be considered characteristic of this type. *Bambusa tulda* (thaikwa) is also usually found in this forest type, especially in lower Myanmar, and is usually an indicator of a stiff soil. Characteristic species are *Tectona grandis* (teak), *Xylia xylocarpa* (pyinkado), *Terminalia crenulata* (taukkyan), *T. chebula* (panga), *T. pyrifolia* (lein), *Pterocarpus macrocarpus* (padauk), *Adina cordifolia* (hnaw), *Shorea siamensis* (ingyin), *Shorea obtusa* (thitya), and occasionally *Dipterocarpus tuberculatus* (in), occurring with *Dendrocalamus strictus* (hmyinwa) and other bamboos.

Lower mixed deciduous forest

In the lower mixed deciduous forest (LMD), teak may be found gregariously or in patches. The species attains a large girth and height, and the trees are greatly fluted in these forests. Teak is usually found in association with *Xylia xylocarpa* (pyinkado), *Anogeissus acuminata* (yon), *Homalium tomentosum* (myaukchaw), *Terminalia tomentosa* (taukkyan), among other species. This type occurs on lower ground, sometimes alluvialand usually clayey soils, and is characterized by the scarcity or absence of bamboos. Other characteristic species of this type are *Lagerstroemia speciosa* (pyinma), *L. tomentosa* (leza), *Dillenia pentagyna* (zinbyun) and *Albizia procera* (sit).

Tropical evergreen forests

Typical evergreen forest is characterized by a dense understory of evergreen trees of numerous species, or by a dense growth of bamboos, such as *Dendrocalamus hamiltonii* (wabo-myet-sangye), *Cephalostachyum pergracile* (tinwa). Trees are generally large and may be associated with *Michelia champaca* (sagawa), *Tetrameles nudiflora* (baing), *Dipterocarpus* spp., *Eugenia* spp., *Cedrela* spp. and others, and of small evergreen trees or shrubs.

Indaing forest (Dipterocarp Forest)

This type is characterized by the prevalence of *Dipterocarpus tuberculatus* (in) which may comprise as much as 80% or even more of the crop. In some places, *Shorea siamensis* (ingyin) or *S. obtusa* (thitya) may replace it as the predominant species. The forest is then known as semi-indaing.

Mangrove forest

Mangrove forests are situated within the tidal limits and are found in the Delta area (Ayeyarwady Division) and on sheltered muddy coastal areas (Taninthayi Division and Rakhine State). This forests are normally dominated by *Rhizophora apiculata* (byu-che-dauk), *R. mucronata* (byu-che-daukma), *Bruguiera gymnorhiza* (byu-u-ta-lon), *Heritiera fomes* (kanazo), *Sonneratia apetala* (kanbala), *Aegiceras corniculatum* (khaya), *Ceriops decandra* (madama) and *Excoecaria agallocha* (thayaw).

Conservation and management practices of forest genetic resources

Management system

Myanmar Selection System (MSS) has been the principle forest management system applied in managing natural forests in the country since 1856. It is an exploitation-cum-cultural system. The system prescribes a felling cycle of 30 years for a felling series. Teak is either girdled or green-felled, depending on the market demand. Non-teak hardwoods are felled and extracted within a year. Extraction of timber is thus carried out within the bounds of the annual allowable cut (AAC). Usually, the AAC is fixed for each felling series based on the growing stock. The AAC is re-adjusted based on inventory data and girdling records as required. Cultural operations comprise sanitary and improvement felling in which climbers and inferior trees impeding the healthy growth of teak and other economically valuable species are removed. Healthy and phenotypically superior trees are left as mother trees to ensure natural regeneration. Today, timber harvesting is not merely extraction of trees, but a silvicultural operation which enhances the growth of the trees left in the forests and maintains the diverse genetic resources.

Strengthening the protected areas system

So far, 9 national parks and 39 wildlife sanctuaries and wetlands have been established throughout Myanmar. They cover altogether 4 938 000 ha or 7.3% of the country's total land area. Specific scientific assessment is still needed in these areas for the conservation and management of forest genetic resources.

Enhancement of seed production areas

By 2007, some 104 seed production areas (SPAs) of a total area of about 2123 ha were established throughout the country. Detailed information on the SPAs is shown in Table 5.

Tree improvement for teak

Several provenance trials have been established for the conservation of teak genetic resources (Table 6). Although phenotypically superior trees were selected for the trials, no genetic information is available on the trees.

Table 5. Seed production areas (SPAs) in Myanmar in 2007.

Species	No. of SPAs	Area (ha)
Tectona grandis (teak)	89	1 834
Xylia xylocarpa (pyinkado)	7	216
Pinus spp.	5	12
Gmelina arborea (yemane)	2	20
Bruguiera gymnorhiza (byu-u-ta-lon)	1	41
Total	**104**	**2 123**

Table 6. Provenance trials for teak in Myanmar.

Location	No. of trials	Year est.
Pyinmana, East Bago Yomas	18	1982
Oktwin, East Bago Yomas	16	1983
Pyinmana, East Bago Yomas	12	1986
Oktwin & Paukkaung, East & West Bago Yomas	10	1998
Nay Pyi Taw, Pyinmana Township, Mandalay Division	1	2007
Kyaukdaga Township, East Bago Division	1	2007

Teak seed orchards were established in Bago and Mandalay Divisions in 1981. A clonal seed orchard (CSO) of 34 ha was established in Toungoo District of Bago Division and one of 6 ha at a research station in the Yemathin District of Mandalay Division. The Forest Research Institute (FRI) of the Forest Department has conducted germination tests on seeds collected from these orchards. Average germination per cent was only 15%. Recently, under the project of *Ex-situ and in-situ conservation of teak to support sustainable forest management*, two CSOs were established in Nay Pyi Taw, Pyinmana Township, Mandalay Division (2.5 ha) and Pyi Township, West Bag Division (1.5 ha). These orchards are still lacking progeny tests and genetic information of clones. Suitable layout design will be needed for establishment of new clonal seed orchards.

Teak hedge gardens (THGs) are used for the production of vegetative planting stock by shoot cutting and for conservation purposes. Seven teak hedge gardens exist in the following townships:

- Bago Township, East Bago Division
- Oktwin Township, East Bago Division

- Taikkyi Township, Yangon Division
- Kyangin Township, Ayeyarwady Division
- Lewe Township, Mandalay Division
- Nattalin Township, West Bago Division
- Forest Research Institute, Yezin, Nay Pyi Taw (part of the ITTO project)

The hedge gardens are mainly located in Bago Yomas region which is situated in the heart of the country. It is said to be the best teak bearing area of Myanmar.

Strengthening and development of tissue culture methods

Tissue culture has become one of the key elements in the successful promoting of plantation forestry. Planting materials need not only be of adequate supply but also high quality. Mass production of quality planting materials could only be achieved by tissue culture.

Research on tissue culture of teak in Myanmar started in the late 1990s, and the first batch of teak seedlings has been planted in field. The plants are being observed to be healthy and grow with good performance. However, this achievement is still at experimental stage, and it needs to be developed with momentum, not only for the technical aspects but also for mass production with reasonable costs per hectare.

Protected tree species

In total 16 tree species have been declared as protected species in order to prevent their over-utilization. The species are protected either in the whole country or in a specific region (Table 7). In addition to these tree species, some medicinal plants and orchid species are protected throughout the whole country.

Table 7. Protected tree species in Myanmar by region (Forest Department Fact and Figure, 2006).

Scientific name	Common name	Region		
		Whole Country	Upper Myanmar	Lower Myanmar
Tectona grandis	Teak	x		
Pentace burmanica	Thitka	x		
Xantolis burmanica	Thitcho	x		
Hopea odorata	Thingan	x		
Xylia xylocarpa	Pyinkado	x		
Acacia catechu	Sha	x		
Pterocarpus macrocarpus	Padauk	x		
Excoecaria agallocha	Thayaw	x		
Shorea obtusa	Thit-ya	x		
Shorea siamensis	Ingyin	x		
Pinus khasya	Tinshu	x		
Dipterocarpus alatus	Kanyin			x
Lindera assamica	Karaway			x
Cinnamomum pachyphyllum	Hmanthin			x
Lagerstroemia floribunda	Kamaung			x
Prunus cerasoides	Cherry		x	

Conservation and management of bamboo species

During an ITTO-funded Bamboo Project (PD 146/02 Rev.1 (I)), bamboo demonstration plots were established in order to conserve some bamboo species of Myanmar (Table 8). Of these, the Kawhmu Bamboo Plantation was converted to a bambusetum during the last year of the project in 2006. To date, already 26 bamboo species have been conserved in the area.

Table 8. Bamboo demonstration plots.

Plantation	Year est.	Area (ha)	Species
Kawhmu Bamboo Plantation	2005	10	14 at the time of est.; currently 26
Pyinmana Bamboo Plantation	2005	20	10
Paukkhaung Bamboo Plantation	2005	20	1
Pyinmana Old Bamboo Plantation*	1984	6	5

* Established by the Forest Research Institute, Forest Department

Capacity building activities, education and training

Organizations involved in the conservation and management of forest genetic resouces

Four institutions under the Ministry of Forestry (MOF) are performing their specific duties and responsibilities mainly related to forestry:

- Planning and Statistics Department (PSD); coordinates and facilitates the tasks of Forest Department, Myanmar Timber Enterprise and Dry Zone Greening Department following the directives of MOF, and deals mainly with policy matters and issues related to forestry.
- Forest Department (FD); responsible for protection and conservation of biodiversity and sustainable management of the forest resources of the country
- Myanmar Timber Enterprise (MTE); responsible for timber harvesting, milling and downstream processing and marketing of forest products
- Dry Zone Greening Department (DZGD); responsible for restoration of degraded forest lands, protection and conservation of remaining natural forests, and restoration of the environment in the dry zone of the Central Myanmar.

Under the guidance of the Forest Department, the Forest Research Institute (FRI) and the Wildlife and Nature Conservation Division undertake activities related to the conservation and management of forest genetic resources in Myanmar. The conservation division has implemented protection and conservation of the wild fauna and flora through the establishment of the protected area system (PAS) across the country. At present, the division focuses on the conservation of wild fauna, especially endangered and threatened animal species. Little attention can be given to the conservation and management of other forest genetic resources because of various reasons.

The FRI is responsible for conducting forestry and forestry-related research in order to provide technical information on all aspects of forests and forestry-based activities to increase the contribution of the forestry sector to the well-being of the nation.

Capacity building methods

In Myanmar, capacity building of the staff in the field of conservation and management of forest genetic resources is urgently required in order to prevent the prevailing loss of these resources. In order to develop conservation and management practices, short-term training courses on vegetative propagation techniques, establishment of seed production areas (SPAs) and teak hedge gardens (THGs) have been regularly given at the FRI and the Central Forestry Development Training Centre (CFDTC).

Public awareness

Conservation without the involvement of local people is not a viable option. Participation will not, however, be easily achieved unless the importance and role of forest genetic resources for the livelihood of the people are widely spread out in rural societies. Generally, local people lack awareness of the benefits of the forests in the long term and the importance of conservation and sustainable utilization of the forest resources. Key information concerning forest genetic resources (if possible each and every species and its potential uses), their ecology and effects for the lives of the people can help to achieve participation. This information can, therefore, be used to develop better conservation plans with an integrated approach. Traditional ways of collecting non-timber forest products (NTFPs) and logging are not necessarily systematic and sustainable. They may damage forests to some extent and considerably reduce the populations of tree species in natural forests. Therefore, the awareness about the environment and importance of forests becomes a necessary ingredient for the conservation of forest genetic resources. Efforts on extension and environmental education programmes are also the major imperatives for a successful implementation of conservation and management of forest genetic resources.

