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Forest genetic resources conservation and management

Proceedings of the Asia Pacific Forest Genetic Resources Programme (APFORGEN) Inception Workshop, Kepong, Kuala Lumpur, Malaysia,15–18 July, 2003

T. Luoma-aho, L.T. Hong, V. Ramanatha Rao *and* **H.C. Sim,** *editors*

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IPGRI is a Future Harvest Centre supported by the Consultative Group on International Agricultural Research (CGIAR)

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The International Plant Genetic Resources Institute (IPGRI) is an independent international scientific organization that seeks to advance the conservation and use of plant genetic diversity for the well-being of present and future generations. It is one of 16 Future Harvest Centres supported by the Consultative Group on International Agricultural Research (CGIAR), an association of public and private members who support efforts to mobilize cutting-edge science to reduce hunger and poverty, improve human nutrition and health, and protect the environment. IPGRI has its headquarters in Maccarese, near Rome, Italy, with offices in more than 20 other countries worldwide. The Institute 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).

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1) Flower buds of *Shorea lumutensis*, a rare dipterocarp endemic to Peninsular Malaysia. Photo © S.L. Lee/FRIM.
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3) Experimental tree nursery in Vietnam. Photo © T. Luoma-aho/IPGRI.
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1) *Shorea* sp. in Meliau Basin, Sabah, Malaysia. Photo © K.M. Wong /Universiti Malaya.
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APAFRI

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 the Heads of Forestry Research Organizations in the Asia Pacific in Bogor on 21 February 1995, and resulted in the establishment of APAFRI.

The International Union of Forest 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 has recently been appointed as the Asia Pacific Regional Coordinator of IUFRO SPDC. APAFRI has also been tasked to coordinate the development of an Asian component in IUFRO's Global Forest Information Service (GFIS).

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Foreword

Conservation, improvement, and effective management of forest genetic resources (FGR) is basic to sustainable forest management but will require a holistic approach at various hierarchical levels (ecosystem, landscape, national and regional). While the concern of governments in managing their FGR has been increasing with the increasing introduction of relevant national policies and guidelines, there is a need for better collaboration at regional level despite the efforts already expanded by international and regional organizations. The FAO Panel of Experts on FGR has played a major role in providing recommendations at the global level and has stressed the need to strengthen national programmes and regional collaboration on FGR in different parts of the world.

Several countries in the Asia Pacific region have taken steps to implement sustainable forest management in practice and there is a need to promote management of FGR within this process. Better management of forest genetic diversity will also help countries to fulfil their commitments as agreed under the Convention on Biological Diversity and to maintain diversity for future use. Responding to this need and following-up on the recommendations of the Southeast Asian Workshop of FGR held in Thailand in 2001, the International Plant Genetic Resources Institute (IPGRI) in collaboration with the Asia Pacific Association of Forestry Research Institutions (APAFRI) have taken the initiative to develop a regional network programme to strengthen the work on conservation and sustainable use of FGR in the region. This regional programme, called the Asia Pacific Forest Genetic Resources Programme (APFORGEN) has the support of fourteen countries in the region. The establishment of APFORGEN will greatly assist national programmes on FGR to be better coordinated and implemented and will also foster closer collaboration in the exchange of information, knowledge and expertise of FGR conservation and management in the region.

The Inception workshop, organized with the technical cooperation of FAO has laid the foundation for initiating FGR networking in the region via APFORGEN. The participation of twelve country representatives in the inception workshop is an indication of support of national governments, which desire closer collaboration in FGR conservation and management.

Dr Percy E. Sajise
Regional Director,
IPGRI–APO

Dato' Dr Abdul Razak Mohd Ali
Chairman,
APAFRI

Preface

The APFORGEN Inception Workshop was organized at an appropriate time noting the concerns and the urgent needs for conservation and sustainable management of forest genetic resources in facing the fast pace of development in the Asia Pacific region (APO). The workshop conducted at the Forest Research Institute Malaysia, Kepong, Malaysia enabled the participating countries to present the status of forest genetic resources (FGR) conservation and management in their countries. The representatives from the 12 countries that were present had the opportunity to interact with each other and also with the FAO representative and the two Danida Forest Seed Centre (DFSC) representatives who also participated in the workshop.

In addition to documenting the status of national FGR conservation and management activities, the 4-day programme enabled the framework for the operation of APFORGEN to be drawn up and also identified concept notes on various FGR-related topics to be developed for potential funding support. The workshop identified a list of priority species for the region to be used as a guide for collaborative R&D in FGR, bearing in mind the limited trained human resources for FGR work in the region. Another area that needs attention is improving the flow and accessibility of FGR information in the region. The participants have endorsed the setting up of the APFORGEN website to improve the situation, in addition to other ways of communication.

It is hoped that this proceeding could serve as one reference and information base for FGR conservation and management in the region, in which closer collaboration could be fostered and improved.

Organizing this workshop would not have been successful without the assistance of various individuals and organizations. We thank them all. The Food and Agriculture Organisation of the United Nations (FAO) / Forestry Research Support Programme for Asia and the Pacific (FORSPA) provided technical support for the workshop; especially we want to thank Pierre Sigaud at FAO, Rome and Dr Simmathiri Appanah (FORSPA), Bangkok. Furthermore, we would like to thank Dr Jarkko Koskela (IPGRI), who has been instrumental in developing the concept of APFORGEN and Dr Weber Amaral (IPGRI) who has been supportive of FGR activities in the region as well as Dr Anders P. Pedersen and Dr Ida Theilade at the DFSC. Finally, thank you to Dato' Dr Mohd Abdul Razak and the FRIM for providing a nice setting for the workshop as well as helping in the practical arrangements.

In addition, we want to thank all those who have been supporting the development of APFORGEN during the past year, for example the organisers of the previous Southeast Asian FGR workshop in Thailand 2001 as well as all the participants of this workshop. We look forward to increased regional collaboration in conservation and sustainable management of the invaluable forest genetic resources in the region.

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Acronyms

5MHRP	Five Million Hectare Reforestation Programme (Vietnam)
ACIAR	Australian Centre for International Agricultural Research
ADB	Asian Development Bank
AEZ	agro-ecological zone
AFLP	amplified fragment length polymorphisms
AO	Administrative Order (Philippines)
APAARI	Asia Pacific Association of Agricultural Research Institutions
APAFRI	Asia Pacific Association of Forestry Research Institutions
APAN	Asia-Pacific Agroforestry Network
APFORGEN	Asia Pacific Forest Genetic Resources Programme
ASEAN	Association of Southeast Asian Nations
BAP	Biodiversity Action Plan
BARI	Bangladesh Agriculture Research Institute
BFRI	Bangladesh Forest Research Institute
BSO	breeding seed orchard
C&I	criteria and indicators
CAF	Chinese Academy of Forestry
CBD	Convention on Biological Diversity
CFBTI	Centre for Forest Biotechnology and Tree Improvement Research and Development (Indonesia)
CFP	Community Forestry Programme (Nepal)
CIDA	Canadian International Development Agency
CIFOR	Centre for International Forestry Research
CIRAD	Centre de Coopération International en Recherche Agronomique pour le Développement
CITES	Convention on International Trade in Endangered Species of Wild Fauna and Flora
CSIRO	Commonwealth Scientific & Industrial Research Organisation (Australia)
CSO	clonal seed orchard
CPT	candidate plus tree
CTSP	Cambodia Tree Seed Project
DA	Department of Agriculture
DAFO	District Agriculture and Forestry Office (Lao PDR)
DANCED	Danish Cooperation for Environment and Development
Danida	Danish International Development Assistance
dbh	diameter at breast height (1.3 m)
DENR	Department of Environment and Natural Resources (Philippines)
DFID	Department for International Development (United Kingdom)
DFO	District Forest Office (Nepal) / Divisional Forest Officer (Pakistan)
DFRS	Department of Forest Research and Survey (Nepal)
DFSC	Danida Forest Seed Centre (Denmark)
DFW	Department of Forestry and Wildlife (Cambodia)
DOF	Department of Forestry (Lao PDR)
DOST	Department of Science and Technology (Philippines)
ERDB	Ecosystems Research and Development Bureau (Philippines)
FAO	Food and Agriculture Organization of the United Nations
FD	Forest(ry) Department
FGR	forest genetic resources
FGRC	forest genetic resources conservation
FINNIDA	Finnish International Development Agency