Identification of national priorities on forest genetic resources

*P*riorities for the conservation of forest genetic resources in Myanmar are as follows:

Enabling conditions for forest genetic resources conservation and management

(1) Availability of forest legislation that supports conservation of forest genetic resources
(2) Development of adequate institutions for the conservation of forest genetic resources
(3) Supporting the adequate trained personnel to undertake activities related to the conservation of forest genetic resources
(4) Improvement sectoral coordination in planning, monitoring, evaluation and feedback on the conservation of forest genetic resources among institutions
(5) Enhancement for information, education and communication material on the genetic resources of forest trees
(6) Generate public awareness on valuation and goals of forest tree genetic resources

In situ conservation of forest genetic resources

(1) Identification and design of conservation areas
- Conduct periodic forest inventory
- Select the target species
    - commercial species
    - endangered species

- Phenology and morphology
- Causes of depletion
- Conservation stands in Reserved Forests and Protected Public Forests

(2) Management
- Protect conservation areas
- Retain seed trees
- Ecological assessment
- Appropriate silvicultural treatments

(3) Monitoring and evaluation
- Establish permanent sample plots
- Use remote-sensing techniques and GIS

Ex situ conservation of forest genetic resources

(1) Selection of target species
- Plant target species in arboreta and botanical gardens
- Establish seed stands, seed orchards and genebanks
- Undertake provenance trials
- Set up facilities for *in vitro* cryopreservation
- Establish protocols for macropropagation for each of the timber species
- Use molecular genetic techniques
- Use recombinant DNA techniques
- Reproductive biology
- Design computerized database system

(2) Monitoring and evaluation
- Use GIS to define the location of target species
- Enhance knowledge on the populations of the target species

Priority research needs related to conservation and management of forest genetic resources in Myanmar are the following:

- Effects of environmental factors on flowering and fruit setting; e.g. climate prior to and during flowering period, soil fertility and fertilizer application, stand age and density
- Flowering biology in relation to seed production, e.g. flower initiation and development, pollination ecology, fruit growth and development
- Effects of leaf defoliators on flowering and seed productivity (e.g. *Hyblaea puera*)
- Effects of insects feeding on flowers and young fruits on seed production
- Effects of hormones and other related substances on the induction of flowering and seed production
- Effects of pollination insects on seed production
- Community-based conservation of forest genetic resources in the areas of Community-Based Forest Management

International cooperation on forest genetic resources

Two international projects which implemented conservation and management activities related to forest genetic resources in Myanmar have recently finished. The first was a project titled Promoting Sustainable Utilization of Bamboo through Community Participation to Enhance Sustainable Forest Management, jointly implemented by FRI of the Forest

Department and the International Tropical Timber Organization (ITTO; 2003-2006). The objective of the second project was to assess plant biodiversity in national parks, and it was funded by the ASEAN-Korea Environmental Cooperation Unit (AKECU).

There are two on-going projects related to the conservation and sustainable utilization of teak genetic resources. Both are jointly implemented by FRI and the ITTO. The other project is titled *Ex-situ and in-situ conservation of teak to support sustainable forest management*. The other project concentrates on the utilization of teak from plantations.

Conclusion

The traditional concept of forest conservation is in need of a shift towards a new concept of conservation of forest genetic resources. The customary practices related to conservation are also in need of modification, applying advanced technologies. As the conservation of forest genetic resources becomes a multidisciplinary subject, relevant stakeholders are called for collaborative effort.

For the purposes of conservation of forest genetic resources (including teak and other valuable tree species) and timber production, forest tree species have been established by artificial regeneration. Methods used include direct sowing of seed, seed broadcasting, seedling transplant and stumps (derived from seeds). Traditionally seed was collected from natural stands which were identified as seed bearers. Unfortunately these trees have now become rare because of heavy logging practices in the past. Although clonal seed orchards have recently been promoted, the amount of seed produced is still below demand. Consequently, seed has been collected from genetically inferior parent trees, which leads to an increased proportion of poor quality teak in plantations.

Clone planting was not common until the recent past because clonal cultivation materials were very difficult to obtain. Budding, grafting and cutting techniques have been successfully developed but applied only to a limited extent. These methods have been employed to multiply plus trees for clonal seed orchards. The successful development of tissue culturing of teak in Myanmar in the past 3-4 years has opened up new horizons for clonal plantations of teak in near future.

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Status of Philippines forest genetic resources: their conservation and management practices

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The forests of South-east Asia, including those of the Philippines, are among the richest terrestrial ecosystems in terms of biological diversity. Pressures from a growing population and the government's efforts to improve the social and economic status of the people have resulted in much of these forests being cleared for cultivation, cash cropping, firewood collection, livestock gazing, logging, and the frequent occurrences of anthropogenic fires. Urbanization to house the increasing population has further exacerbated not only forest losses, but also the degradation of forest genetic resources (FGR).

Despite these socio-economic demands, the Philippine government is aware of the uniqueness and biodiversity of the country's forests, while recognizing the importance of the forest genetic resources in sustaining the productive and protective functions of the forests.

This paper reviews the forest resources of the Philippines, including the threats to their existence and the attendant measures to arrest these threats to forest genetic resources in particular. Additionally, it provides information regarding the priority thrust of the government to conserve FGR.

Forest resources

The Philippines once had an abundant forest cover. As of 2003, about 15 900 000 ha of the country's land area were classified as forest lands (Table 1). However, only 7 168 000 ha of this area are actually covered by forest (Table 2), representing 24% of the total land area, or 0.1 ha of forest per capita (FAO 2007). This proportion is the second-lowest in the South-east Asian Region, higher only to Singapore which does not really have any forest land at all.

Alienable and disposable lands (A & D; Table 1) refer to lands which are no longer needed for forestry purposes. Under the Forest Land Classification, the Philippine government defines the Forest reserves as forest land which has been reserved by the President of the Philippines for any specific purpose or purposes. Timberlands include public forest, permanent forest or forest reserves and forest reservations. National parks are forest reservations essentially of natural wilderness character which have been withdrawn from settlement, occupancy or any form of exploitation, except in conformity with an approved management plan. They are set aside as such exclusively to conserve the area, preserve the scenery, the natural and historic objects, wild animals and plants therein, and provide enjoyment of these physical features in such area. Game refuge and bird sanctuary (GRBS) refers to a forest land designated for the protection of game animals, birds and fish. They are closed to hunting and fishing in order that the excess population may flow and restock surrounding areas. Military and Naval Reservation refers to forest land which has been proclaimed by the President for military purposes, such as airbase, campsite, docks and harbors, firing range, naval base, target range or wharves. Civil Reservations refer to forest land which has been proclaimed by the President for a specific purpose such as town sites, resettlement areas or ancestral lands.

Table 1. Land classification in the Philippines in 2003. For explanations of the categories, see text. (Philippine Forestry Statistics 2004)

Class	Area (1000 ha)
Certified alienable and disposable lands (A & D)	14 145
Total forest land	15 855
Unclassified forest land	1 090
Classified forest land	14 766
Established Forest Reserves	3 273
Established Timberland	10 228
National Parks, Game refuge and bird sanctuaries (GRBS) or Wildlife areas (WA)	893
Military & Naval Reservations	130
Civil Reservations	166
Fishpond	76

Table 2. Forest classification in the Philippines in 2003 (Philippine Forestry Statistics 2004).

Forest type	Area (1000 ha)
Forests total	7 168
Closed forests	
Broad-leaved	2 449
Mixed	25
Coniferous	87
Open forests	
Broad-leaved	3 847
Mixed	70
Coniferous	113
Mangrove	247
Plantations[1]	
Broad-leaved	325
Coniferous	3
Mangrove	2
Other Wooded Land	7 589
Shrubs	365 258
Fallow	61
Wooded Grassland	3876
Other land uses	14 478
Inland Water	298

[1]Incomplete data

The optimal forest area for the Philippines is believed to be about 12 000 000 ha, or 40% of the land area. Given that only 7 168 000 ha are currently forested, this means that an additional 4 832 000 ha of land should be reforested.

One of the strategic programme thrusts of the Revised Master Plan for Forestry Development is called *Enhancing watershed integrity and its capacity in sustaining supply of goods (wood, water, food, shelter, medicine, etc) and enhancing delivery of environmental services*. The strategic targets that are envisioned to be addressed by this programme thrust are

- Sustainable management of 1 500 000 ha of residual forests, self-sufficiency in wood in 10 years

- Establishment, maintenance, and renewal of 460 000 ha of commercial forest plantations within 12 years after the initiation of the programme.

Specifically, the priority programme of protected area and biodiversity conservation will directly address the concern of conserving forest genetic resources. Among the programmes with the largest requirements are the expansion of forests with a total of 34 000 million Philippine Pesos (approx. 739 million US$).

The Philippine flora belongs to the plant geographical region of Malaysia, specifically the West Malaysia sub-floristic province (van Steenis 1950; Jacobs 1974). The East Malaysian floristic elements are also represented in the Philippines, and in addition the country shares plants from Sulawesi (Tan & Rojo 1989), mainland Asia (van Steenis 1950) and the Australian-Papuasian zones (van Steenis 1987). The floral diversity patterns could be attributed to the complex geological history, archipelagic nature, climatic conditions, and topographic features of the country (DENR–PAWB 2006).

Flora in the Philippines is approximately 14 000 species, which is about 5% of the world's flora (DENR–PAWB, CI & UP–CIDS 2002). It is estimated that there are over 8000 species of angiosperms, 33 species of gymnosperms, 1100 species of pteridophytes (Barcelona 2002), 1271 species of bryophytes, more than 3550 species of fungi and molds, about 1355 species of algae (DENR–UNEP 1997; Villareal & Fernando 1999) and 79 species of lichens (Gruezo 1979). In total 26 genera of flowering plants and ferns are endemic to the Philippines (van Steenis 1987; Madulid 1989; Johns 1995). Flowering plant endemism ranges from 45% to 60% (DENR–UNEP 1997; Mittermeier *et al.* 1999).

Under the National Biodiversity Strategy and Action Plan, 18 sites were identified as centers of plant diversity in the country (Table 3). On the other hand, the Philippine Biodiversity Conservation Priorities identified 43 important plant areas or priority areas for plant conservation (Table 4).

Table 3. Centers of plant diversity in the Philippines (after DENR–UNEP 1997).

Mountain or area	Location
Mt Iraya	Batan Island
Sierra Madre Mountains	Isabela Province, Luzon Island
Mt Pulag	Cordillera Mountains, Luzon Island
Mt Arayat	Pampanga Province, Luzon Island
Mt Makiling	Laguna and Batangas Provinces, Luzon Island
Lobo	Batangas Province, Luzon Island
Mt Isarog	Camarines Sur Province, Luzon Island
Mt Halcon	Mindoro Island
Coron	Coron Island
Palawan	Palawan Island
Southern Samar	Samar Island
Sibuyan	Sibuyan Island
Mt Kanlaon	Negros Island
Mt Talinis and Lake Balinsayao	Negros Island
Mt Baloy	Panay Island
Mt Kitanglad	Mindanao Island
Agusan Marsh	Mindanao Island
Mt Apo	Mindanao Island

Table 4. Priority areas for plant conservation (*Important Plant Areas* or *Important Plant Sites*; after DENR–PAWB, CI, & UP–CIDS 2002).

Island & important plant area	Province
Batanes Islands	
Batanes Islands Protected Landscape & Seascape	
Luzon	
Peaks of Central Cordillera (1000 m a.s.l.)	Abra, Mt Province, Benguet, Ifugao, and Ilocos Sur Provinces
Mt Arayat National Park	Tarlac, Pampanga and Nueva Ecija
Bataan Natural Park & Subic Bay Forest Reserve	Bataan and Zambales
Mt Makiling Forest Reserve	Batangas and Laguna
Mt Palaypalay – Mt Mataas na Gulod National Park	Cavite and Batangas
Mt Isarog National Park	Camarines Sur
Isabela – Sierra Madre	Isabela
Aurora –Sierra Madre	Aurora
Mt Tapulao	Zambales
Northern Quezon (Central Sierra Madre)	Quezon
Southern Quezon (Central Sierra Madre)	Quezon
Bicol National Park – Mt Labo	Camarines Sur
Mindoro	
Mt Halcon	Mindoro Occidental and Oriental
Naujan Lake National Park	Mindoro Oriental
Sibuyan Is.	
Sibuyan Island	Romblon
Panay	
Central Panay Mountains: Madjaas–Baloi Complex	Aklan, Capiz, Antique, and Iloilo
Negros	
Mt Canlaon National Park	Negros Occidental and Oriental
Cuernos de Negros Region	Negros Oriental
Samar	
Mt Cabalantian – Mt Capotoan Complex	Samar, Eastern and Northern Samar
Sohoton – Loquilocon area	Eastern and Western Samar
Mindanao	
Dinagat (Mt Kambinlio & Mt Redondo)	Surigao del Norte
Mimbilisan Protected Landscape	Misamis Oriental
North Diwata (Bislig, Mt Agtuuganon – Mt Pasian)	Agusan Del Sur, Compostela, Davao Oriental, and Surigao del Sur
Mt Kaluayan – Kinabalian (Kimangkil Ridge), Bukidnon – Agusan del Norte border	Misamis Oriental, Bukidnon, Davao, Davao del Sur, Agusan del Norte and Agusan del Sur
Mt Kitanglad	Bukidnon
Mt Kalatungan Range	Misamis Oriental, Bukidnon, Lanao del Norte and Lanao del Sur
Munai Tambo Complex (Kolambugan uplands & associated mountains	Lanao del Norte and Lanao del Sur
Lake Lanao	Lanao del Sur
Mt Piagayungan (Ragang) Complex	Bukidnon, North Cotabato, Lanao del Sur and Maguindanao

Island & important plant area	Province
Mt Butig / Lake Butig National Park	Lanao del Sur and Maguindanao
Marilog Forest Reserve, Bukidnon – Davao boundary	Davao and Davao del Sur
Mt Apo Range	North Cotabato and Davao del Sur
Mt Matutum	North Cotabato, Davao del Sur, Sarangani, South Cotabato, and Sultan Kudarat
Mt Latian Complex (Sarangani Mountains)	Davao del Sur and Sarangani
Mt Malindang & Lake Duminagat	Misamis Occidental and Zamboanga del Norte
Calamian Islands	
Calamianes	Palawan
Palawan	
Northern Palawan	
Central Palawan	Palawan
Southern Palawan, including Balabac Group of Islands	Palawan
Leyte	
Mt Pangasugan & Anonang – Lobi Range	
Camiguin Island	
Mt Hibok-hibok	Misamis Oriental
Tawi-tawi	
Tawi-tawi	

Legal framework

The Philippines has promulgated several national policies and legislations concerning conservation, protection and proper utilization of its natural resources. The following are examples of government laws which are directly or indirectly related to the protection and conservation of forest genetic resources.

The Philippine Constitution

The Philippine constitution includes provisions related to forest resources:

(1) Protection and achievement by the State of the right of all Filipino people to a balanced and healthful ecology in accordance with the rhythm and harmony of nature (Sec. 16, Art. II); framework of national unity and development (Sec. 22, XI);
(2) State of ownership of all natural resources and inalienability, except for agricultural lands (Sec. 2, XII);
(3) Full control and supervision by the State on exploration, development, and utilization of natural resources either by directly undertaking such activities or by entering into co-production, joint venture or production-sharing agreements with Filipino citizens or Filipino owned or controlled corporations or associations (Sec. 2, XII);
(4) Small scale utilization of natural resources (Sec. 2, XIII);
(5) Determination by Congress of the specific limits of forest lands by marking of their boundaries on the ground (Sec. 4, XII);
(6) Protection of the rights of indigenous cultural communities (ICC) by the State to their ancestral lands to ensure their economic, social, and cultural well being (Sec. 5, XII).

Of the seven provisions by the Philippine constitution, Article XII of the sections 4 and 5 are relevant to the conservation of tree species.

National legislation and policies

The growing concern for the environment and proper utilization of the natural resources for economic development has resulted to the enactment of policies which advocate the protection of the country's resource base. Specific policies and legislations and the status of their implementation are briefly listed in the following.

Act No. 315 and the Republic Act No. 826

Enacted in 1932, Act No. 315 is one of the earliest legislations related to biodiversity conservation and management. It provides for the establishment of national parks; for example, game refuges with panoramic, historical, scientific or aesthetic values for the benefit and enjoyment of the Philippine people. The law prohibits occupation of the national parks and harvesting of timber or other forest products and wildlife resources therein without permit or license. It was one of the earlier accounts on natural resources management that considered the principle of inter-generational responsibilities.

Through the Republic Act No. 826, a Commission on Parks and Wildlife was created in 1952 under the supervision of the President in order to promote effective planning, development, maintenance and supervision of national parks, monuments, wildlife and game refuges and bird sanctuaries. The same act also promotes the establishment and conservation of provincial, city and municipal parks to comply with the fundamental purpose of national parks for the benefit and enjoyment of the future generations. It was one of the earlier accounts on natural resources management that considered the principle of inter-generational responsibilities.

Presidential Decree No. 705

This law, enacted in 1975, provides the major framework for the management, conservation and utilization of the forest resources in the country. The law mandated the Bureau of Forestry Development (BFD) with the responsibility for protection, development, management and preservation of national parks, game refuges and wildlife. The law declares the occupation of national parks and recreation and vandalism activities therein illegal.[13]

Executive Order No. 192

Through the Executive Order No. 192, the Department of Environment and Natural Resources (DENR) is tasked with the primary responsibility to promote the well-being of the Filipino people through sustainable development of natural resources, optimal utilization of forest lands, social equity and efficiency of forest resource use and effective forest management. The Order created, among others, the Protected Area and Wildlife Board (PAWB). The aim was to consolidate governmental efforts in the conservation of natural biological resources, specifically through the institutionalization of the National Integrated Protected Areas System (NIPAS). The enactment of the NIPAS Law or Republic Act (RA) of No 7586 of 1992 was pursued by PAWB.

Republic Act No. 7586 (the NIPAS Law)

The most important piece of legislation on biodiversity in the country is the RA 7586, enacted in 1992, otherwise known as the National Integrated Protected Areas System (NIPAS) law,

[13] A Sustainable Forest Management Act is languishing in the Philippine Congress since the late 1980s. It should revise this fundamental forestry law which has served its purpose and requires the needed overhauling in the view of new national and global developments, including the changing environment.

which mandated DENR in its implementation. It contained the twin objectives of biodiversity conservation and sustainable development.

As early as 1998, 34 protected areas were proclaimed under the NIPAS category, encompassing 1 443 000 ha. The regional offices of DENR also identified 25 old-growth and mossy forests that have been proposed for inclusion in the protected area system. In the same year, the Protected Area and Wildlife Board (PAWB) designed the Biodiversity Monitoring System (BMS) for data collection focusing on priority species and their utilization. In 2000, the BMS was institutionalized through the issuance of the Administrative Order (AO) No. 13 of DENR, entitled "Guidelines on the Implementation of the Biodiversity Monitoring System in Protected Areas". The system serves to improve the participation of communities in the protected areas and other stakeholders in the management of protected areas.

Executive Order No. 247 (the Bioprospecting Law)

The Executive Order No. 247, enacted in 1995, is to provide a regulatory framework for bioprospecting, the exploitation of indigenous knowledge on natural resources or the search for previously unknown compounds for medicinal use. Also called the Bioprospecting Law, it prescribes the guidelines and establishes a regulatory framework for the bioprospecting of biological and genetic resources, their by-products and derivatives for scientific, commercial and other purposes. This law is in line with the provisions of the Convention on Biological Diversity (CBD) to which the Philippines is a signatory. The law declares:

> "It shall be the policy of the State to regulate the prospecting of biological and genetic resources to the end that these resources are protected and conserved, are developed and put to the sustainable use and benefit of the national interest. Further, it shall promote the development of local capability in science and technology to achieve technological self-reliance in selected areas."

Republic Act No. 9147 (the Wildlife Resources Conservation and Protection Act)

This legislation, enacted in 2001, provides for the conservation and protection of wildlife resources in protected areas and critical habitats. It is also known as the Wildlife Resources Conservation and Protection Act. The law assigns jurisdiction over terrestrial plants and animal species to DENR and over aquatic plants and animals to the Department of Agriculture (DA). The DENR Secretary will determine whether any wildlife species or subspecies are threatened and classify them as critically endangered, endangered, vulnerable or under other categories based on scientific data and internationally accepted criteria. The act allows the collection of wildlife for scientific or breeding propagation purposes, and for the breeding or propagation of threatened species to enhance their populations in natural habitats (restoration purposes) and establishment and protection of critical habitats outside protected areas where the threatened species are found. The National List of Threatened Philippine Plants and their categories, and the List of Other Wildlife Species were established through the DENR AO 2007-01. Subsequently, the DENR AO 2007-02 was issued to provide the guidelines on the establishment and management of critical habitat for species under the jurisdiction of DENR.

Other legislations and policies affecting genetic resources conservation

The Philippine Forestry Code or PD 705 still remains as the primary legal instrument guiding the conservation and utilization of forest resources in the country. Legal issuances cover the protection of specific areas with rich natural resources. These include RA 7611 (1991) which

declared a Strategic Environmental Plan (SEP) for Palawan. The Plan calls for the conservation, utilization and development of such natural resources in tandem with the provision of optimum yield on a continuing basis. This was followed by the DENR AO 45 (1992) which declared a moratorium on all commercial logging in Palawan. Proclamation No. 926 is another conservation-oriented legal issuance establishing the Subic Watershed Forest Reserve. The DENR AO No. 25 (1991) prohibited logging from old-growth or virgin forests and declared these areas as part of the integrated protected areas systems. Likewise, large tracts of mangrove areas all over the country have been declared wilderness areas, thus limiting the extraction of forest resources in these areas.

In 2000, the DENR AO 2000-44 allowed the sustainable use of forest resources inside multiple-use and buffer zones, except any form of logging or timber cutting involving the natural forest. Subsequently, the DENR AO 2002-02 provided an opportunity to organized tenured migrant communities and interested indigenous peoples to manage, develop, utilize, conserve and protect the resources in designated Community-based Program (CBP) area. These opportunities are subject to prior vested rights, with activities consistent with the Protected Area Management Plan (PAMP). Additional guidelines were later spelled out in the DENR AO 2004-32 which provide tenured migrant communities and interested peoples within protected areas and buffer zones tenure over established CBP areas, provided that the activities to be undertaken are consistent with PAMP.

The Memorandum Circular (MC) 2004-06 of DENR adopts the so-called rainforestation technology to restore, manage and rehabilitate degraded and secondary forest in protected areas and other appropriate forest lands. Indigenous and endemic tree species are the recommended species for planting. The DENR MC 2007-02 provides the guidelines for the establishment and management of critical habitats in the country which will cover public lands (terrestrial and wetland areas) outside protected areas as well as privately-owned lands where threatened species are found.

Republic Act No. 7303 (the Seed Industry Development Act)

The Seed Industry Development Act of 1992 promotes and accelerates the development of seed industry and mandates the conservation, preservation and development of plant genetic resources in the Philippines. It vests the University of the Philippines, Los Baños (UPLB), with leadership in plant biotechnology activities related to plant improvement, conservation of genetic resources and *in vitro* mass production of planting materials including biotechnology.

Executive Order 578

Issued in the latter part of 2006, this is the policy of the state on biological diversity. It specifically states that "it is the policy of the state to protect, conserve, and sustainably use biological diversity to ensure and secure the well-being of the present and future generations of Filipinos. This state policy extends to all the components of biodiversity – ecosystem, species and **genes**."

Clearly, policies are set in place to insure protection of biodiversity in the Philippines including forest genetic resources but based on field observations, the actual implementation of these policies is the big hindrance to successful to conservation efforts.

Characterization of the forest types and forest genetic resources

Biological diversity of the different forest types found in the Philippines is significantly high. In fact, the country has been classified as one of the world's 25 mega-diversity countries, with

an impressive record of species diversity and endemism (Mittermeier *et al.* 1999). The complex geological history, archipelagic character and mountainous terrains of the more than 7000 islands are the major causes for the diverse habitats and broader ecological opportunities that have enhanced adaptive radiation and speciation (Fernando *et al.* 2001). The Philippines is also considered a biodiversity hotspot (Myers *et al.* 2000). As such, its species and habitats are one of the most endangered in the world and face imminent threat of destruction. DENR has classified the country into 15 biogeographical regions primarily based on the floristic, faunistic and geological composition.

Forest vegetation in the Philippines is categorized into twelve (12) types (DENR–PAWB 2006): They are briefly described in the following chapters.

Lowland evergreen rain forest

This forest type is the most common of the tropical rain forest formation in the Philippine Islands. It includes the dipterocarp and the mixed-dipterocarp forests described by Ashton (1997). It could be found at elevations from 0 to 900 m above sea level and is well observed in sites with evenly distributed rainfall or of only a short dry season. Tree species of the family Dipterocarpaceae, in particular, dominate this forest type. In a study done a century ago, the relative density of dipterocarps among trees exceeding 40 cm in diameter at breast height (dbh) varied from 3% on Mindoro Island to 89% on Negros Island (Whitford 1911). This forest type is situated along the typhoon belt. The canopy structures are diffused and allow more light penetration in the understory. These light conditions promote a dense growth of rattans, lianas, epiphytes and herbaceous plants on the forest floor, and arecoid tree palms and seedlings and saplings as emergents.

Semi-evergreen rain forest

These forests are characteristically dominated by a single dipterocarp species, *Dipterocarpus grandiflorus* or *Shorea contorta.* This forest type is found in the western side of the archipelago, including Palawan and Zambales on Luzon, which has a seasonally dry climate.