FORDA	Forestry Research and Development Agency (Indonesia)
FORGENMAP	Forest Genetic Resources Conservation and Management Project
FORSPA	Forestry Research Support Programme for Asia and the Pacific
FORTIP	UNDP/FAO Regional Forest Tree Improvement Project
FRIM	Forest Research Institute Malaysia
FSIV	Forest Science Institute of Vietnam
FUG	forest-user group (Nepal)
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic Product
GEF	Global Environmental Facility
GIS	Geographic Information Systems
GMO	genetically modified organism
GNP	gross national product
GRA	genetic resources area (Malaysia)
GTZ	Deutsche Gesellschaft für Technische Zusammenarbeit (German Agency for Technical Cooperation)
HQ	headquarters
HYV	high-yielding variety
ICFRE	Indian Council of Forestry Research and Education
ICRAF	World Agroforestry Centre (International Centre for Research in Agroforestry)
IDA	International Development Agency
IDRC	International Development Research Centre (Canada)
IFF	Intergovernmental Forum on Forests
INBAR	International Network on Bamboo and Rattan
IPF	Intergovernmental Panel on Forests
IPGRI	International Plant Genetic Resources Institute
ITSP	Indochina Tree Seed Programme
ITTO	International Tropical Timber Organization
IUCN	World Conservation Union
IUFRO	International Union of Forest Research Organizations
JICA	Japan International Co-operation Agency
km^2	square kilometre
KOICA	Korea International Cooperation Agency
LIL	low-impact logging
LTSP	Lao Tree Seed Project
m^3	cubic metre
MAB	UNESCO Man and the Biosphere Programme
MAF	Ministry of Agriculture and Forestry (Lao PDR)
MAFF	Ministry of Agriculture, Forestry and Fisheries (Cambodia)
ME	Ministry of Environment (Lao PDR etc)
MOE	Ministry of Education (Lao PDR) / Ministry of Environment (Cambodia, Indonesia)
MOF	Ministry of Forestry (Indonesia, China)
MOST	Ministry of Science and Technology (Vietnam)
MPCA	medicinal plant conservation area (India)
MPFS	Master Plan for the Forestry Sector
MPTS	multipurpose tree species
MUS	Malayan Uniform System (Malaysia)
NAFES	National Agriculture and Forestry Service (Lao PDR)
NAFRI	National Agriculture and Forestry Research Institute (Lao PDR)
NBCA	National Biodiversity Conservation Area (Lao PDR)
NBFGR	National Bureau of Forest Genetic Resources (India)
NC-IUCN	Netherlands Committee for IUCN
NFP	national forest policy / National Forest Programme (Cambodia)

NFSC	National Forest Seed Center (Bangladesh)
NGO	non-government organisation
NIPAS	National Integrated Protected Area System (Philippines)
NOFIP	National Forest Inventory and Planning Division (Lao PDR)
NTFP/NWFP	non-timber forest products (also: non-wood forest products)
NUoL	National University of Laos (Lao PDR)
ODA	Overseas Development Agency/Overseas Development Administration (United Kingdom – later DFID)
PA	protected area
PAWB	Parks and Wildlife Bureau (Philippines)
PCR	polymerase chain reaction
PGT	progeny trial
PFE	Permanent Forest Estate (Malaysia)
PIC	prior informed consent
PFI	Pakistan Forest Institute
PVT	provenance trial
R&D	research and development
RAPD	random amplified polymorphic DNA
RFD	Royal Forest Department Thailand
RFLP	restriction fragment length polymorphism
RGC	Royal Government of Cambodia
RIL	reduced-impact logging
RRA	rapid rural appraisal
SEAMEO	Southeast Asian Ministers of Education Organization
SEAMEO-BIOTROP	Southeast Asian Regional Centre for Tropical Biology
SFD	State Forest Departments (e.g. India)
SFM	sustainable forest management
SIDA	Swedish International Development Cooperation Agency
SMS	Selective Management System (Malaysia)
SPA	seed production area
SPRIG	South Pacific Regional Initiative on Forest Genetic Resources
SSO	seedling seed orchard
TEAKNET	Teak Network for Asia and the Pacific
TFAP	Tropical Forestry Action Plan
TFSMP	Thai Forestry Sector Master Plan
TIP	tree improvement programme
TISC	Tree Improvement and Silviculture Component (Nepal)
TRIPS	Trade-Related Aspects of Intellectual Property Rights
UN	United Nations
UNCCD	United Nations Convention to Combat Desertification
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
UNFCCC	United Nations Framework Convention on Climate Change
UNFF	United Nations Forum on Forests
UNHCR	United Nations High Commissioner for Refugees
UPLB	University of the Philippines Los Baños
USDA	United States Department of Agriculture
VMG	vegetative multiplication garden
WAC	World Agroforestry Center (=ICRAF)
WB	World Bank
WCMC	UNEP World Conservation Monitoring Centre
WFF	World Wide Fund For Nature
WFP	World Food Programme
WTO	World Trade Organization

Summary of the APFORGEN Inception Workshop[1]

DAY 1: 15 July 2003 (Tuesday)

The APAFRI Executive Secretary Dr Daniel Baskaran Krishnapillay welcomed the participants to the Workshop. This was followed by the welcoming remarks of Dr Percy Sajise (IPGRI Regional Director for Asia, the Pacific and Oceania), Dr Simmathiri Appanah (Senior Programme Officer, FAO Regional Office for Asia and the Pacific,) and Dato' Dr Abdul Razak Mohd. Ali (Chairman of APAFRI). Dr Razak officially declared the workshop opened.

Session I **Forest genetic resources conservation and APFORGEN**

Session I started with adoption of the workshop programme. Mr Hong, L.T. (IPGRI) presented a background document, which traced the evolution of APFORGEN and its proposed organisational framework. Thirteen countries have expressed interest in participating in APFORGEN. More countries are expected to join APFORGEN in the future.

Dr Jarkko Koskela (IPGRI) presented IPGRI's activities on conservation and use of forest genetic resources and IPGRI's strategic choices, one of which is conserving and using forest genetic resources. He gave some examples of IPGRI's past and present activities related to forest genetic resources (FGR) conservation in Sub-Saharan Africa, South America, Europe as well as Central and West Asia and Asia-Pacific. He also provided a brief introduction to the launching process of the Sub-Saharan Africa Forest Genetic Resources Programme (SAFORGEN) and highlighted some challenges and opportunities to the future work in the Asia-Pacific region.

Dr Ida Theilade (DFSC) gave a presentation on *ex situ* conservation of trees in living stands, giving examples of dipterocarps in Indonesia and tropical pines in Central America. The examples showed that the primary problem for long-term management would be the unsuccessful regeneration of the *ex situ* stands. Dr Koskela also gave a presentation on the European Forest Genetic Resources Programme (EUFORGEN). He presented the history and structure of the Programme and how it operates through the five species-specific networks.

Day 2: 16 July 2003 (Wednesday)

Session II **Forest genetic resources in South Asia: update and capacity-building needs**

Session III **Forest genetic resources in Southeast Asia: update and capacity-building needs**

Session IV **Forest genetic resources in Southeast and East Asia: update and capacity building needs**

During sessions II, III and IV country reports updating the status and conservation efforts of FGR in South and Southeast Asia were presented and the respective country representative identified capacity building needs. These included Bangladesh (Dr Sk. Sirajul Islam), India (Mr R.P.S. Katwal), Nepal (Mr P.R. Tamrakar), Pakistan (Dr Shams ur Rehman), Sri Lanka (Mr J.E. Munashinghe), Cambodia (Mr Sok Srun), Indonesia (Dr Nur Masripatin), Lao PDR (Mr Chansamone Phongoudome), Malaysia (Dr S.L. Lee & Dr D.B. Krishnapillay), Philippines (Dr R.A. Razal), Thailand (Mr V. Sumantakul) and Vietnam (Dr N.H. Nghia). The country report of China (Prof Wang Huoran), which was received was not presented owing to the absence of the representative. The information presented was used as reference at subsequent working group meetings.

Dr Anders Pedersen (DFSC) gave a presentation on "*Revisiting the Moving Workshop 2001: Conservation, Management & Use of Forest Genetic Resources in SE-Asian Region*". He explained the purpose of and reasons for arranging the 2001 workshop as well as reviewed

[1] Held at Forest Research Institute Malaysia (FRIM), Kepong, Kuala Lumpur, Malaysia. 15–18 July 2003

some of the key achievements, conclusions and recommendations. One of the conclusions of the 2001 workshop was that there was a strong need and interest for a FGR conservation network in the region.

Dr Suchitra Changtragoon (National Wildlife and Plant Conservation Department, Thailand) presented a paper on the *"Potential for using molecular markers to facilitate gene management and the in situ and ex situ conservation of tropical forest trees"*.

Session V Working groups formation and APFORGEN web page

Dr Jarkko Koskela gave a presentation on the EUFORGEN website. He presented the structure and contents of the EUFORGEN website so that the participants could have some ideas on what kind of information they would like to access through an APFORGEN website, which will be developed later. The participants felt that the EUFORGEN website could serve as a useful model when developing the APFORGEN website.

To start the Working Group session, Mr Hong and Dr Koskela gave an introduction to the Working Group tasks. Dr Ramon Razal and Mr R.P.S. Katwal were elected to chair the Southeast Asia and South Asia working groups, respectively.

Day 3: 17 July 2003 (Thursday)

Session VI Working Groups – discussion and drafting of framework for FGR needs/ collaboration and APFORGEN strategies

Dr Percy Sajise (IPGRI) facilitated the Session to review the organisational framework of APFORGEN as presented in the background document. He emphasised that a successful network involves both a 'net' of people and some activities (*network = net + work*). The facilitation was followed by a plenary discussion with both sub-regional Working Groups. The items reviewed included:

APFORGEN objectives

Dr Sajise presented four draft objectives for APFORGEN. This was followed by a discussion. The revised objectives that have the consent of the workshop participants have been included in the Workshop Recommendation 1.

APFORGEN organizational structure

The question of what kind of governance the APFORGEN programme should have was discussed in detail. The participants stated that the Programme should be *sustainable* and *effective* in terms of governance. The following suggestions were derived from the group after a brainstorm session:

a) Organisational structure to comprise:
   - A Secretariat
   - Regular meetings of committee or staff
b) The APFORGEN organisation should encompass the elements of good management, transparency, fund generation, being supportive and facilitative, encouraging wide participation, focussing on specific subjects, collaboration, open-mindedness, benefit sharing, equality, effective system of communication, HRD and capacity building (education, training), frequent interactions and exchange of information and experiences.

No changes were suggested to the proposed structure that consists of the Steering Committee, Secretariat and National Coordinators.