Semi-deciduous forest

The species growing in this forest type are capable of growing in water-stressed conditions. They are often on the leeward side of mountains or on dry coastal hills (Ashton 1997). In western Mindoro, this forest type is dominated by *Pterocarpus indicus, Intsia bijuga, Toona calantas, Koordersiodendron pinnatum, Pometia pinnata, Dipterocarpus validus, Bischofia javanica,* and *Alstonia scholaris* (Merritt 1908). *Vitex parviflora* dominates this forest type in the northwestern coastal hills of Luzon and near the east coast of Mindoro (Maun 1958). Associated species include *Wallaceodendron celebicum, Litchi chinensis* ssp. *philippinensis, Pterocarpus indicus, Intsia bijuga, Lagerstroemia piriformis,* and *Kingiodendron alternifolium.* In Palawan, patches of this formation are still present in the Irawan valley, Calauag, and south of Roxas (Podzorski 1985), with the common emergents including *Pterocymbium tinctorium, Pterospermum diversifolium, Garuga floribunda,* and *Intsia bijuga.*

Forest over limestone

This formation occupies low, karst limestone hills, either coastal or bordering large uplifted river valleys, which are mainly composed of crystalline limestone covered by a shallow or very thin soil. A number of leguminous trees are dominant in this formation, namely *Afzelia rhomboidea, Sindora supa, Intsia bijuga, Albizia acle, Wallaceodendron celebicum, Pterocarpus*

indicus and *Kingiodendron alternifolium.* Other dominant species include *Pterocymbium tinctorium, Ziziphus talanai, Toona calantas, Mimusops elengi, Maranthes corymbosa, Wrightia pubescens* ssp. *laniti, Lagerstroemia piriformis* and *Heritiera sylvatica,* and such smaller trees as *Diospyros ferrea, Pterospermum diversifolium* and *Mallotus floribundus*. This formation is apparently similar to the so-called Molave (*Vitex parviflora*) forest as described by Whitford (1911) on other substrates.

Forest over ultramafic rocks

This forest type occurs on Palawan (Podzorski 1985), eastern Isabela and northern Zambales on Luzon, north-eastern and south-eastern Mindanao, and on Dinagat Island. This forest type is found soil high in heavy metals. Some of the ultramafic forests on Palawan are only about 2–5 m of height and contain a unique flora including, among others, *Planchonella* sp. and the heavy metal indicators *Scaevola micrantha*, *Brackenridgea palustris* and *Exocarpus latifolius* (Podzorski 1985). Other tree species include *Neissosperma glomerata* and species of *Gymnostoma, Suregada, Archidendron* and *Pouteria.* The Mt Victoria area is the largest region of ultramafic forests on Palawan and is home to the endemic tree *Embolanthera spicata*, one of only two species in the genus (the other being in Indo-China). The ultramafic forests in north-eastern Mindanao are taller, reaching 15 to 20 m, and include *Tristaniopsis micrantha, Sararanga philippinensis* and *Terminalia surigaoensis*. On Dinagat Island and also the north-eastern tip of Mindanao and Leyte the ultramafic forest contains the endemic tree *Xanthostemon verdugonianus*.

Beach forest

The principal species occurring in the Philippine beach forests are *Terminalia catappa, Erythrina orientalis, Barringtonia asiatica, Thespesia populnea, T. populneoides, Hibiscus tiliaceus, Calophyllum inophyllum, Pongamia pinnata, Tournefortia argentea, Casuarina equisetifolia* and *Scaevola frutescens*. They are usually found along the sandy beaches of seacoasts. *Terminalia catappa* may occur in small patches of pure stands in rich river bottoms. On sandy flood plains near rivers, *Casuarina equisetifolia* usually forms pure stands. *Dendrolobium umbellatum* and *Pandanus odoratissimus* also occur commonly in the beach forest. On the accreting sand there is usually a narrow strip of herbaceous vegetation dominated by *Ipomoea pescaprae*.

Mangrove forest

A total of 39 mangrove tree species have been recorded for the Philippines (Fernando and Pancho 1980). The following are the more common and abundant: *Rhizophora apiculata, R. mucronata, Bruguiera cylindrica, B. gymnorhiza, B. parviflora, B. sexangula, Ceriops decandra, C. tagal, Avicennia marina, A. officinalis, Sonneratia alba* and *S. caseolaris.*

The seaward side where the soil is generally mixed with sand or coral limestone is occupied by species of *Avicennia* and *Sonneratia*. *Osbornia octodonta* of Australian affinity is the associated species, which forms almost pure thickets. *Rhizophora stylosa* also invades sandy shores and coral terraces and does not occur inland. On the inner edges of the mangrove formation the following species can be found: *Bruguiera* and *Ceriops,* as well as *Lumnitzera littorea, L. racemosa, Aegiceras corniculatum, A. floridum, Camptostemon philippinense, Scyphiphora hydrophyllacea, Excoecaria agallocha, Heritiera littoralis,* and *Cerbera manghas*. The following species may be rare to frequent and occur along the borders: *Glochidion littoralis, Dolichandrone spathacea, Barringtonia racemosa, Xylocarpus granatum* and *X. moluccensis*. In cut-over areas and along the edges, the swamp fern *Acrostichum aureum* and two species of the spiny scandent *Acanthus* are prominent. On the inland edge of the mangrove and the upper

tidal limit of estuaries, extensive pure stands of *Nypa fruticans* occur, especially along water courses.

Peat swamp forest

The flora of the peat swamp forest has never been documented. It is present in southern Leyte and probably in Mindanao (Whitmore 1984a).

Fresh-water swamp forest

Two areas in the Philippines were cited to have fresh-water swamp forests: the middle Agusan valley and west of Pagalungan, both areas on Mindanao (Whitmore 1984b). Mineral-rich fresh-water from rivers and streams regularly to occasionally inundated this formation. The area has been converted to either rice paddies, human settlements or other uses. The floristic composition of this forest type is still unknown, but it is likely that *Metroxylon sagu* may have been a dominant component. In the drainage system of Agusan and the nearby provinces, the freshwater swamp forest is occasionally dominated by *Terminalia copelandii* and *Nauclea orientalis*. Likewise, these areas have been cleared for agricultural purposes. Other co-dominants are *Albizia saponaria* and *Sesbania cannabina.* Common sedges and grasses found in the marshland include *Phragmites balatoria, Eriochloa procera, Scirpodendron ghaeri* and *Paspalum* spp.

Lower montane rain forest

Found at elevations ranging from 400 to 950 m and extending up to 1500 m above sea level, this forest formation is dominated by *Shorea polysperma* together with oaks (*Lithocarpus*), oil fruits (*Elaeocarpus*), laurels (*Litsea*) and makaasim (*Syzygium*) (Brown 1919; Ashton 1997). The understory is composed of epiphytic ferns, herbaceous shrubs of Rubiaceae (e.g. *Psychotria*) and Acanthaceae (e.g. *Strobilanthes*). *Saurauia* and species of Urticaceae including climbers such as *Freycinetia* are common in gaps and gullies.

Pinus kesiya occurs as a fire climax tree species in pure stands in the Cordillera Mountains of Luzon (Jacobs 1972). *Pinus merkusii*, on the other hand, occurs on the driest sites in Western Mindoro and Luzon (Zambales and Abra).

Upper montane rain forest

Considered as the mossy forest type in the Philippines, this forest formation occurs in elevations greater than 1000 m. Characteristically, the topography is rough with steep ridges and canyons. High rainfall pattern and humidity promote growth of mosses, liverworts, ferns and other epiphytes on the tree trunks. Strong winds prevents tall trees, hence most of the trees are dwarf. Ferns and grasses occupy open areas. *Dacrydium, Dacrycarpus* and *Podocarpus*, and broadleaf genera such as *Lithocarpus, Symplocos, Engelhardtia, Syzygium* and *Myrica* are the most common tree species. Additionally, species of Ericaceae (*Rhododendron, Vaccinium and Diplycosia*) and Melastomataceae (*Astronia, Medinilla,* and *Melastoma*) are common, as is the tree fern genus *Cyathea*.

Subalpine forest

Found in very high elevations (2470–2587 m a.s.l.), the vegetation of subalpine forests is generally regarded as open shrub heaths, mainly characterized by the dominance of small, woody dicots with microphyllous-sclerophyllous leaves which form a low, dense canopy

(Merrill 1907; Mandia 2001). This forest formation is found in Mt Halcon – Mt Sialdang range on Mindoro Island and some sites in Mt Pulag (Jacobs 1974), Mt Mantalingahan and Mt Kinasalapi. The more common woody dicots in the Mt Sialdang subalpine rain forest are *Styphelia suaveolens, Rhododendron quadrasianum, Vaccinium myrtoides, Myrica javanica, Leptospermum flavescens* and *Eurya coriacea* (Mandia 2001). The plant community is quite similar to those of Mt Kinabalu (4101 m, Borneo) and Mt Kerinci (3800 m, Sumatra).

Non-timber forest products

In the Philippines, the non-timber forest products (NTFP; also non-wood forest products, NWFP) which are considered valuable and important are rattan, bamboo, fibres, vines, palms and exudates. Other NTFPs include essential oils, dyes, wild food plants, medicinal plants, honey and butterflies (EC–FAO 2002). For the local and international markets in the Philippines, almaciga resin (*Agathis philippinensis)*, anahaw leaves and poles (*Livistonia rotundifolia)*, bamboo poles, hinggiw (*Ichnocarpus frutescens)*, diliman (*Stenochlaena palustris*) and other vines, rattan, rono, honey, buri (*Corypha elata)*, salago fiber (*Wikstroemia* spp.), and tanbark the are in trade (Philippine Forestry Statistics 2004). From 1971 to 2001, the reported export value of non-timber forest products was 12.54 million US$ (Revised MPFD 2003). The amount may appear quite insignificant, but considering the difficulties in reporting and monitoring, the actual amount may be much higher than this reported value. Nevertheless, the importance and role of NTFPs is profound for various sectors of the society. For rural upland people, NTFPs represent an important food source, while the furniture and handicraft industries value NTFPs as raw materials. Similarly they are important in the manufacture of pulp and paper, plastic, paint and varnish, soap and shampoo. They are also essential sources of materials for low-cost housing, food and beverages, clothing materials, medicine and other valuable products. They provide many people, especially those living in or near the forests, with some form of livelihood (Neri 1994).

Approximately 62 species of rattan are found in the Philippines. Of these, 12 are of commercial value: palasan (*Calamus merrillii*), limuran (*C. ornatus* var. *philippinensis*), tumalim (*C. mindorensis*), sika (*C. caesius*), panlis (*C. ramulosus*), malacca cane (*C. scipionum*), lambutan (*C. halconensis*), apas or lukuan (*C. reyesianus*), kurakling (*C. microsphaerion*), tagiktik (*C. filispadix*), ditaan (*Daemonorops mollis*) and hiyod (*D. pedicellaris*). Rattan plantations have been developed under government projects, and they were reported to cover a total area of 12 000 ha (Tesoro 2000). Some of these areas were developed prior to the formulation of the Master Plan of Forestry Development.

It is estimated that there are about 52 000 ha of bamboo with 62 species in the Philippines. The major five species are kawayan tinik (*Bambusa blumeana*), kawayan kiling (*B. vulgaris*), bayog (*Bambusa* sp.), giant bamboo (*Gigantochloa aspera*), and bolo (*G. levis*). They are distributed in forest lands (20 500 to 34 000 ha), government plantations (2240 ha), private lands (3040 ha) and natural stands (1340 ha). Potential production of these bamboo stands is estimated to be from 29 to 52 million poles annually (EC–FAO 2002). The reported harvest in 2000 was 2.34 million pieces (RMPFD 2003).

In the international markets, almaciga (*Agathis philippinensis*) and elemi (*Canarium ovatum*) are exudates that are commercially traded. The former is for the manufacture of paints and varnishes, while the latter is valued for its essence in the manufacture of perfumes and similar products. Practically no production data is available for elemi (RMPFD 2003).

Apart from bamboo and rattan which are considered as the major NTFPs, other important NTFPs in the Philippines, their uses, and inventory are presented in Table 5.

Table 5. Important non-timber forest products in the Philippines (excluding bamboo and rattan; EC–FAO 2002).