National coordinators

The role and preliminary Terms of Reference (TOR) for the National Coordinators (NC) and the process for appointing NC were discussed. It was emphasized in the discussion that NCs may be holding high positions in their respective institutions but that they should be involved in genetic conservation. Thus, identifying suitable persons as national coordinators is critical. Dr Sajise emphasised that, for the time being, it is necessary to continue the work with participants of this workshop as focal points. The respective government organisations would be requested to nominate the NCs to ensure legitimacy and official representation of national governments in APFORGEN. IPGRI/APAFRI has been delegated the task to write to the appropriate national government authorities for nomination of NC. The focal points participating in this workshop will facilitate in this task.

One change was made to the draft TOR suggested. However, the Workshop Participants decided that this Workshop would only make recommendations to elements to be included in the TOR that will be finalised during the first National Coordinators' meeting or the first Steering Committee meeting (refer to Workshop Recommendation 4).

APFORGEN steering committee

The role and Terms of Reference of the APFORGEN Steering Committee were discussed. No revisions were made to the proposed draft TOR at this point. However, it was decided that this Workshop would only make recommendations on elements to be included in the TOR that will be finalised during the first National Coordinators' meeting or first Steering Committee meeting. The proposed TOR is found in Workshop Recommendation 6.

However, there was discussion on the number of international bodies representation in the Steering Committee. It was agreed that the final structure of the Steering Committee would be decided during the first National Coordinators' meeting or first Steering Committee meeting.

The need for a separate Technical/Scientific Advisory Committee to assist the Steering Committee was also discussed. Dr Koskela expressed a view that, in the case of APFORGEN, the proposed Steering Committee includes also relevant regional and international organisations and therefore the Technical Advisory Committee is not necessary.

As for launching of the APFORGEN programme, it was suggested that the National Coordinators should meet soon after their countries have nominated them. The National Coordinators' meeting would then finalise the TOR for the Steering Committee as well as for the National Coordinators. After that, the Steering Committee will hold its first meeting to officially launch the APFORGEN programme.

Systems of communication

In addition to the APFORGEN web page, the participants suggested additional means to enhance communication to include: annual steering committee meetings or technical seminars, an APFORGEN Newsletter and regular (internal) email-newsletter

It was suggested that APFORGEN news could be published in the existing newsletters of APAFRI or IPGRI-APO until APFORGEN is able to source funds for publishing its own newsletter. However, it was also argued that the advantage of having a separate newsletter will give a "higher profile" to the Programme.

Legitimacy of the programme

Legitimacy of the Programme was briefly discussed. It was concluded that legitimacy could be created through approval and commitment by national governments as well as regional organisations such as ASEAN, FAO Asia-Pacific Forestry Commission and others.

APFORGEN action plan

The two working groups then continued discussion on drafting the action plan for APFORGEN in their respective sub-regions, South Asia and Southeast Asia.

Day 4: 18 July 2003 (Friday)

Session VII Working Groups continued

The Working Groups continued to finalise their discussions for presentation.

***Session VIII* Working Groups presentations**

The two working groups presented their proposed action plans and a discussion followed. Sub-regional and eco-regional approaches for collaboration were recommended by some of the participants. There was also a thorough discussion on the role and use of the priority species lists created by the countries as well as the sub-regional groups. The South Asia group considered priority species for tree improvement/multiplication and species for conservation separately, while the Southeast Asia group did not. The regional priority species identified by the Working Groups are presented in the Working Group reports. For the pre-workshop lists of national priority species, refer to the background document.

The common areas of interest tentatively proposed for the whole region include:

1. *Ex situ* & *in situ* conservation (including management of germplasm)
2. Exchange of genetic materials
3. Tree improvement and silviculture
4. Strengthening national programmes on plant genetic resources by networking, extension, public awareness, human resources development, training etc.
5. Evaluation, documentation and characterisation of FGR information
6. Social aspects of the protection of forest genetic resources (local communities, gender issues, etc.)
7. Inclusion of FGR into national policies and strategies
8. Capacity building

It was stated, that all the countries in the region are in need of both human resources development and physical capacity building to be able to improve FGR conservation. The emphasis on training should be on:

a) Short and long term training
b) Scientist exchange
c) Collaboration in e.g. training material production
d) Workshops and meetings
e) Study tours
f) Fellowships for young scientists/conservationists

Some specific areas where training is needed could include:

a) FGR conservation methods
b) Molecular aspects of FGR conservation
c) Taxonomy
d) Planning and management of FGR conservation
e) Tree breeding and improvement
f) Training in participatory approach towards FGR
g) Pests and diseases management
h) Livelihood generation from the use of FGR

However, the detailed training needs should be assessed. The workshop participants highlighted the need to include the practising forestry professionals into capacity building programmes.

There was also a discussion on the modus operandi for the APFORGEN programme. In addition to the modus operandi presented by the groups, the following suggestions were given during the discussion:

1. Eco-regional approach to FGR and their conservation
2. End-use-based approach to FGR and their conservation (timber, fuelwood, fodder, medicinal NTFP, etc.)
3. Effective networking to ensure that all participating countries are linked
4. Helping and facilitating sourcing for funding
5. Facilitation through translation of key documents from English to local languages

The participants suggested that the Programme should be flexible in choosing the right approach for each activity and the group that developed the concept note should also select the approach. In addition, some countries' need for information and technology transfer was highlighted. As to the role of APFORGEN, one workshop participant reminded that member countries would be responsible for implementation of the conservation efforts and that the APFORGEN Secretariat would only play a facilitative role. It was later decided that, for the time being, APFORGEN modus operandi should be kept open and flexible.

Session IX Workshop recommendations and concept notes

The Workshop made 12 recommendations for the further development of APFORGEN. In addition, the workshop participants discussed and committed themselves to develop the concept notes on the following topics:

Southeast Asia Working Group

1. Use of native species (*Aquilaria crassna, Dipterocarpus alatus, Pterocarpus macrocarpus*) in Vietnam (Lead), Laos, Cambodia and Thailand (Lead: Dr N.H. Nghia, deadline for concept note 30 September 2003)
2. Conservation of endangered species in Vietnam (Lead), Laos, Thailand, Cambodia and China (Lead: Dr N.H. Nghia, deadline 30 September 2003)
3. Developing and establishing *ex situ* conservation stands (*Pinus* spp.) in all SE-Asia member countries (except Malaysia). Lead by Philippines (Lead: Dr Ramon Razal, deadline 30 September 2003)
4. Demography, genetics & reproduction biology on priority and endangered species in SE-Asia: Malaysia (Lead), Indonesia, Thailand, Vietnam, Laos, Cambodia and Philippines (Lead: Dr S.L. Lee, deadline 15 October 2003)
   (Rattan, Aquilaria crassna, Afzelia xylocarpa, Dalbergia cochinchinensis, D. oliveri, Gonystylus bancanus, Eusideroxylon zwageri, Pinus merkusii)
5. Evaluate the genetic resource status of forest tree species (*Hopea odorata* and *Dalbergia cochinchinensis*) by using molecular markers. Thailand (Lead) and other Southeast Asian country members. (Lead: Dr Suchitra Changtragoon, deadline 31 October 2003)
6. Operational management in conservation of forest genetic resources (DFSC partnership with Indonesia, Malaysia, Vietnam and Philippines; Lead: Dr A. Pedersen, DFSC, deadline 15 October 2003)
7. Monitor and verify Criteria & Indicators in conservation of forest genetic resources. (DFSC partnership with Philippines, Vietnam and Thailand. Lead: Dr A. Pedersen, DFSC, deadline 15 October 2003)

South Asia Working Group

8. Institutional capacity building of APFORGEN South Asia countries for Forest Genetic Resources Conservation (Lead: P.R. Tamrakar, Nepal, deadline 30 September 2003)
9. Extension services – awareness programme: The needs for extension services and awareness programme for APFORGEN South Asia countries (Lead: J.E. Munashinghe, Sri Lanka, deadline 30 September 2003)
10. Germplasm collection, storing, and propagation: Development of mechanism for exchange & trading of forest reproductive materials for conservation and use for APFORGEN South Asia and Southeast Asia countries (Lead: Dr A. Paliwal and A. Pedersen, deadline 30 September 2003)

It was recommended that the concept notes should be 3–4 pages long and a common format should be used. The concept notes should identify: a) the problem, b) what should be done and c) ways to obtain funding for the project.

Session X Closing of Workshop

Dr P. Sajise provided the wrap-up and closing of the workshop. He concluded that the two issues that provoked most discussion were the priority species lists as well as exchange of genetic material. In this workshop, a tentative structure for APFORGEN has been agreed upon and the need for political support as well as for resource generation was recognised. He elaborated that it is important to transmit the key conclusions of the workshop to the authorities of participating countries.

He also pointed out a need for a vision for APRFORGEN. Dr Vichien Sumantakul has volunteered to provide a draft vision statement and submit to the APFORGEN secretariat for circulation and comments by all the participants. Other participants have also been requested to give their suggestions. It was decided that APFORGEN should also develop a logo. All participants are encouraged to provide suggestions and deadline for this would be end of July 2003.

Finally, all the participants were given an opportunity to provide feedback regarding the workshop and the arrangements.

Workshop recommendations

Recommendation 1

The Workshop participants recommend the adoption of the following objectives for APFORGEN:

i) Strengthen national programmes on forest genetic diversity in the participating countries
ii) Enhance regional networking and collaboration on conservation and management of forest genetic resources
iii) Locate, characterize, conserve and facilitate exchange of genetic diversity of selected priority forest species
iv) Promote sustainable utilization of genetic diversity in natural and man-made forests
v) Enhance linkages with other regional and international networks

Recommendation 2

The Workshop participants recommend the adoption of the organizational structure, which was outlined in the workshop background document. The main elements of the organizational structure consist of:

i) National Coordinators
ii) Steering Committee and
iii) APFORGEN Secretariat

Recommendation 3

The Workshop participants recommend that APAFRI and IPGRI should approach relevant governmental institutions and policy-makers in each country, with help of the workshop participants, and initiate a process to officially nominate the National Coordinators for APFORGEN.

Recommendation 4

The Workshop participants recommend that National Coordinators:

i) act as a link between the APFORGEN Secretariat and various national institutions carrying out work on forest genetic resources
ii) be responsible for involving relevant institutions and stakeholders within their respective countries to carry out agreed tasks and
iii) for coordinating APFORGEN related activities

Recommendation 5

The Workshop participants recommend that the APFORGEN Steering Committee be composed of National Coordinators from all participating countries and that the Steering Committee should also include representatives from APAFRI, IPGRI and DFSC.

Recommendation 6

The Workshop participants recommend that the Steering Committee:

(i) to oversee APFORGEN and meet regularly to review the progress made and

(ii) to discuss issues relevant to conservation and use of forest genetic resources and make recommendations for the future work of the Programme.

Recommendation 7

The Workshop participants recommend that official endorsement, both at national and regional level, should be obtained for APFORGEN. Relevant fora for seeking endorsement could be the Association of Southeast Asian Nations (ASEAN), the FAO Asia-Pacific Forestry Commission and the South Asia Association for Regional Collaboration (SAARC).

Recommendation 8

The Workshop participants identified the following common areas of interest in forest genetic resources among participating countries:

i) evaluation, characterization and documentation

ii) *in situ* and *ex situ* conservation

iii) exchange of genetic materials

iv) domestication and utilization

v) strengthening national programmes on forest genetic resources

vi) involvement of local communities and the role of livelihood and gender in conservation and use of forest genetic resources, and

vii) development of relevant policies and enhancement of the linkage between conservation of forest genetic resources and national forest programmes. The Workshop participants recommend that these areas should be given priority in developing regional collaboration.

Recommendation 9

The Workshop participants identified several regional capacity building needs, such as short and long-term training courses, exchange of scientists, collaboration in developing training materials, workshops and fellowships for scientists and professionals. More specifically, training would be needed on conservation methods, molecular tools, taxonomy, management of forest genetic resources, domestication, participatory approaches in conservation, and livelihood generation through the use of forest genetic resources. The Workshop participants recommend that these areas should be given priority in developing regional capacity-building efforts.

Recommendation 10

The South and Southeast Asia Working Groups developed a tentative list of priority species for the two sub-regions. The Workshop participants recommend that APFORGEN should give priority to these species initially. These lists would be subject to updating.

Recommendation 11

The Workshop participants discussed a wide range of approaches, which could be used in developing the modus operandi of APFORGEN. For further development of APFORGEN, the Workshop participants recommend that the modus operandi should be kept flexible and that specific groups or networking could not be established at this point of the Programme.

Recommendation 12

The Workshop participants recommend that one of the first concrete activities for APFORGEN should be developing more effective means for information dissemination and effective communication among participating countries.

Asia Pacific Forest Genetic Resources Programme (APFORGEN)[1] The way to the Inception Workshop, Kuala Lumpur, 15–18 July 2003

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Background and rationale

The Asia-Pacific region is diverse in many ways. Its forests vary from humid tropical rain forests to boreal forests and to desert scrubs. The tropical forests host most of the terrestrial biodiversity in the region. Rapid economic development and population growth have greatly affected forests and forestry in the region (Durst 2000). Despite its economic prosperity, the region is suffering from a lack of policies that could reconcile economic growth with sustainable use of resources, particularly forest ecosystems, which are being severely affected by land use changes. The Asia-Pacific Forestry Sector Outlook Study projected, among other issues that demand for the wide range of forest products and services will continue to increase, the multiple roles of forests will receive increased attention, and the roles and opportunities for all forest sector stakeholders are dynamic and changing (Durst 2000).

The forests are important both, for the region's wood-based industries and also for over a billion rural people. More than half of the world's population lives in the Asia Pacific region, which is both a threat and opportunity for the forest sector. There is a constant need to increase agricultural production for the increasing population and currently wood energy is a basic source of fuel for more than 2 billion people in the region (Durst 2000). In addition to fuelwood and traditional medicines, forests provide a significant amount of foods that supplement what is obtained from agriculture, thus increasing food security (Warner 2000). Forests also have an important role in poverty alleviation through the income generating opportunities that various wood and non-wood forest products (NTFPs) offer to local communities. The forests in the region also have global significance as a source for industrial wood and non-wood products and currently, for example, the region accounts for about 40 percent of all internationally traded NTFPs (Durst 2000).

In addition to the direct contribution as noted above, forests host significant amount of wild relatives of crops and other useful plants, though much of their value is generally unrecognised. They also contain numerous plant species that have potential to become future crops. Thus, conservation of forests is an important element in conservation of agricultural biodiversity. In addition, forests contribute to ecosystem services, such as carbon sequestration and control of soil erosion. Forests are important to watershed management, thus contributing to water quality and quantity as well.

Presently, in many countries, forest resources are threatened by deforestation, forest fragmentation and habitat degradation as a result of unsustainable harvesting of forest products and the conversion of forests to agriculture and urban development. Human activities and forest degradation are also reducing forest genetic diversity at unprecedented rates as well as food security and income opportunities for millions of people (Lipper 2000). Forest genetic diversity is needed by rural people, farmers, foresters and breeders to sustainably manage forest species with desired characteristics for the benefit of present and future generations.

Climate change makes conservation of forest genetic resources an even more urgent task. It is possible to increase the long-term use of trees and other forest species in the future only if the evolutionary potential of forest species is safeguarded, i.e. the species are able to adapt to the changing environmental conditions following the climatic change. Thus, management of forest genetic resources is an integral component of sustainable use of forests.

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[1] A background document for the Inception Workshop, Kuala Lumpur, 15-18 July 2003

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During the past decade, international dialogues on forests have considerably promoted the development of sustainable forest management. However, although the need to conserve and manage forest genetic resources has long been recognised in international fora, no global action plan has been developed for this purpose. The FAO Panel of Experts on Forest Gene Resources plays a major role in providing recommendations at the global level and has stressed the need to strengthen national programmes and regional collaboration on forest genetic resources in different parts of the world.

Several countries in the Asia Pacific region have taken steps to implement sustainable forest management practices. However, there is a need to further promote management of forest genetic resources *per se* within this process. Better management of forest genetic diversity will also help countries to fulfil their commitments as agreed under the Convention on Biological Diversity (CBD) and to maintain diversity for future use. While the CBD recognises that countries have sovereign rights over their own biological resources, it also assigns them the responsibility for conserving their biological diversity and urges them to use the biological resources in a sustainable manner. Countries are also urged to enhance technical and scientific cooperation, training and information exchange on conservation and sustainable use of biological diversity. However, national programmes on forest genetic resources are not well established in most countries in the region.

One of the major problems for designing a positive agenda for these issues is the lack of coordinated efforts and support for the establishment of national programmes on forest genetic resources despite the fact that several existing species-specific networks carry out valuable work in the region. These include the International Neem Network, TEAKNET, the International Network on *Leucaena* Research and Development (LEUCANET), the International Network on Bamboo and Rattan (INBAR) and the International Centre for Research and Training on Seabuckthorn (ICRTS) (see Sigaud *et al*. 2000 for a review). The worldwide Tropical Montane Cloud Forest Initiative, focusing on conservation of overall biodiversity, is also operating in the Asia Pacific region. However, a number of island states in the South Pacific, are collaborating under a formal networking framework, the South Pacific Regional Initiative on Forest Genetic Resources (SPRIG).

The lack of coordinated efforts in the APO region is especially true in the case of natural forests. This is surprising when one considers the fact that these forests supply raw materials for many economically valuable goods and products in addition to providing important environmental services. Dipterocarps are a good example of this negligence. Timber and non-timber products derived from these natural forests provide substantial revenues for many countries, especially in Southeast Asia. At local level, their importance is also considerable where lowland tropical rainforests, commonly dominated by dipterocarps, host a huge array of biological diversity and support the livelihood of rural people in numerous ways. Several institutions have been conducting research on dipterocarps and their genetic resources in the region but the major factor constraining progress has been the lack of coordinated action with well-defined objectives and priorities (Bawa 1998).

A new regional network with a holistic scope to conservation and management of forest genetic resources and well-defined objectives is needed to facilitate the establishment and strengthening of national programmes on forest genetic resources and alleviate the various problems and obstacles in the Asia Pacific region. Through networking, it is possible to avoid duplication of efforts and to gain synergy among collaborating countries and other stakeholders. This promotes partnership and efficient use of limited resources. Networking can also enhance the dialogue between scientists, managers, policy-makers and users, and increase interaction between different sectors at the national and regional levels.

Development of APFORGEN

The need to enhance regional collaboration and support national efforts on conservation and use of forest biological diversity has been highlighted in various meetings and workshops held in the Asia Pacific region during the past years. This has paved the way for the development of a regional programme on forest genetic resources. The following sections provide a short overview of these efforts.