Species	Uses
Vines & bast fibre	
buri (*Corypha elata*), kaong (*Arenga pinnata*), sago (*Metroxylon sagu*) and vines such as hinggiw (*Ichnocarpus frutescens*)	Basketry industry
nipa (*Nypa fruticans*)	Sap can be used for alcohol, wine, sugar and vinegar; leaves for bags and hats and to make shingles for roofing and walls for low-cost houses; fruits are used as medicine for intestinal worms; the midribs are made into brooms and the petioles are used as fuel. The fermented juice is a popular local drink.
anahaw (*Livistonia rotundifolia*)	Stem used for handicrafts, utensils and construction materials, and the leaves for roofing. Edible buds. Also used as ornamental plant.
diliman (*Stenochlaena palustris*)	Tying material in the preparation of fish traps because of its durability in salt water. Also used for making ropes and baskets.
lukmoy (*Rhapidophora monticola* or *Pothos* sp.)	The central cylinders of the roots of *Pothos* are used in baskets.
nito (*Lygodium circinnatum*)	Manufacture of baskets, hats, bags and other fancy articles
baling-uai (*Flagellaria indica*)	Used in tying, in sewing nipa shingles and in making baskets
Salago (*Wikstroemia* spp.): small-leaf salago (*W. indica*); lance-leaf salago (*W. lanceolata)*; large-leaf salago (*W. meyeniana)*, round-leaf salago (*W. ovata*)	Manufacture of high grade paper used in bank notes, cheques, paper for legal documents and other specialty papers requiring strength and durability.
40 known species of pandan (*Pandanus*): bariu (*P. copelandii*); taboan (*P. dubius*); alasas (*P. uzonensis*); oyango (*P. radicans*); sabutan (*P. sabotan*); karagomoi (*P. simplex*); common or beach pandan (*P. tectorius*) and pandan layugan (*P. exaltatus*)	
Plants producing gums and resins	
piling liitan (*Canarium luzonicum*)*;* Almaciga/Manila copal (*Agathis philippinensis)*; Benguet pine (*Pinus kesiya*); apitong (*Dipterocarpus grandiflorus*) and Manila elemi (*Canarium luzonicum*)	
Medicine	
lagundi (*Vitex negundo*), sambong (*Blumea balsamifera*), yerba buena (*Mentha cordifolia*) and tsaang gubat (*Carmona retusa*)	
Perfumes	
citronella (*Andropogon nardus*), salai/tanglad (*Cymbopogon citratus*), moras (*Vetiveria zizanioides*), ilang-ilang (*Cananga odorata*), kalingag (*Cinnamomum mercadoi*), lumbang (*Aleurites moluccana*) and baguilumbang (*A. trisperma*)	For essential oil industry
Plant dyes	
sikalig (*Morinda bracteata*)*,* sibukao (*Caesalpinia sappan*) and talisay (*Terminalia catappa*). Sappan wood (sibukao) from *Caesalpinia sappan*.	colouring mats, textiles and in food products.

Conservation and management practices of forest genetic resources

Paradoxically, the Philippines claimed both the titles of a mega-diversity country and a biodiversity hotspot (DENR–PAWB, CI & UP–CIDS 2002). Habitat destruction continues and is mainly caused by land conversion for settlement and agricultural development, kaingin or slash-and-burn farming, logging, forest fire, chemical pollution, and to some extent mining, energy projects, and pests and diseases (DENR–PAWB 2006). Dr Edwino Fernando, member of the Philippine Plant Conservation Committee, cited during the National Consultative Workshop on FGR held in February 2007 that the country's FGR are threatened by overexploitation for commercial purposes (collection of wild orchids for export), land conversion (logging and shifting cultivation) and habitat fragmentation. He also added the threat posed by non-native or alien invasive species due to the disturbed state of the forest ecosystems. The 2000 IUCN Red List included 227 species of plants from the country. As of 2005, the Philippine National List of Threatened Species of Plants prepared by the Philippine Plant Conservation Committee includes 696 species. Of the most recent list, 94 are considered in the critically endangered category while 188 are in the endangered category.

To insure that forest genetic resources are adequately protected and conserved, *in situ* and *ex situ* conservation strategies have been instituted and implemented in various part of the country. These specific conservation strategies are discussed in the following.

In situ conservation

Conservation of wildlife species, including flora and fauna, in their natural environment is carried out through the *in situ* conservation. *In situ* conservation started in the Philippines as early as 1932, through the institution of the National Parks System. In total 60 national parks and 8 game refuges and bird sanctuaries were established under this system. These parks, refuges and sanctuaries became a core component of the National Integrated Protected Areas System (NIPAS) which was established in 1992 through RA 7586. The objective of NIPAS is to "*integrate outstanding remarkable areas and biologically important public lands that are habitats of rare and endangered species of plants and animals, biogeographic zones and related ecosystems whether terrestrial, wetland or marine, all of which shall be designated as protected areas*". A total of 99 protected areas with an aggregate area of 2 900 000 ha have already been proclaimed under NIPAS, as of the latest statistics from the Protected Area and Wildlife Bureau (PAWB 2004).

Other projects for the management of the protected areas include the Conservation of Priority Protected Areas Project (CPPAP) funded by the World Bank and the Global Environmental Facility (WB–GEF), the National Integrated Protected Areas Program (NIPAP) funded by the European Union (EU), and the Samar Island Biodiversity Project (SIBP) funded by the United Nations Development Programme (UNDP) and the GEF. Subsequently, other conservation projects have come into reality: Administration and Development of Hinulugan Taktak Protected Landscape, and Mt Apo Restoration and Development Project. Non-government organizations such as the Haribon Foundation are actively involved in the restoration and protection work.

Ex situ conservation

Field genebanks and plantations

Ex situ conservation efforts for timber trees in the Philippines generally involve field genebanks or plantations for species and provenance trials. Species and provenance trials

and establishment of seed orchards have long been conducted by DENR for species of *Acacia, Casuarina, Eucalyptus, Gmelina, Pterocarpus, Pinus, Swietenia, Xanthostemon* and other multipurpose species (Garcia 1999). Many of these projects faltered due to changes in leadership and institutional reorganizations and lack of sustained government support (Ordinario 1992). Some of the provenance trial plots later formed seed sources for the younger plantations by DENR and private planters. The PICOP Resources Incorporated (PICOP), the Provident Tree Farms Incorporated (PTFI) and the Bukidnon Forests Incorporated (BFI) have been practising *ex situ* conservation activities through provenance introduction and multiplication of phenotypically superior industrial forest plantation species such as *Paraserianthes falcataria, Gmelina arborea, Endospermum peltatum* and *Eucalyptus deglupta* (Fernando 2001).

PICOP in Mindanao was one of the first few logging concessionaires which established large-scale forest plantations in the Philippines to support its own pulp and paper mill in the early 1970s. The species in PICOP's plantations are *Swietenia macrophylla, Pinus caribaea, Gmelina arborea, Acacia mangium, Paraserianthes falcataria* and *Eucalyptus deglupta*. PICOP's industrial tree plantations in total covered more than 46 000 ha of mainly *P. falcataria* and *E. deglupta* (Reyes 1987). The forest plantations are supported by PICOP's own forest research and tree improvement programmes such as species provenance trials, progeny testing and parent trees selection.

A collaborative effort of DENR and the New Zealand government on plantation development and management gave rise to the Bukidnon Forest Inc. (BFI). Among its significant contributions is the domestication of exotic acacias, eucalyptus and pines for planting in open grassland (*Imperata cylindrica*) sites. An extensive study on species selection and suitability of seed origin was conducted. Based on the two-year results, the most promising species are *Acacia aulacocarpa, A. auriculiformis, A. crassicarpa, A. mangium, Eucalyptus urophylla, E. camaldulensis, E. tereticornis, E. pellita, E. grandis, E. deglupta, E. deglupta* × *pellita, E. grandis* × *urophylla,* and *Pinus caribaea* var. *hondurensis* and var. *bahamensis*. Information gathered from the project revealed that the BFI had adequate genetic resources of *E. urophylla, A. mangium* and *A. crassicarpa* to establish seed production areas and seedling seed orchards (Cuevas 1999; Crizaldo 1999). In 1997, the BFI started a trial planting of indigenous species, such as *Shorea contorta, Anisoptera thurifera* and *Vitex parviflora* (Cuevas 1999).

Timber harvesting in old growth forests, mossy forests, and those over 1000 m of elevation and with more than 50% slope was banned by the Philippine government at the beginning of 2000s. Many of these forest areas now form part of NIPAS (Fernando 2001). However, most of the genetic resources of timber species in the Philippines are restricted to the lowland rain forests where much of the large-scale commercial logging has been undertaken for many decades. Thus, a consensus has been growing that protected areas alone will not be sufficient to effectively conserve forest tree genetic resources in the Philippines. Consequently, the present challenge is to develop measures to maintain biodiversity within the practice of forestry (Aplet *et al.* 1993).

The Surigao Development Corporation (SUDECOR), another private logging company in eastern Mindanao, has launched a research project in cooperation with DENR. The project is funded by the International Tropical Timber Organization (ITTO) and implemented by the Sustainable Ecosystems International Corporation (SUSTEC). The project collected information for assessing biodiversity and developing conservation measures in order to integrate these aspects in a sustainable forest management plan for the logging company (Fernando 2001). A total of 42 400 ha of proposed protection areas were identified with support from the ITTO. The areas identified for this purpose are highly valuable for biodiversity conservation; for example, areas with high endemism, species richness and diversity (ITTO and SUSTEC 2002).

Botanical gardens and parks

The Philippines has nine botanical gardens with a total of 16 000 taxa (Fernando and Balatibat 1998). The Makiling Botanic Gardens (MBG) is the only fully developed botanical garden in the country and the first to be legislated through RA 3523, in 1963. It maintains an arboretum of Dipterocarpaceae which represents more than half of all the known species in the Philippines. It also has plantations of *Swietenia macrophylla*, representing probably the earliest seed lots of this species. The MBG's collections of commercial timber trees in its approximately 5-ha site also include *Paraserianthes falcataria, Afzelia rhomboidea, Intsia bijuga, Sindora supa, Madhuca betis, Pterocarpus indicus, Petersianthus quadrialatus, Agathis philippinensis, Tectona philippinensis, Cedrela odorata, Endospermum peltatum, Tectona grandis* and *Vitex parviflora*. The problem with these conservation stands is the lack of a continuing record which would reflect the origins of the introduced species.

Seed banks, clone banks and in vitro genebanks

The Institute of Plant Breeding (IPB) is maintaining a genebank for agroforestry species such as *Gliricidia sepium* and a collection of indigenous and endemic fruit tree species. The Institute also has facilities for storing seeds and tissues for an indefinite length of time. Currently it is keeping specimens of cereals, horticultural and ornamental collections, but none yet on timber species. Nevertheless, the Institute, in collaboration with the MBG, is going to a programme on the conservation of biodiversity of high value crops, including indigenous palms and selected forest species (Garcia 1999). The Ecosystems Research and Development Bureau (ERDB) has established a genebank for rattan (Lapis 1998) and bamboo in the Mt Makiling Forest Reserve. Halos (1981) established a seed bank for *Leucaena* species at the ERDB, but it was not maintained.

At its central office, DENR has established a seed storage and testing centre. Unfortunately, the seed storage facility has been converted into a hostel for DENR personnel. The establishment of seven other seed storage and testing centres is planned for different regions around the country (FMB 1999).

Plant rescue

Scientists at the National Museum in Manila have started a Plant Rescue Operation which was inspired by the recent Mt Pinatubo eruption. No similar activities have been planned for other volcanic areas in the Philippines to prepare for future natural events (Garcia 2000).

Clonal propagation

As to macropropagation, the protocols for rooting of *Gmelina* shoot tip and nodal cuttings were developed by Umali-Garcia as early as 1990. The importance of clonal testing was demonstrated in several *Gmelina* provenances (Umali-Garcia *et al.* 1998). The propagation of several endangered Philippine species, such as *Diospyros philippinensis* (Oporto and Umali-Garcia 1999) and *Dracontomelon dao* (Oporto and Umali-Garcia 1998a) has been successfully demonstrated. There are already available protocols for rooting of stem cuttings of certain species of dipterocarps (Pollisco 1995; Dela Cruz 1996; Oporto and Umali-Garcia 1998c), *Paraserianthes falcataria*, (Umali-Garcia 1989), *Eucalyptus* hybrid (Siarot 1991), *Swietenia macrophylla, Vitex parviflora* (Umali-Garcia 1995), *Pittosporum pentandrum* (Oporto and Umali-Garcia 1998b) and *Pinus merkusii* (Garcia 1999).

As to micropropagation, the status of the use of tissue culture propagation of various tree and plant species in the Philippines is summarized in Table 6. Except for *Eucalyptus deglupta, Paraserianthes falcataria* and *Cratoxylon sumatranum*, the clones have not found their way in the nursery. An on-going programme on forest biotechnology based at the University of the Philippines, Los Baños (UPLB), under the College of Forestry and Natural

Resources (UPLB–CFNR) focuses on tissue culture of industrial plantation species such as *Acacia mangium, Gmelina arborea, Pterocarpus indicus, P. falcataria* and *Swietenia macrophylla* using explants from selected plus trees.

Tissue culture of various rattan species has been worked on. An ongoing project on 'Research and Development Program and Capability Building on the Mass Propagation of Rattan through Tissue Culture' collected seeds of different provenances of rattan from Bukidnon (Mindanao) and Aklan (Visayas), and from Makiling and Ilocos (Luzon). The project utilizes embryos and tissues from *in vitro* -germinated seeds as explants (Garcia 2002).

Tree improvement and provenance trial

Through its regional research offices, DENR has started a number of species and provenance trials. Since as early as 1958, trial plantings of Eucalyptus have been conducted all over the Philippines (Lizardo 1960). Other species trials of Eucalyptus provenances, obtained from the Northern Territories of Australia, Italy, Philippines, New South Wales and Brazil, have been reported by Maun (1978). Agpaoa (1980; see also Agpaoa and Tangan 1981) claimed that E. camaldulensis planted in Ilocos Norte, Benguet, Nueva Ecija and Nueva Vizcaya grew and survived better than Casuarina equisetifolia, Leucaena leucocephala, Gmelina arborea and Albizia procera.