The Asia Pacific Association of Forestry Research Institutions (APAFRI) held a regional seminar on 26–27 March 1999 during which its member institutions presented their visions and country-based research needs (Hoon and Awang 2000). The discussions during this seminar focused on a wide range of issues from environmental values of forests to globalisation and economic changes (APAFRI 1999a). The seminar identified APAFRI as a key facilitator for regional collaboration and information exchange to enhance forestry research in the region. The key recommendations of the seminar concerning networking are summarised as follows (APAFRI 1999b):

- Information support services at national and institutional levels should be upgraded so that the national, regional and global knowledge pool can be better utilised.
- Area and skill-based regional and global networking efforts should be strengthened.
- APAFRI should promote information exchange in the rapidly developing areas of science, such as biodiversity assessment and conservation, and biotechnology.
- APAFRI should also support the establishment of research networks to meet the needs of its members, and to strengthen the cooperation among the researchers through networking.

In addition to these recommendations, many papers and country reports presented at that seminar identified other needs for research and development that are closely related to conservation and use of forest genetic resources, e.g. sustainable management of natural forest, tree improvement and domestication (Hoon and Awang 2000). Action plans and research needs to conserve forest genetic resources in Asia have also been examined (Ramanatha Rao and Koskela 2001).

During the XXI IUFRO World Congress in Kuala Lumpur in August 2000, APAFRI and IPGRI discussed informally with several of their partners regarding the need to enhance regional collaboration on forest genetic resources. After the Congress, APAFRI and IPGRI continued these discussions and in November 2000, the IPGRI Regional Office for Asia, the Pacific and Oceania formally approached APAFRI during its Executive Committee meeting and presented a concept note for increasing regional networking on forest genetic resources (Koskela 2000). Other relevant international and regional organisations were also notified of these discussions.

FORGENMAP

Since 1997, the Forest Genetic Resources Conservation and Management Project (FORGENMAP) has been securing forest seed sources and improving seed supply for reforestation and rehabilitation purposes in Thailand. The FORGENMAP is being implemented by the Royal Forest Department (RFD) of Thailand and funded jointly by the RFD and the Danish Cooperation for Environment and Development (DANCED, now under the Danish International Development Agency (Danida)). Similar Danish-supported projects have also been carried out or are currently being implemented in several other Southeast Asian countries (i.e. Cambodia, Indonesia, Lao PDR and Vietnam) and in South Asia (Nepal).

While the major focus of these projects has been on improvement of tree seed sources and supply, they have also contributed to the conservation and management of forest genetic resources in a broader sense. Between 25 February and 10 March 2001, FORGENMAP organised a regional workshop for Southeast Asian countries in Thailand. This workshop brought together delegates from Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Thailand and Vietnam. Myanmar was unable to send a delegate but provided a country report. IPGRI, the FAO Forestry Research Support Programme for Asia and the Pacific (FORSPA) and the Danida Forest Seed Centre (DFSC) provided additional support and their staff also participated in the workshop. In addition, the CSIRO Forestry and Forest Products, Australia provided technical contributions to the workshop. This Southeast Asian workshop assessed the national status of forest genetic resources in different countries and initiated strategic thinking on how to improve conservation and management of forest genetic resources at both national and regional levels. It also made several recommendations for further action (Koskela *et al*. 2002). One of the workshop recommendations was that, in future efforts, special emphasis should be given to enhance regional networking on conservation and use of forest genetic resources. Furthermore, the delegates suggested that IPGRI should coordinate further action in collaboration with other relevant international and regional organizations.

APFORGEN

During late 2001 and early 2002, APAFRI and IPGRI intensified their collaboration and held a number of joint meetings. A result of those interactions was to initiate the Asia Pacific Forest Genetic Resources Programme (APFORGEN). Soon it became obvious that not only the Southeast Asian countries but also other countries in the Asia Pacific region could benefit from increased regional collaboration on forest genetic resources. Furthermore, as IPGRI was already coordinating similar regional programmes in other parts of the world (namely the European Forest Genetic Resources Programme (EUFORGEN) and the Sub-Saharan Forest Genetic Resources Programme (SAFORGEN)), lessons learnt from them were carefully analysed while initiating APFORGEN.

It has also been agreed that the initial focus of APFORGEN should be on tropical and sub-tropical forests as these host most of the terrestrial biodiversity in the APO region and are exposed to major threats. It was further agreed to focus on South, Southeast and East Asia, as the SPRIG Programme was already operational in the Pacific. A consultation process was then engaged with selected APAFRI members and IPGRI partners in February 2002 to find out:

1. What kind of activities on forest genetic resources different institutions are involved in
2. What is the level of existing regional collaboration and the countries' interest to increase this collaboration
3. What human and financial resources are available
4. What activities are needed to strengthen the countries' capacity to conserve and sustainably use forest genetic resources
5. What are the most important priority forest species for regional collaboration

In 2002, APAFRI and IPGRI developed joint proposals or concept notes to obtain start-up funding for APFORGEN and these were submitted to various donor agencies, such as the Canadian International Development Agency (CIDA), Ford Foundation, the Ministry of Foreign Affairs of Finland and the International Tropical Timber Organization (ITTO), to name a few. Unfortunately, none of the fund-raising efforts have yet been successful. The ITTO proposal was executed in collaboration with Forest Research Institute Malaysia (FRIM) and in early 2003 a revised version was submitted. More feedback is expected from ITTO in early 2004.

APAFRI and IPGRI have also been promoting APFORGEN in various meetings in the region. For example, in April 2002, APFORGEN was presented at the ASEM (Asia-Europe Meeting) Workshop on Conservation and Sustainable Use of Forests, held in Chiang Mai, Thailand. APAFRI and IPGRI also organised a Satellite Meeting for their partners during the '*Bringing Back the Forests – Policies and Practises for Degraded Lands and Forests'* Conference, held in Kuala Lumpur in October 2002. The participants of this Satellite Meeting recommended that APAFRI and IPGRI organise an inception meeting in June or July 2003 to discuss and identify priorities for APFORGEN. As a follow-up to this recommendation, the Inception Workshop of APFORGEN is now organized. The purpose of this workshop is to assess the present status and the activities that have taken place in the Southeast Asian countries since the 2001 workshop in Thailand. The workshop would also provide clear recommendations regarding the operational structure of APFORGEN as well as its objectives, priorities and future work on conservation and use of forest genetic resources in the Asia Pacific region.

Results of the APFORGEN consultation process in 2002

At the end of February 2002, APAFRI and IPGRI initiated a consultation process with potential national partners and had sent out a questionnaire to 21 institutes in 14 countries in the region. The objective of that consultation was to obtain information about the activities that were being carried out by their partners and the research and capacity-building needs on conservation and use of forest genetic resources. It also explored what kind of resources partners were willing to commit for the development and implementation of APFORGEN activities in each country.

By September 2002, a total of 16 partners in 13 countries had indicated their strong interest on APFORGEN and provided valuable feedback. These partners were Bangladesh Forest Research Institute, Indian Council for Forestry Research and Education, Department of Forest Research and Survey of Nepal, Tree Improvement and Silviculture Component of Nepal, Pakistan Forest Research Institute, Sri Lanka Forest Department, Cambodian Department of Forestry and Wildlife, Research and Development Centre for Biotechnology and Forest Tree Improvement of Indonesia, Forest Research Centre in Lao PDR, Forest Research Institute Malaysia, College of Forestry and Natural Resources in the Philippines, Royal Forest Department and Kasetsart University in Thailand, Forest Science Institute of Vietnam, and Research Institute of Forestry and Research Institute of Tropical Forestry, both under the Chinese Academy of Forestry.

The scope of work and areas of activities carried out by the partners are summarised in Appendix 1. Most of the work carried out under research and development (R&D) activities focused on *in situ* and *ex situ* conservation, tree improvement and evaluation of species and provenances. Many of the partners have also been dealing with silvicultural and agroforestry systems as well as NTFPs. In addition, a large number of partners were carrying out genetic studies. Training and extension activities were focused on short-term training courses, production of training materials and providing extension services. Similarly, most partners were also focusing on planning and implementation for *in situ* and *ex situ* conservation. Other common activities in this category included natural forest management, tree plantations and tree improvement.

The feedback revealed that much of the international collaboration on forest genetic resources took place with partners outside the Asia Pacific region. International collaboration was generally bilateral, involving an Asian country and one or more of European or US agencies in the form of relatively short-term projects. Similar bilateral arrangements prevailed in cooperation between the Asia Pacific countries and Australia, Japan and South Korea. Only a few activities or projects had been carried out between the neighbouring countries or with other countries that replied to this consultation. In some cases, these activities included exchange of information and forest germplasm but this kind of regional collaboration did not seem to be widespread. Subsequently, all partners indicated that there was a need to enhance regional collaboration with other countries in the region and that they considered APFORGEN as a very useful initiative. A regional approach to conservation of forest genetic resources is necessary as forest ecosystems and species span across the political boundaries.

Most partners indicated that they were willing to provide in-kind support to facilitate and coordinate APFORGEN activities at national level. The in-kind support included assignment of part-time professional staff to act as focal points and provision of associated office space and facilities. Several partners also indicated their willingness to establish joint field trials, for example, and that they would be able to cover, at least partly, the costs related to these kinds of activities.

The partners highlighted a wide range of issues and activities to strengthen the countries' capacity to conserve and sustainably use forest genetic resources. At the institute level, there seemed to be a large demand for long-term capacity-building as well as short-term training on conservation methods, monitoring and evaluation of genetic resources, documentation and information management, and development of proposals and projects. At the national level, the partners frequently considered that development of new or revision of existing policies and strategies would be needed to promote long-term conservation and sustainable use of forest genetic resources. A number of countries specifically indicated that establishment of a national body or programme to coordinate the efforts would be much needed. The feedback also indicated that links between conservation of forest genetic resources and the overall biodiversity conservation needed improvement. Similarly, many partners highlighted the need for increased efforts for linking genetic conservation and forest management as well as management of protected areas and promotion of inter-sectoral collaboration.

For future R&D efforts, the partners indicated a number of activities that can be broadly grouped as follows (not in any order of priority). Firstly, many partners felt a need for national assessment of forest genetic resources to be carried out in their country, including mapping of species' natural distribution areas and evaluation of genetic diversity. The need to apply GIS tools for the assessments was also highlighted. Secondly, the need to enhance genetic conservation efforts was frequently emphasised. A wide range of topics on genetic conservation was mentioned, such as germplasm collection and storage, establishment of *in situ* and *ex situ* conservation areas, conservation through use, indicators for monitoring biodiversity, endangered species, taxonomy and involvement of local people in conservation. Thirdly, the increased use of biotechnology in management of forest genetic resources, for example in studies on population genetics, tree breeding and micropropagation of planting materials was noted. Fourthly, the need to increase the use of forest genetic resources in tree improvement, plantation establishment and management of natural forests was also often mentioned. In addition to these four broad categories, the partners also indicated the need to enhance information dissemination and increase the awareness on genetic conservation among forestry professionals and the general public.

In the questionnaire, a list of priority species, developed by the Southeast Asian workshop on forest genetic resources in 2001, was provided to the partners and they were asked to indicate which of those species they considered important for APFORGEN. Furthermore, the partners in South Asian countries and in China were specifically asked to suggest additional priority species, as these countries did not participate in the previous workshop in 2001. The results regarding the priority species are presented in Appendix 2.

Overall objective and scope of APFORGEN

The broad objective of APFORGEN is to promote the management of tropical forest genetic diversity more equitably, productively and sustainably in the member countries in the Asia Pacific region (currently 13 countries, namely Bangladesh, India, Nepal, Pakistan, Sri Lanka, Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Thailand, Vietnam and China). Other countries in the region are welcome to join the Programme. The specific objectives of the programme are to: strengthen national programmes on forest genetic diversity in the participating countries, enhance regional networking and collaboration on conservation and management of forest genetic resources, locate, characterize, conserve and appropriately deploy genetic diversity of selected priority forest species, increase sustainable management and use of genetic diversity in natural and man-made forests

The main activities of the Programme are (1) promoting the establishment and strengthening of national programmes on forest genetic resources, (2) locating forest genetic diversity, (3) developing and applying appropriate conservation methods and strategies, and (4) increasing the level of management and use of tropical forest genetic diversity in the participating countries. Regional activities, including information exchange, development of regional conservation strategies and action plans, country-to-country technology transfer and exchange of forest germplasm, will also be facilitated. The Programme will focus on priority forest species, which are identified by the participating countries themselves. The activities will be linked to ongoing networking efforts on forest genetic resources in the South Pacific, i.e. to the SPRIG programme so that the APFORGEN countries can learn from the experiences of the Pacific countries and also to increase information exchange with them. These are considered to be necessary activities to provide the countries a sound basis for long-term conservation and sustainable management of tropical forests in the Asia Pacific region. A tentative logical framework for the APFORGEN Programme is presented in Appendix 3.

Suggested programme structure and mode of operation

Individual countries will join the Programme by signing an agreement specifying the contributions to be made to operate their own activities and nominating a National Coordinator. The Programme will be overseen by a Steering Committee including the National Coordinators from all participating countries who will be acting as formal representatives of their countries. The National Coordinators will also act as a link between the APFORGEN Secretariat and various national institutions carrying out work on forest genetic resources. The National Coordinators' responsibilities are also to commit relevant institutions and stakeholders within their respective countries to carry out agreed tasks and liase between them.

In addition to the National Coordinators, it is proposed that the Steering Committee should include representatives from a few key international and regional organisations, such as APAFRI, IPGRI, FAO, the Centre for International Forestry Research (CIFOR), the International Centre for Research on Agroforestry (ICRAF), the Danida Forest Seed Centre (DFSC), the Asia Pacific Association of Agricultural Research Institutions (APAARI) and others. The Steering Committee will meet regularly to review the progress made, discuss issues relevant to the conservation and use of forest genetic resources and make recommendations for the future work of the Programme.

IPGRI and APAFRI will set up the APFORGEN Secretariat (comprising a Coordinator and support staff) at Kuala Lumpur, Malaysia to provide backstopping for the national programmes, coordinate regional efforts and monitor the implementation of the Programme activities in different countries. The Secretariat will report to the Steering Committee. An important task of the Secretariat, with support from Steering Committee members, will be to contribute to the mobilization of resources for the activities undertaken within the framework of the network. Separate concept notes and proposals will be developed for specific research, capacity building and information activities.

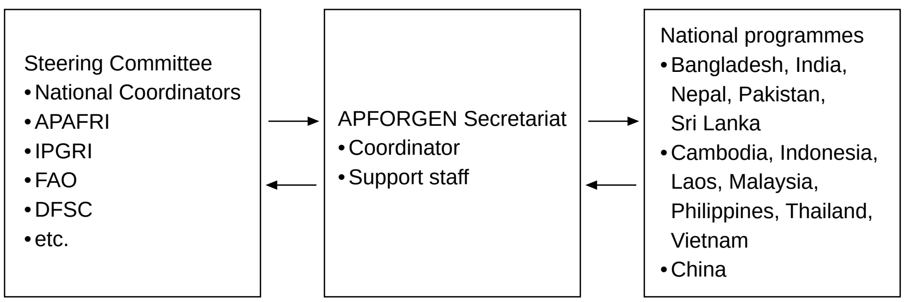

Figure 1. Proposed organisational structure of the Asia Pacific Forest Genetic Resources Programme (APFORGEN) (Note: the list of countries is based on the consultation feedback received by September 2002).

Expected outputs of APFORGEN

There are two major expected outputs:

1. Active national programmes in the participating countries collaborating with each other within a well-coordinated regional network
2. Increased conservation of genetic resources of selected priority forest species and increased use of these resources in natural and human-made forests

The more specific outputs are:

1. Active national programmes and an operational regional network

- A large group of stakeholders interacting within a national programme
- Human and institutional capacities strengthened through training courses and workshops
- Information disseminated through a website and by other means
- Availability of long-term funding increased and collaborative initiatives developed among countries

- Conservation strategies and action plans developed and implemented for priority forest species
- Guidelines developed for sharing and exchange of forest germplasm and information

2. Increased conservation and sustainable use of priority forest species

- Genetic diversity of priority forest species located and assessed
- Priority species conserved in cooperation with local people
- Genetic resources management guidelines developed for logging, forest rehabilitation and tree domestication
- Germplasm production, propagation and distribution methods developed for priority forest species

Target beneficiaries

There are four groups of target beneficiaries for the proposed programme and its activities.

Forest research institutions in the participating countries will be able to increase their institutional capacity to conduct relevant research to support sustainable forest management and utilisation. Their staff will directly benefit from increasing interaction with colleagues in other countries and the training they will receive within the programme will increase their technical and scientific skills. The programme activities will also help the national research institutions to increase public awareness on conservation and sustainable use of forest genetic resources. Subsequently, this will also facilitate the institutions' attempts to obtain long-term funding for their work from the policy-makers in respective countries and improve their capacity to contribute to policy formulation at national level.

Policy makers in the participating countries will have a concrete way to partly fulfil their commitment to international agreements, such as the CBD. Most of the countries in the Asia Pacific region have signed and ratified the CBD and thus also committed themselves to the global efforts to conserve and sustainably use forest genetic resources among other biological resources. The policy-makers will be able to demonstrate concrete steps towards sustainable forest management as the programme aims at providing practical guidelines on how to manage forest genetic resources within the overall concept of sustainable forest management. The policy-makers will be able to develop more meaningful policies for biodiversity conservation and management as soon as the national efforts on forest genetic resources are better linked to the national forest programmes, which are already in place, in various forms and capacities, in most countries in the region.

Local communities and NGOs will also benefit from the proposed programme in a number of ways, both directly and indirectly. They will be invited to participate in national workshops and meetings, which will be organised to discuss and plan various conservation activities among a large group of national stakeholders. Local people will also be incorporated into the implementation of the Programme activities, such as establishment and management of *in situ* conservation areas, and collection of germplasm for research and other purposes, for example. Increased *in situ* conservation efforts for selected priority species will also enhance the conservation of other important forest species providing non-wood forest products (e.g. fruits, medicinal plants, bamboo, rattan etc.). Thus, the programme activities will generate income for local people and contribute to their food and livelihood security as well. As a long-term benefit, local communities would also be able to benefit from the improved policies on natural resources management and their implementation.

Staff of government forestry departments and private forest companies will be able to apply new genetic management guidelines while implementing reduced-impact logging, forest rehabilitation and tree domestication to increase the sustainable management and use of forest resources. Forestry departments and companies will also benefit from the improved propagation methods for priority forest species and the increased availability of forest germplasm for reforestation, rehabilitation and establishment of commercial plantations. Subsequently, this will also provide environmental benefits for the participating countries as well as strengthen their forestry sectors, which have significant roles in national economies in several countries. Forestry departments and companies can also address practical research and development needs, which scientists and policymakers may not be aware.

Conclusion

From the above discussion, it is clear that countries in the Asia Pacific region are in favour of the proposed regional programme to better coordinate conservation and management of forest genetic resources at national and regional levels. This Programme will also enable the strengthening of national programmes on forest genetic resources and support related capacity-building efforts in different countries. APFORGEN can also serve as a channel for national partners to increase collaboration with regional and international organisations to source for funding for their research work. APFORGEN is initially directed to the above-mentioned 13 countries that provided feedback for the consultation but other countries in the region are welcome to join the Programme.