Table 6. Tree species studied using tissue culture in the Philippines (adapted from Lapitan and Garcia 1993).

Species	Status of research
Agathis philippinensis, *Pseudocarpus philippinensis*	Sterilization procedure and medium for callus initiation protocol developed
Paraserianthes falcataria	Plantlets developed Callus and bud formation and rooting
Pterocarpus indicus	Media identified for callus and shoot formation
Shorea contorta, *Eucalyptus camaldulensis*, *E. deglupta*, *Pogostemon cablin*	Nutritional requirements for callus initiation established Callus formation, shoot and root formation Plantlets acclimatized in the nursery Callus induction, plantlet regeneration, shoot formation, survival of plantlets
Citrofortunella mitis, *Citrus* spp.	Multiple shoot formation in defined medium
Cratoxylon sumatranum	Plantlets acclimatized under nursery condition and some were planted out in the field
Paraserianthes falcataria	Tissue culture for tree improvement
Rattans:	
Daemonorops mollis, *Dendrocalamus latiflorus*, *Calamus merrillii*, *C. ramulosus*, *C. ornatus*, *C. caesius*, *C. manilensis*	Plantlets, regeneration, problem in callus maintenance protocols established
Bamboos:	
Dendrocalamus latiflorus, *Bambusa blumeana*, *B. vulgaris*, *D. merrillianus*, *Gigantochloa levis*, *G. aspera*	Protocol for spindle, node and ground tissue established. Species differed in nutritional requirements
Schizostachyum lumampao	Cultured clones acclimatized in nursery, established in grasslands

In line with the Research and Development Projects of the National Forestation Program, a project called Establishment and Management of SPAs (Seed Production Areas) was conducted. One study under the project concentrated on the roles of seed production areas in forest plantation (Lustica *et al.* 1999). During the 5-year study, information on the seeds and phenology of *Casuarina equisetifolia*, *C. rumphiana, Eucalyptus camaldulensis* and *Shorea macrophylla* were obtained at Dumarao, Capiz, Iloilo and Aklan. Another study under the project was national provenance trial for narra (*Pterocarpus indicus;* Favila 1996). The five-year study compared five different provenances of *P. indicus* at two locations, the Leon National College of Agriculture (LNCA) and the Calinog Agricultural and Industrial College.

More provenance trials of *P. indicus* have been conducted in a volcanic ecosystem at Mt Mayon in Albay (Matusalem 1993), and at the Bicol National Park (Lauricio 1997). Lauricio (1997) compared the growth of prickly *P. indicus* from Bukidnon and Camarines Sur and smooth *P. indicus* from Camarines Sur, Capiz and Quezon. The different provenances showed good growth.

Siarot and Paler (1992) did in PICOP a provenance trial of 17 seedlots of *Acacia mangium* from Sabah (Malaysia) and Queensland. The study reported no significant differences in terms of average total height, but a highly significant difference was observed in terms of average diameter at breast height after five years. The study further noted that a seedlot from Sabah was free from canker. Siarot and Paler (1992) recommended further genetic improvement to attain perfectly straight boles. Lanting and de Chavez (2002) also reported a provenance trial of *Acacia mangium* and species trials of *A. auriculiformis, A. aulacocarpa, A. crassicarpa, A. mangium, A. mangium* × *auriculiformis* and *Gmelina arborea* at Ternate, Cavite. Seeds of *A. auriculiformis* were sourced from Queensland, whereas *G. arborea* seeds originated from Makiling Forest Reserve, Sabah Wood Industry and from Diadi, Nueva Vizcaya. The other four species came from Papua New Guinea. The study identified 150 seed trees of the different species but further noted that the seed yield from these trees was inadequate to support the national reforestation project.

A provenance trial of *Pinus caribaea* var. *hondurensis* was conducted at Jalau Reforestation project in Calinog, Iloilo by Eusebio (1983). There were nine provenances tested. Moreover, DENR has conducted provenance trials of *Pterocarpus indicus* (Matusalem 1993; Lauricio 1997; Favila 1996); *Casuarina equisetifolia, C. junghuhniana, Acacia mangium, A. auriculiformis, A. crassicarpa, A. aulacocarpa, G. arborea, A. mangium* × *auriculiformis, Pinus caribaea* (Eusebio 1983); *Eucalyptus camaldulensis* (Agpaoa and Tangan 1981) and *Xanthostemon verdugonianus* (Nasayao and German 1993). All these species, except for *P. indicus* and *X. verdugonianus*, are exotics.

Mangrove ecosystems have been another active area of research in the Philippines. For example, an inventory and assessment on mangrove biodiversity was conducted in Central Visayas. The study included research to better understand the stand structure, phenology, species composition, pests and diseases, silvicultural attributes and environmental factors which affect the survival and growth of mangrove plantation. In addition, seed sources of selected mangrove and associated species were established. Other studies on mangroves include the provenance studies of various mangrove species in Western Visayas (Malabanan 1992), rehabilitation of the coastal areas of the National Capital Region (NCR; Esteban 1998), and documentation and assessment of mangrove reforestation using indigenous practices in Bohol (Mantanilla and Melana 1992).

With the objective of selecting plus trees of several species, the UNDP and FAO realised a project called FORTIP (Regional Project on Improved Productivity of Man-made Forests through Application of Technological Advances in Tree Breeding and Propagation). The project selected more than 100 plus trees of *Swietenia macrophylla* in the Makiling Forest Reserve and the Atimonan National Park, over 150 plus trees of *Pinus kesiya* in natural

stands at Baguio City and Bukud Watershed Reservation area, about 30 plus trees of *Pterocarpus indicus* in the Makiling Forest Reserve and about 35 plus trees of *Gmelina arborea* in Magat, Nueva Vizcaya (Zabala 1996). The same project reported the establishment of seed production areas of *Acacia mangium* in Puerto Azul in 1994. The Tree Seed Center of the Commonwealth Scientific and Industrial Research Organisation of Australia (CSIRO) in cooperation with FORTIP, the Ecosystems Research and Development Bureau (ERDB), the Bukidnon Forests Incorporated (BFI) and the Forest Management Bureau (FMB) established seed production areas (SPA) of *Eucalyptus urophylla, Acacia mangium* and *A. crassicarpa* at Bansud, Mindoro, Malaybalay, Bukidnon and Baslay, Negros Oriental. Detailed information about the SPAs in Bansud is presented in Table 7.

A clonal seed orchard of *Gmelina arborea* of 1.5 ha with 29 clones, and hybridizing seedling seed orchard of *A. mangium* and *A. auriculiformis* (0.75 ha) were established at Puerto Azul by the ERDB under the FORTIP project in 1995 and 1994, respectively. Similarly, a 1.5-ha clonal seed orchard of *Swietenia macrophylla* and a 2-ha clonal seed orchard of *Pterocarpus indicus* were established at Tayabas, Quezon in 1994–1995.

The National Forest Tree Seed Committee has identified seed production areas all over the country. Teams conducted a country-wide survey and identified 27 candidate plantations in 10 regions. The species in the identified plantations included indigenous species (*Casuarina equisetifolia, Pterocarpus indicus* and *Vitex parviflora*) and exotics of different origins (*Swietenia macrophylla*, *Gmelina arborea, Eucalyptus camaldulensis E. deglupta, Paraserianthes falcataria, Tectona grandis* and *Succirubra pabon*). Unfortunately, the programme did not prosper due to fear of public criticism over tree rouging; the Committee was later dissolved.

The Provident Tree Farms Inc. (PTFI) in southern Philippines ventured into an Industrial Tree Plantation License Agreement (ITPLA) in 1982 (Nuevo 1997). This private company included tree improvement in its long-term management strategy to meet the challenges of increasing volume and quality of logs and fibre. The company focused on *Gmelina arborea* and *Acacia mangium*. The PTFI made an extensive first generation selection of landraces of ***G. arborea*** throughout Mindanao (Southern Philippines) and a high intensity selection of ***A. mangium*** from the best trees among the provenances introduced

Table 7. Seed production areas and seedling seed orchard established in Bansud, Oriental Mindoro (ERDB 2001).

Species	Origin*	Seedlot nos.	Seed stand type**	Year planted	Area established/ developed (ha)
Acacia mangium (SSI)	PNG, Fiji, QLD	19139, 19211, 19235, 19256, 19286	SPA	1996	1.5 ha (2000 seedl.)
Eucalyptus urophylla var. *wetarensis* (SS2)	IND	17832, 17834, 17835, 17837, 17838	SPA	1996	1.5 ha (2000 seedl.)
E. urophylla var. *urophylla* (SS3)	IND	13828, 17565, 17841, 17843, 18094	SPA	1996	1.125 ha (1500 seedl.)
A. mangium (SS4), *A. mangium* (SSO)	PHIL, PNG, Fiji, QLD, MLAY	Bulk collection of MSFBIx 19674, 19705, 19760, 19828, 19674, 19760	SPA SSO	1997 1998	1.5 ha (2000 seedl.) 3.5 ha (3240 seedl. exclusive of buffer rows)

***** PNG = Papua New Guinea; IND = Indonesia; QLD = Queensland, Australia; MLAY = Malaysia
****** SPA = seed production area, SSO = seedling seed orchard. xMSFBI = Manila Seedling Bank Foundation Inc.

from Australia and Papua New Guinea. The PTFI also developed a technology for the cloning of terminal shoot utilizing unsterilized shoot tips and mass-growing them in unsterile rooting medium of ordinary river sand. The company's ramet multiplication garden has been able to produce in total one million stecklings, which is sufficient to fulfil its planting stock requirements with some surplus for external demands (Nuevo 1997).

As to dipterocarps, DENR has selected over 50 plus trees at the seed production area in the Experimental Forest, Bislig, Surigao del Sur and at the Forest Reserve in Subic, Olongapo, Zambales (Zabala 1996).

A farmer-operated association for the production, collection, processing, development and marketing of seeds was established in 1998 in Lantapan, Bukidnon. Since then the Agroforestry Tree Seed Association of Lantapan (ATSAL) has grown from the initial 15 to 60 members. The association has been instrumental in training thousands of farmers in collecting, handling and marketing of quality agroforestry seeds (WAC 2002). The marked difference of this group with other seed vendors is that this non-formal system for seed production and distribution enabled smallholders to produce and market quality germplasm based on standardized methods, as noted by Koffa and Garrity (2001). The same authors described the approaches in maintaining diversity in germplasm sources in farming systems, namely: (a) work directly with the genetic resources which the smallholders value and conserve; (b) create and conserve protected areas; and (c) provide smallholders with genetic diversity in the form of landrace germplasm from a range of sources.

To date, ATSAL has sold more than 5000 kg of assorted seeds of exotic and indigenous tree species, and thousands of seedlings to buyers in Mindanao, Visayas and even in Nairobi, Kenya. Since its foundation, ATSAL has earned three million Philippine Pesos (60 000 US$). The profits were distributed among the member farmers and used to support the organization. This example highlights the significant roles of upland farmers in contributing towards genetic conservation of important forest resources. Additionally, it emphasizes the fact that forest genetic conservation is not a monopoly of corporate or government agencies.

Recently, the Public Sector Linkages Program of the Australian Government's Overseas Aid Program (PSLP of AusAID) funded two activities in North-eastern Mindanao: one on improving the productivity and profitability of trees in farms and community-managed plantations in Northern and North-eastern Mindanao, and the other on the application of advanced forest tree seed technologies to improve rural wood-based economic opportunities in the tree plantation provinces of Mindanao. During the first activity, progenies totaling 6 ha were established in sites near Butuan and Cagayan de Oro. The area will later be converted to seedling seed orchard of *Acacia mangium* and *Swietenia macrophylla*. Another 4 ha of tree plantations (genetic conservation archives) were established among tree farms and community-managed forest lands in Barangay Bonbon and Barangay Nong-Nong, Butuan City and at the cattle grazing land of RAMCAR Inc. in Impasugong, Bukidnon. The objective of the second activity was to enhance the capabilities of the local DENR personnel in managing seed production areas and seed orchards, and in distribution and marketing of seeds to tree farmers. Trainings and workshops on other important aspects of seed technology, specifically seed collection, processing, storage and seed data banking were conducted under this activity.

Non-timber forest products

An extensive research on the genetic conservation and management of non-timber forest products (NTFPs) was conducted by the Ecosystems Research and Development Service (ERDS) and DENR. This research included plantation establishment of rattan (Bernadas and Llave 1999; Gigare 1997), bamboo (Escario 1998; Gigare *et al.* 1997; Cacanindin 1991), *Donax*

canniformis, Stenochlaena palustris, Enhalus acoroides (Balane 1994), *Scyphiphora hydrophyllacea* (Sinohin *et al.* 1998) and anahaw (*Livistonia rotundifolia*) (Operio 1994). An integrated research and development initiative on bamboo and rattan (Uriarte and Binoya 1995) included various livelihood components, such as an integrated nursery project, swine production project, duck and poultry production, sericulture production, greening project, fish production and goat production project. Table 8 presents the rattan plantations established by the Ecosystems Research and Development Bureau together with other government and private groups.