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Appendix 1

Scope of work in different partner institutions based on the information provided during the consultation in 2002

	BGD	IND	NEP		PAK	SRL	CAM	INS	LAO	MAL	PHI	THAI		VIE	CHN	
	FRI	I CFRE	DFRS	T I SC	F RI	FD	DFW	RDCBFT I	NAFRI	FRI M	UPLB	RFD	KU	FSIV	RI F	RITF
Research and development																
Eco-geographic surveys	X	X		X	X				X		X		X	X	X	X
Genetic studies / population genetics	X	X		X	X			X		X	X	X	X	X	X	X
Reproductive biology	X	X						X		X	X	X		X		
Germplasm collection and storing	X	X		X		X			X	X		X	X	X	X	X
Germplasm production and propagation	X	X		X		X			X	X	X	X	X	X	X	X
Evaluation (species and provenance trials etc)	X	X	X		X	X		X	X	X	X	X	X	X	X	X
Tree improvement (including domestication)	X	X	X	X	X	X		X	X	X	X	X	X	X	X	X
In situ conservation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ex situ conservation	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Taxonomy	X	X					X		X	X	X	X	X	X	X	
Ethnobotanical studies	X	X					X			X	X	X	X			
Silvicultural systems		X	X	X		X	X			X	X	X	X	X	X	X
Agroforestry systems	X	X	X		X				X	X	X	X	X	X	X	X
Forest management guidelines		X	X				X		X	X	X	X	X	X	X	X
Wood products (manufacturing / marketing)		X								X	X	X	X	X		X
Non-timber forest products	X	X	X	X	X				X	X	X	X	X	X	X	X
Training and extension																
Formal forestry education		X			X	X				X	X	X	X			X
Distance learning											X					
Short-term training courses	X	X		X		X	X	X	X	X	X	X	X	X	X	X
Production of training/extension material	X	X	X	X			X		X	X	X	X	X	X	X	
Extension services	X	X	X	X		X			X	X	X	X	X	X	X	X
Planning and implementation																
National forest programmes		X		X		X	X		X	X		X	X	X	X	X
Conservation policies and strategies		X				X	X		X	X	X	X	X	X	X	
Forest conservation (natural parks etc)		X				X	X			X	X	X	X		X	X
Germplasm collection and storing	X	X		X	X				X	X	X	X	X	X	X	
Germplasm production and propagation	X	X		X					X	X	X	X	X	X	X	X
Tree improvement (including domestication)	X	X	X	X	X	X	X	X	X	X		X	X	X	X	X
In situ conservation	X	X	X	X	X	X	X		X	X	X	X	X		X	X
Ex situ conservation	X	X	X	X	X	X	X		X	X	X	X	X	X	X	X
Natural forest management		X	X	X	X	X	X		X	X	X	X	X	X	X	X
Tree plantations (including agroforestry)		X	X	X	X	X	X		X	X	X	X	X	X	X	X

Bangladesh: FRI=Forest Research Institute: India: ICFRE=Indian Council for Forestry Research and Education; Nepal: DFRS=Department of Forest Research and Survey, TISC=Tree Improvement and Silviculture Component; Pakistan: FRI= Forest Research Institute; Sri Lanka: FD=Forest Department; Cambodia: DFW=Department of Forestry and Wildlife; Indonesia: RDCBFTI=Research and Development Centre for Biotechnology and Forest Tree Improvement; Lao PDR: FCR=Forest Research Centre; Malaysia: FRIM=Forest Research Institute Malaysia; Philippines: CFNR=College of Forestry and Natural Resources; Thailand: RFD=Royal Forest Department, KU=Kasetsart University; Vietnam: FSIV=Forest Science Institute of Vietnam; China: RIF=Research Institute of Forestry, RITF= Research Institute of Tropical Forestry.

Appendix 2

Important forest species for APFORGEN

The first set is based on the priority species identified by the SE Asian workshop in 2001 and the second set includes additional species suggested mainly by South Asian countries and China during the consultation in 2002.

	BGD	IND	NEP		PAK	SRL	CAM	INS	LAO	MAL	PHI	THAI		VIE	CHN	
	FRI	I CFRE	DFRS	T I SC	PFI	FD	DFW	IFSP	NAFRI	FRIM	UPLB	RFD	KU	FS I V	RI F	RITF
Afzelia xylocarpa							X		X				X	X		
Agathis borneensis										X						X
Albizia lebbeck		X		X	X	X	X						X			
A. procera	X	X		X	X								X			
Alstonia scholaris								X					X			X
Anisoptera costata									X				X	X		
Aquilaria crassna							X		X				X	X		
Artocarpus heterophyllus	X	X		X							X		X			
Avicennia alba					X								X			
Azadirachta excelsa										X		X	X			
A. indica		X	X	X	X	X						X	X			
Calamus manan (rattan)										X			X			X
Cassia siamea	X			X									X			X
Casuarina equisetifolia	X	X		X	X							X	X			
Chukrasia tabularis	X					X				X			X	X		
Dalbergia bariensis		X					X							X		
D. cochinchinensis							X		X			X	X	X		
Dipterocarpus alatus									X			X	X	X		
D. grandiflorus											X		X			
D. tuberculatus													X			X
Dryobalanops aromatica										X						
Durio spp.													X			
Dyera costulata										X			X			
Eusideroxylon zwageri								X								
Fagraea fragrans							X			X			X			
Gonystylus bancanus								X		X						
Hopea odorata	X	X					X		X	X		X	X	X		
Intsia bijuga											X					
I. palembanica										X			X			

	BGD	IND	NEP		PAK	SRL	CAM	INS	LAO	MAL	PHI	THAI		VIE	CHN	
	FRI	I CFRE	DFRS	T I SC	PFI	FD	DFW	IFSP	NAFRI	FRIM	UPLB	RFD	KU	FS I V	RI F	RITF
Koompassia malaccensis										X						
Lagerstroemia ovalifolia		X		X									X			
Litchi sinensis											X		X			
Melaleuca cajuputi								X		X			X	X		
Metroxylon sagu													X			
Palaquium rostratum										X						
Parashorea stellata													X			
Parkia speciosa													X			
Pinus kesiya							X				X	X	X	X		
P. merkusii								X	X		X	X	X			
Pterocarpus indicus		X				X				X	X		X			X
P. macrocarpus							X		X			X	X	X		
Rhizophora spp.	X				X						X	X	X	X		
Samanea saman	X										X		X			
Schima wallichii			X	X											X	X
Shorea cochinchinensis		X					X						X			
S. leprosula								X		X						
S. macrophylla								X		X			X			
S. ovalis								X		X						
S. parvifolia								X		X						
S. roxburghii										X			X			
S. stenoptera								X								
Sindora cochinchinensis													X	X		
Sterculia lychnophora																X
Tectona grandis	X	X		X		X		X	X	X		X	X		X	X
Terminalia chebula		X		X		X										
Toona sinensis													X		X	X
T. sureni													X			
Vatica odorata									X							
Vitex parviflora											X		X			
Xylia dolabriformis	X															
X. xylocarpa		X										X	X			

Additional priority species

	BGD	IND	NEP		PAK	SRL	CAM	INS	LAO	MAL	PHI	THAI		VIE	CHN	
	FRI	I CFRE	DFRS	T I SC	PFI	FD	DFW	IFSP	NAFRI	FRIM	UPLB	RFD	KU	FS I V	RI F	RITF
Acacia spp.								X								X
A. mangium												X			X	
A. nilotica		X			X											
Afzelia rhomboidea											X					
Araucaria cunninghamii								X								
Ailanthus excelsa		X														
Bamboo		X										X				
Bambusa vulgaris (bamboo)	X															
B. blumeana (bamboo)											X					
Betula alnoides																X
Bombax alba					X											
Calamus erectus (rattan)	X															
C. longisetus (rattan)	X														X	
Calocedrus macrolepis														X		
Castanopsis histrix															X	X
C. fabri															X	
Cedrus deodara					X											
Chloroxylon swietenia						X										
Chukrasia velutina												X				
Cinnamomum cassia														X		
Cunninghamia lanceolata															X	
Dalbergia cultrata									X							
D. latifolia		X	X	X												
D. sissoo		X		X	X											
Dendrocalamus giganteus (bamboo)	X															
Dipterocarpus turbinatus	X															
Diospyros bejaudi							X									
D. crumenata							X									
D. ebanum						X										
D. mun														X		
Dysoxylom loureiri							X									
Endospermum malaccense										X						
Eucalyptus spp.		X						X								X
E. camaldulensis												X				
E. urophylla															X	
E. grandis															X	
E. globulus															X	
Erythrophloeum fordii														X		

	BGD	IND	NEP		PAK	SRL	CAM	INS	LAO	MAL	PHI	THAI		VIE	CHN	
	FRI	I CFRE	DFRS	T I SC	PFI	FD	DFW	IFSP	NAFRI	FRIM	UPLB	RFD	KU	FS I V	RI F	RITF
Fokienia hodginsii									X					X		
Gmelina arborea	X										X					
Gardenia ankorensis							X									
Heritiera fomes	X															
Khaya ivorensis										X						
Keteleeria fortunei															X	
Lagerstroemia speciosa	X															
Lasianthus kamputensis							X									
Mangifera spp.												X				
Melia azedarach															X	
M. dubia											X					
Morus spp.					X											
Persea kerrii													X			
Picea smithiana					X											
Pinus armandii															X	
P. caribaea															X	X
P. massoniana															X	
P. roxburghii					X											
P. wallichiana					X											
P. yunnanensis															X	
Platanocephalus chinensis																X
Populus deltoides					X											
Prosopis cineraria		X														
P. juliflora		X														
Pterocarpus marsupium			X	X												
Santalum album		X						X								
Sesbania sasban/grandiflora					X											
Shorea robusta	X	X		X												
S. javanica								X								
Swietenia macrophylla											X					
Syzygium grandee	X															
S. cumini			X													
Taxus wallichiana														X		
Toona ciliata				X								X				