Use of biotechnology for characterization and protection of forest genetic resources

The first and only work on the characterization of timber species using molecular markers in the Philippines was a dissertation produced on *Swietenia macrophylla* populations in the Luzon Island using Random Amplified Polymorphic DNA (RAPD; Quimado 2002). The study showed high polymorphism (80%) of the large leaf mahogany trees in Mt Makiling, Laguna and in Atimonan, Quezon. Within-population diversity (90%) was significantly higher than variation between populations (10%). The study also showed two major groupings and the distinctness of one population from the rest. As noted, this study is the first of its kind and more such studies are needed.

In another study, the mating system of *Pterocarpus indicus* (narra) population in a mixed planted forest at Mt Makiling, Luzon Island, was investigated using five polymorphic isozyme loci. The population was noted to have a predominantly outcrossing nature (De Guzman 1996). Pollen competition or early selection against selfed progenies, or both, were suggested as possible reasons for the low estimates of selfing rates. The estimated outcrossing rates of the isolated trees showed that the unidentified pollinators of *P. indicus* were very efficient to ensure a high degree of cross-pollination even for spatially isolated trees. Future research to investigate the taxonomy of *P. indicus* through isozyme analysis, and studies to elucidate mating patterns of other tropical trees were suggested (De Guzman 1996). Using isozyme analysis, *Parashorea malaanonan* was confirmed to be outcrossing (Gamboa-Lapitan & Hyun 2005). The same study also observed biparental inbreeding in the species in some individuals in the Makiling Forest Reserve. Abasolo (2007) used a satellite marker derived from *Shorea* species to study the genetic diversity of *Parashorea malaanonan*. The results showed that diversity within sites was 64% while diversity among sites was 36%, indicating a high diversity between sites in the Makiling Forest Reserve. There was no significant correlation between genetic and geographical distances in the four sites studied.

In addition to the past and current efforts to conserve forest genetic resources (FGR), the National Consultative Workshop on FGR held in February 2007 identified the following important management strategies for conservation sites:

- Assessment of existing experimental and research centers (dipterocarps, conifers, mangrove) and recommendation for their establishment as field genebanks
- Development of a database for priority species and priority areas, including success stories
- Creation of a network of Regional Botanical Gardens (both for *in* and *ex situ*)
    - (i) evaluation of existing botanical gardens
    - (ii) establishment of new botanical gardens
- Identification or listing of Philippine National Heritage Trees
- Resolutions or ordinances of the Local Government Units
- Development of a list of economically important species (for specific sites)
- Public awareness
- Reference to the strategies identified under the Framework for Philippine Plant Conservation.

Table 8. Rattan plantations established by the Ecosystems Research and Development Bureau (ERDB) and by government and private entities (Maligalig 1988).

Region (Center) or Institution	Area (ha)	Year est.	Location
A. ERDB			
Central Luzon (Forestry Research Centre, FRC)	4	1980	Carranglan, Nueva Ecija
Agroforestry and Mangrove	200	1979	Pagbilao, Quezon Sta.
Palawan (FRC)	5	1980	Monica; Bagumbayan,
Makiling	2	–	Puerto Princesa City Los Baños, Laguna
Western Visayas (FRC)	7	1983	Agkaningay, Forest Research, Agkaningay, Burias, Mambusao, Capiz
Central Visayas (FRC)	5	1980	Minglanilla, Cebu
Western Mindanao (FRC)	5	1980	Western Mindanao Experimental Area, La Paz, Zamboanga City
North Central Mindanao (FRC)	5	1980	Impalutao, Impasugong, Bukidnon and Sumpong, Malaybalay, Bukidnon
Eastern Mindanao (FRC)	7	1986	Bislig, Surigao del Sur
B. Other private and government entities			
Swedish Match Hillshog	50	1983	San Teodoro, Oriental Mindoro
Iloilo National Agricultural College	5	–	Iloilo
Swedish Match	100	1984	Tacloban, Agusan

Capacity building activities, education and training

The ASEAN Regional Centre for Biodiversity (ARCBC, now ASEAN Centre for Biodiversity) has actively conducted several trainings to upgrade the capacities of different organizations on biodiversity. Some of the training courses include a *National workshop on Understanding and Managing Biodiversity at the Provincial and Landscape Levels*, a *National Trainers' Training on Biodiversity Conservation and Sustainable Development Education at the Tertiary Level*, and a *Regional Plant Taxonomy Training*. The Protected Area and Wildlife Bureau (PAWB) has conducted training courses on techniques for plant identification and vegetation assessment. However, during the field interview related to the ITTO-funded project on forest genetic resources, many staff members of PAWB expressed the need for more training considering that only a few people were included in the previous training courses. Other government agencies, such as the Ecosystems Research and Development Bureau (ERDB), have conducted short training courses on plant collection and herbarium techniques and macro- and micro-propagation of selected premium and indigenous species. The Philippine National Museum–Plants Unit has training programs on plant conservation techniques, plant collection and identification, biodiversity assessment (flora/vegetation), curation of herbaria, and inventory and documentation of ethnomedicinal plants, using of Botanical Resources and Herbarium Management System (BRAHMS; DENR–PAWB 2006).

Based on an earlier assessment by Zabala (1996), there is a dearth of capable personnel to tackle the challenging task of tree breeding and improvement. Intuitively, the situation is similar for the conservation of forest genetic resources, as these two concerns are closely related. Prior to 1996, there were hardly any researchers trained either in tree

improvement, or the conservation and management of forest genetic resources. After 1996, a number of graduate students have enrolled at the College of Forestry and Natural Resources and specialized in tree improvement. With a global and national concern for biodiversity conservation, the interests of younger scientists are slowly catching up with the trend to major in the conservation of forest genetic resources. The UPLB has a graduate programme focusing on Plant Genetic Resources Conservation, but most of the students and faculty involved are agriculture-based.

During the National Consultative Workshop on forest genetic resources in 2007, the concerned stakeholders identified the following capacity building needs for the country:

(1) Capability-building needed by institutions to enhance FGR Conservation
- Education & Training
- Public Awareness (Information, Education and Communication, IEC)
- Resource mobilization to support FGR conservation activities
- Management Information System (MIS)
- Inclusion of FGR conservation in academic curriculum
- Other extension programs – demonstartion farms, cross site visits

(2) Training courses
- Strategies on FGR conservation (*in situ, ex situ*) and results of R & D technology
- Stakeholders' participation in FGR conservation
- Advocacy of FGR conservation – policy makers, implementers of conservation activities, e.g. forest managers, community, academe
- Product utilization, processing and marketing
- Policy issues on FGR conservation – Bioprospecting, biosafety

To complement these management strategies, important research and development initiatives are needed. Some critical gaps in research and development were identified in the aforementioned national consultative workshop:

- Continuing assessment of conservation status of all FGRs (e.g. inventory, taxonomy, database of FGR on *in situ* conservation sites)
- Conservation biology (reproductive biology)
- Ecological studies of FGRs (carbon sink, watershed and environmental services, ecotourism, genetic diversity)
- Policy assessment and formulation in support of FGRs (e.g. bioprospecting, rescue centers)
- Development of a guidebook for identifying FGRs
- Valuation studies of FGRs (for bio-prospecting purposes, ecological services, etc.)
- Assessment of socio-economic and cultural practices and their impacts to FGR conservation (e.g. ethno-botany)
- Production technologies or silvicultural requirements for FGRs

Public awareness

The NIPAS programme contains proposals for intensive information, education and communication with local communities and the public in general. On its part, DENR has always been involved in educating and communicating to the public the importance of

biodiversity conservation. State colleges and universities, on the other hand, continue to promote programmes on biodiversity conservation through instruction, research and extension. Many publications on the conservation of forest genetic resources or even the conservation publications are in technical form which prevents ordinary citizens and uneducated locals to comprehend the message. Efforts are now underway to produce education and campaign materials in local dialects to promote a widespread education and communication of FGR conservation. Hopefully, these efforts, which are done on a national scale, will inculcate the importance of biodiversity conservation among the general public and lead to support for more in-depth studies at the species and genetic levels.

Identification of national priorities

Important issues which are related to biodiversity conservation in general but could have significant bearing on the conservation of forest genetic resources were identified in the Revised Master Plan for Forestry Development:

- Inadequate skills and knowledge on species identification and inventory
- Lack of ground demarcation of forest lands, e.g. production areas, protection areas, restoration areas
- Lack of protection of residual forests which are biodiversity-rich areas
- Inconsistencies between the NIPAS Act and the Indigenous People's Rights Act (IPRA)
- Biological pollution
- Need for habitat rehabilitation
- Extinction of species and genetic resources
- Severe disturbance in ecological and evolutionary processes
- Erosion of indigenous knowledge
- Management constraints
- Local interest, rights concerns
- Development potential
- Access and benefit-sharing from forest biodiversity development
- Management of biodiversity zones or areas outside protected areas

Although it may appear that only the above points (7) and (8) are directly related to forest genetic resources, an examination of the list will reveal that all of them will be important in order to promote the conservation and development of these resources. Many field personnel lack the necessary skills in identifying thousands of other plants (and even animals) for conservation and appreciating their importance. Information on inventory and actual state of these plants is likewise limited. An actual delineation of conservation areas from the production areas seldom exists. Protected areas are frequently occupied by people who practice continuous upland agriculture. Institutional and management limitations restrict protection in biodiversity-rich areas. Budget constraint and political will are the common causes of insufficient forest protection programmes. The National Integrated Protected Area System (NIPAS) and the Indigenous Peoples' Rights Act (IPRA) clash with each other in many respects, particularly along the issues of actual management, administration, rights of extraction and exploitation, and protection of conservation forests. Conflicts in claims and interests between major stakeholders result in stalemate in conservation programs. As the forest genetic resources hang precariously, this delicate balancing act of harmonizing interests, claims, vision, policies and programs among the major stakeholders is sorely longing for immediate and stable resolution.

Global and regional concerns for biodiversity conservation (including FGR conservation) are teeming with energy and resources. In the Philippines, conservation efforts are mainly focused on fauna. Although a number of individuals and institutions are actively working on floral conservation works, the efforts are currently fragmented and should be properly coordinated with concerned stakeholders (DENR–PAWB 2006).Along this line the Plant Conservation Strategy and Action Plan was developed by a group of plant experts in the Philippines (Appendix 1). The strategic action plan has in view to bring to an end the current loss of Philippine plant diversity for the intergenerational benefit of the Filipino people and the global community. The plan provided

> "a framework to enhance existing initiatives aimed at plant conservation, identify gaps where new initiatives are required, and promote mobilization of the necessary resources; and, mechanisms to enhance species and ecosystem approaches to the conservation and sustainable use of plant diversity and focus on the vital role of plants in the structure and functioning of ecological systems and assure their provision of goods and services" (DENR–PAWB 2006).

From this strategic and action plan, the priorities of the Philippines for the conservation of forest genetic resources could be identified as follows:

- Identify and designate Important Plant Sites (IPS) or Important Plant Areas (IPA) or i*n situ* Plant Conservation Centers
- Develop and implement conservation and management plan for each of the designated IPS. Such plan must include mechanisms that will ensure active participation of concerned local government units and other stakeholders.
- Publish a book on the Flora of the Philippines
- Establish and maintain *ex situ* conservation centers of wild plants
- Establish a National Botanic Garden that showcases the Philippine native plants
- Conduct studies on threatened endemic plants, specifically focusing on conservation biology and demography or population studies
- Conduct research on plant uses of the local communities and the impact of use on the conservation of the species
- Conduct research on valuation of plant resources
- Establish a system, including websites, which will ensure a constant exchange of information on the genetic resources of Philippine plants between and among concerned institutions and organizations, and make this information accessible to all interested parties
- Establish a national list of threatened Philippine plants
- Establish a national list of economically important species
- Assess the conservation status of all known Philippine plants periodically
- Promote education and awareness of plant diversity through improved libraries, popular and technical publications, lectures, seminars, workshops and conferences
- Invest in capacity building for human and infrastructural resources development on FGR conservation
- Review and harmonize existing policies on the conservation and export, import and transport of plant genetic resources.

Conclusion

The Philippines has claimed both the titles of a mega-diversity country and at the same a biodiversity hotspot (DENR–PAWB, CI & UP–CIDS 2002). However, habitat destruction continues at a high pace because of various reasons. Our present knowledge falls short of a thorough analysis to make categorical statements on how many and what species are extinct, threatened, or near-threatened by human actions, other biotic and abiotic factors.

In situ and *ex situ* conservation measures are being implemented by various individuals and institutions but are fragmented and mostly are focused on fauna and not on flora. A 10-point strategic action plan for plant conservation was recently crafted with the mission of arresting the current loss of Philippine plant diversity. The plan created a framework for enhancing the existing initiatives aimed at plant conservation by coordinating the activities and mobilizing resources, and providing mechanisms for more effective conservation and sustainable use of plant diversity (Appendix 1). The identified actions which are considered as priorities for the conservation of forest genetic resources in the Philippines will address important issues like important plant areas, documentation of plant diversity, research gaps, information system, monitoring of conservation status, education and heightened awareness, capacity building, sustainable production and utilization, and policy development and enforcement. The legal and technical foundations for the conservation of forest genetic resources in the country appear sufficient at the moment, but they could be further strengthened by a complete resolve to insure the ground implementation of these policies and programs.

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Appendix 1.

Plant conservation strategy and action plan

(Source: DENR-PAWB 2006).

10.1 Mission

Halt the current loss of Philippine plant diversity to ensure its perpetual existence essential to meet the present and future needs of the Filipino people and the global community.

10.2 Objectives

1. Provide a framework to enhance existing initiatives aimed at plant conservation, identify gaps where new initiatives are required, and promote mobilization of the necessary resources; and,
2. Provide mechanisms to enhance species and ecosystem approaches to the conservation and sustainable use of plant diversity and focus on the vital role of plants in the structure and functioning of ecological systems and assure their provision of goods and services.

10.3 Strategies

Strategy 1: Conserve important plant areas in the Philippines and plant species of direct importance to human societies.

Actions:

1.1 Formulate criteria for identification of Important Plant Sites (IPS) or Important Plant Areas (IPA);
1.2 Identify and designate Important Plant Sites (IPS) or Important Plant Areas (IPA) or In-Situ Plant Conservation Centers;
1.3 Develop and implement conservation and management plan for each of the designated IPS. Such plan must include mechanisms that will ensure active participation of concerned local government units and other stakeholders; and,
1.4 Identify key plant species that will serve as emblem of plant conservation in each region of the country.

Strategy 2: Document Philippine plant diversity, including its uses and its distribution in the wild, *in-situ* within and outside protected areas, and in *ex-situ* collections.

Actions:

Conduct specimen-based plant inventory throughout the country;
Develop a checklist of Philippine plants (per protected area, mountain, province, region);
Publish a book on the Flora of the Philippines;
Establish and maintain ex-situ conservation centers of wild plants; and,
Establish a National Botanic Garden that showcases the Philippine native plants.

Strategy 3: Promote and support research on the genetic diversity, systematics, taxonomy, ecology and conservation biology of plants and plant communities, and associated habitats and ecosystems.

Actions:

3.1 Conduct studies on threatened endemic plants
   a. conservation biology
   b. demography / population studies;
3.2 Pursue / support / encourage taxonomic studies; and,
3.3 Develop research proposals for funding support solicitation.

Strategy 4: Promote and support research on social, cultural and economic factors that have impact on biodiversity.

Actions:

4.1 Conduct research on plants uses by the local communities and the impact of these uses on plant species conservation; and,
4.2 Conduct research on plant resource valuation.

Strategy 5: Develop an integrated, interactive database information system to manage and make accessible information on plant diversity.

Actions:

5.1 Enhance capacity of staff to use software or databases;
5.2 Develop / update / enhance digital information on Philippine plants to include their traditional knowledge;
5.3 Establish a system, including websites, that will ensure constant exchange of information on Philippine plant genetic resources between and among concerned institutions/organizations and make these information accessible to all interested parties; and,
5.4 Establish a system that will link the local databases to regional and international information centers.

Strategy 6: Monitor the conservation status of Philippine plant diversity.

Actions:

6.1 Establish the National List of Threatened Philippine Plants;
6.2 Establish the National List of Economically-Important Species; and,
6.3 Assess the conservation status of all known Philippine plants periodically.

Strategy 7: Promote education and awareness about plant diversity.

Actions:

7.1 Develop libraries on Philippine plants;
7.2 Develop and publish popular and technical papers on Philippine plants, including articles on plant conservation-related undertakings regularly;

7.3 Produce plant identification guides;
7.4 Work for the declaration and celebration of Plant Conservation Day/Week or restore the celebration of Arbor Week;
7.5 Conduct lectures/seminars and organize workshops, conferences, fora and other venues to disseminate and articulate issues relating to plants and their conservation; and,
7.6 Integrate topics on plant conservation in school curricula.

Strategy 8: Develop capacity including physical and technological infrastructure and financial support for plant conservation.

Actions:
8.1 Establish the roster of plant experts and agencies, research institutions and organizations involved in plant conservation in the country;
8.2 Provide career opportunities for botanists and plant taxonomists;
8.3 Assess the plant taxonomic needs of the Philippines;
8.4 Develop centers of excellence on plant conservation;
8.5 Implement technical capacity building programs on plant conservation and management (e.g. trainings on plant identification, preservation, etc. at the national, regional and local level); and,
8.6 Identify and implement appropriate community training programs.

Strategy 9: Promote sustainable production and utilization of plant resources.

Actions:
9.1 Produce 'how-to-manuals' on plant propagation and utilization;
9.2 Promote establishment of nurseries and propagation centers for commercial plant production purposes; and,
9.3 Promote sustainable utilization of plant resources in production areas.

Strategy 10: Develop and enforce policies on plant conservation.

Actions:
10.1 Develop guidelines on the accreditation and registration of plant nurseries/establishments/breeders;
10.2 Develop guidelines on the exchange of plant specimens between and among researchers/taxonomists, locally and internationally; and,
10.3 Review and harmonize existing policies on the conservation and export, import and transport of plant genetic resources.

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 uppest 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., *Afzelia* 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, Afzelia 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 interfertile 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**

[1] IUCN 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
Total [2]	**1 221**	**2 304**	**1 221**	**2 303**

[1] Includes Nakhon Sawan, Kamphaeng Phet and Uthai Thani
[2] Compiled 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 Sivicultural 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 Ministerai 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	+
Dipterocarpus alatus	16	30	26	14	10	-	10	-	-	-	52	44
Dalbergia cochinchinensis	16	25	10	-	10	-	10	-	10	13	56	38
Xylia xylocarpa	20	30	10	30	10	-	-	-	10	25	50	85
Pterocarpus macrocarpus	16	25	10	30	10	-	-	-	10	26	46	81
Shorea roxburghii	16	25	10	-	10	-	-	-	-	-	36	25
Afzelia xylocarpa	16	25	4	-	10	-	-	-	10	28	40	53
Dalbergia oliveri	20	30	4	-	10	-	-	-	-	-	34	30
Hopea odorata	16	25	26	5	10	-	-	-	-	-	42	30
Total											**356**	**386**

Sites: (1) Kampangphet Sivicultural Research Station, Kampangphet, (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
Acacia mangium	20	*Adenanthera pavonina*	10
Aquilaria malaccensis	23	*Afzelia xylocarpa*	18
Eugenia grandis	10	*Mangifera quadrifida*	10
Artocarpus lanceifolius	20	*Mangifera caloneura*	88
Cassia siamea Britt	20	*Artocarpus lakoocha*	10
Cotylelobium melanoxylon	46	*Toona ciliata*	23
Palaquium obovatum	20	*Chukrasia velutina*	71
Dalbergia oliveri	20	*Dipterocarpus alatus*	68
Gmelina arborea	24	*Azadirachta indica*	22
Xylia kerrii	95	*Sandoricum koetjape*	10
Anthocephalus chinensis	19	*Tectona grandis*	32
Hopea odorata	35	*Sterculia foetida*	10
Alstonia scholaris	5	*Parkia javanica*	10
Pterocarpus macrocarpus	85	*Dalbergia cochinchinensis*	43
Shorea roxburghii	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.

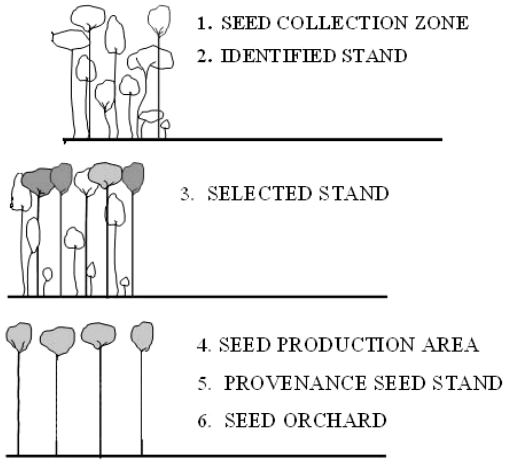

Figure 1. Classification of seed sources into six classes based on stand quality (Tangmitcharoen 2007).

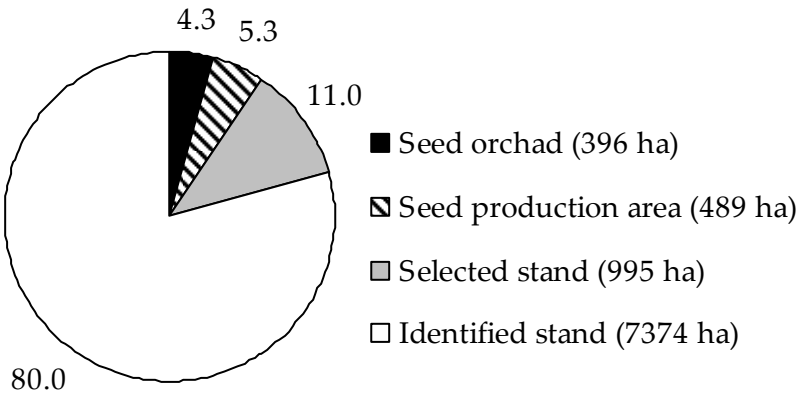

Figure 2. Proportion of seed sources during the years 1998-2002 (% and ha; FORGENMAP 2002b).

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
	Ex situ facilities	*In situ* 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, agro-forestry, 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 stared 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								
Afzelia xylocarpa Craib.		3	3	3	●●●	1 (S)	●	1
Dipterocarpus alatus Roxb.		3*	3	3	●●●		●	1
Hopea odorata Roxb.		3	3	3	●●●		●	1
Pterocarpus macrocarpus Kurz.		3+	3	3*	●●●		●●	1
Tectona grandis Linn.		3+	2	+	●●●	1	●	1
Very high priority								
Alstonia scholaris (L.)R.Br.		2	2	2	●●●		●	2
Aquilaria crassna Pierre ex Lec.		2	3	2	●●			1
Dalbergia cochinchinensis Pierre.		2+	3	2*	●●		●	1
D. oliveri Gemble.		2	3	2	●●		●	1
Intsia palembanica Miq.		2	2	2	●●●			2
Mangifera (wild species)	1	2	3	2	●●●			2
Millettia kangensis Craib.		2	3	2	●	2 (N)		2
Pinus merkusii Jungn &De Vriese.		1+	1+	+	●●●	2 (NE)	●●	2
Wrightia tomentosa Roem. & Schult.		2	2	2	●●●			2
Xylia xylocarpa var. *kerrii* Craib& Hutch.		2	2	2	●●●		●●	2
Other priority								
Azadirachta excelsa (Jack) Jacobs		1	1	1	●●			3
Chukrasia tabularis A.Juss	2	1*	1	1*	●●●		●●	3
Cotylelobium melanoxylon Pierre.		1+	1	1	●●	2 (S)		3
Dipterocarpus tuberculatus 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
Durio mansoni Bakh.		1	1	1	●●	2 (S)		3
Fagraea fragrans Roxb.		1	1	1	●●	2 (C,E)		3
Gmelina arborea Roxb.		1+	1	1	●●●		●	3
Holoptelea integrifolia (Roxb.) Planch.		1	1	1	●●	2 (NE,E,W)		3
Hopea ferrea Pierre.		1	1	1	●●●	2 (W,C)		3
Manglietia garretti Craib.		1	1	1	●●	2 (W,C)		3
Mansonia gagei Drumm.		1	1	1	●●			3
Melia azedarach Linn.		1	1	-	●●●			3
Meliantha suavis Pierre.		1	1	1	●●●			3
Parashorea stellata Kurz.		1	1	1	●●	2 (E)		3
Parkia speciosa Hassk.		1	1	1	●●●	2 (C)		3
Pinus kesiya Royle ex Gordon.		1+	1+	1	●●●		●	3
Shorea henryana Pierre.		1	1	1	●	2 (S,E,W)		3
S. roxburghii G. Don.		1	1	1	●●●	2 (C,E,W)	●	3
Tetrameles nudiflora R.Br.		1	1	-	●●●			3
Toona ciliata 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

Index of plant species

Priority species of the Asia Pacific Forest Genetic Resources Programme (APFORGEN) are marked in bold (see http://www.apforgen.org)