Bangladesh: FRI=Forest Research Institute: India: ICFRE=Indian Council for Forestry Research and Education; Nepal: DFRS=Department of Forest Research and Survey, TISC=Tree Improvement and Silviculture Component; Pakistan: FRI= Forest Research Institute; Sri Lanka: FD=Forest Department; Cambodia: DFW=Department of Forestry and Wildlife; Indonesia: RDCBFTI=Research and Development Centre for Biotechnology and Forest Tree Improvement; Lao PDR: FCR=Forest Research Centre; Malaysia: FRIM=Forest Research Institute Malaysia; Philippines: CFNR=College of Forestry and Natural Resources; Thailand: RFD=Royal Forest Department, KU=Kasetsart University; Vietnam: FSIV=Forest Science Institute of Vietnam; China: RIF=Research Institute of Forestry, RITF= Research Institute of Tropical Forestry

Appendix 3

A tentative logical framework for the APFORGEN Programme

Summary	Indicators	Means of verification	Risks and assumptions
Goal: To conserve, manage and sustainably use tropical forests in the Asia Pacific region.	• Areas of conserved and sustainably managed forests increased • Amount of biological diversity in the remaining forests maintained	• Country reports and statistics • Global environmental statistics	
Purpose: To increase networking and conservation and sustainable use of forest genetic resources in the Asia Pacific region.	• Active national FGR programmes • Regional cooperation and new initiatives • Number of species in conservation and breeding programmes • Adoption of C&I for FGR in forest management	• Country reports and statistics • Surveys on FGR status • Reports of the FAO Panel of Experts on FGR	• Importance of FGR recognised by policy-makers in various countries. • Availability of financial and human resources. • Different stakeholders are willing to cooperate.
Output 1: National FGR programmes strengthened and a regional network established.	• Active national programmes • Number of various stakeholders within national programmes increased • The network operating in the region • Number of new policies adopted • New guidelines implemented • Long-term national funding increased	• National and regional workshop proceedings • Technical reports • Annual programme reports • National forest policy and other reports by national forest programmes	• Existing national efforts have limited capacity to promote FGR conservation and management. • Linkages between research, policy-making and practical forest management need to be enhanced. • Lack of coordinated efforts to conserve and manage FGR in the region.
Activity A: Promote capacity-building and networking among national programmes.	• Number of training workshops • Number of trainees • Training material developed and used • Collaborative initiatives increased among national programmes • Number of joint projects increased	• National workshop proceedings • Technical reports • Training material	• Many countries in the region do not have well-established national FGR programmes. • Policy-makers have low priority for FGR management. • Lack of financial and human resources.
Activity B: Collect, disseminate and exchange research results and other relevant information.	• web site made available • Databases developed (research, publications, species conservation status) • Articles published and disseminated in IPGRI-APO Newsletter, IPGRI FGR research Highlights and APAFRI Brief	• Web site • Databases • Network reports • Various newsletters	• Relevant information is documented and available • Limited accessibility and awareness of existing FGR information. • Countries are able and willing to provide country level information for databases.

Summary	Indicators	Means of verification	Risks and assumptions
Activity C: Develop national and regional conservation strategies and action plans on forest genetic resources.	• Workshops held • Conservation strategies developed and adopted • Action plans developed • Number of participating countries	• Status reports • Meeting reports • National and regional workshop proceedings • Programme publications	• National FGR conservation strategies and action plans poorly formulated, if any. • No regional FGR conservation strategies or action plans exist. • These are needed to enhance both regional and national activities.
Activity D: Promote sharing and exchange of forest germplasm.	• Code of Conduct developed for the participating countries • Countries signed the Code of Conduct • Material Transfer Agreements among the participating countries done	• Meeting reports • Code of Conduct • Material Transfer Agreements	• There is a need to develop exchange protocols that are consistent with the CBD and national legislation. • Countries are interested in exchanging forest germplasm to increase the use of FGR.
Output 2: Genetic resources of priority forest species conserved and their sustainable use increased in natural and man-made forests.	• Priority forest species conserved • Countries applying improved forest management methods increased • Genetic diversity of natural tropical forests maintained • Use of genetic resources increased in tree plantations and agroforestry systems	• Country reports and statistics • Scientific publications • Surveys on FGR status • Reports of the FAO Panel of Experts on FGR • Global environmental statistics	• Lack of information on the amount of genetic diversity and how it is located in priority forest species. • Present conservation efforts are inadequate. • Management of forest genetic diversity needs to be improved in practical forest management. • The potential of forest genetic resources is poorly recognised and utilised for sustainable development.
Activity A: Locate and assess genetic diversity of priority forest species.	• Species and populations surveyed • Number of genetic studies • Distribution maps produced	• Technical reports • Scientific publications • Country statistics	• Lack of information on the amount and location of genetic diversity in priority forest species.
Activity B: Conserve priority forest species and collect traditional knowledge on their uses.	• Number of species and conservation programmes • Number of *in situ* and *ex situ* conservation stands • Traditional knowledge collected • Number of local communities involved in conservation	• Technical and meeting reports • Other publications • Country statistics	• Priority forest species are inadequately conserved. • Knowledge of local people on priority species and their uses is poorly documented. • Involvement of local people is essential for effective conservation.

Summary	Indicators	Means of verification	Risks and assumptions
Activity C: Develop gene management guidelines for priority forest species (logging, forest rehabilitation and tree domestication).	• Sites, species and management systems assessed • Guidelines developed	• Technical reports • Guidelines and other publications	• Effects of logging, forest rehabilitation and tree domestication on genetic diversity of priority forest species are not properly understood. • It is not known how well forest genetic diversity can be recovered through forest rehabilitation measures.
Activity D: Develop germplasm production, propagation and distribution methods for priority forest species.	• Species evaluated • Protocols and methods tested and developed	• Technical reports • Guidelines and other publications	• There is a lack of high quality reproductive material for forest rehabilitation, plantation establishment and agroforestry purposes.

COUNTRY REPORTS

Status of forest genetic resources conservation and management in Bangladesh

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Introduction

Bangladesh is located between latitudes 20° 34' to 26° 38' N and longitudes 88° 01' to 92° 41' E. The country consists mostly of flood plains (80%) with some hilly areas (12%), with a sub-tropical monsoon climate. In winter, temperature ranges from a minimum of 7°C to 13°C to a maximum of 23°C to 32°C. In summer, the temperature varies from 36°C to 41°C. The mean annual rainfall ranges from 143 to 434 cm (BBS 1994). The population stood at 131.6 million in 2001.

Forest resources

Bangladesh has a total area of 14.39 million ha, of which 9.12 million ha is cultivated, 2.14 million ha public forests, 0.27 million ha village groves, and 1.64 million ha constantly under water. The remaining land area (1.22 million ha) is occupied by tea gardens, uncultivable areas, rural and urban houses and ponds (Kibria *et al.* 2000). The area of government and village forests is about 16% of the total land area. However only 0.93 million ha (6.5%) is under tree cover, which is about 40% of the forests controlled by the government. The remaining 60% includes denuded lands (grassland, scrubland and encroached areas). About 24 000 ha of forest is lost annually as a result of homestead development, urbanization and deforestation (Anon 1992).

The mangrove forests composed of two major components, *viz.*, the Sundarbans and the Coastal Afforestation. The Sundarbans forest is spread over 0.58 million ha in the south-western region (Ali 1989), with an annual depletion rate of about 1.7%. A large-scale coastal afforestation programme has been undertaken since 1966, covering about 170 000 ha. The hill forests cover an area of 0.67 million ha. The growing stock has been estimated to be about 28 million m^3 or 100 m^3 ha^{-1} (Anon 1992). Annual depletion of the growing stock stands at 1.65%. The estimated average annual forest growth is 2.5 m^3 ha^{-1}. The forest cover of 0.12 million ha mainly consisting of *Shorea robusta* (sal) is located in the central and northern part of the country. The area under tree cover in this region has been estimated to be 32%. A large portion of this forestland has been encroached. About 0.02 million ha of plantations have been established. The unclassified state forests include 0.73 million ha of hilly land located at the southeast corner of the country. The village forest area is 0.27 million ha (TFYP 1985). The growing stock of the woodlots and bamboo resources have been estimated to be 54.7 million m^3 and 7480 million culms respectively.

The contribution of forestry to the national Gross Domestic Product (GDP) at current prices has been estimated to be 3.28% (BBS 1994). The supply of various forest products such as timber, poles, fuelwood, bamboo, etc. cannot meet the present demand. Village forest areas, being one-tenth of the national forest area, supply 70% of sawlogs, 90% of fuelwood and 90% of bamboo consumption of the country (Douglas 1982). The annual per capita consumption of timber and fuelwood was estimated to be 0.01 m^3 and 0.08 m^3, respectively, based on a population of 90 million as at 1980 (Byron 1984). The figure would be less if the present forest production and population were considered. The gap between demand and supply has been increasing with the increase in population. This gap may be narrowed through the establishment of plantations of fast growing trees in the denuded forest areas, wastelands as well as homestead areas.

Status of forest genetic resources

Bangladesh, located in the humid tropical region is rich in species diversity and is unique in the diversity of genetic resources compared to its land area. It has about 5700 species of angiosperms and four species of gymnosperms (Khan 1977; Troup 1975) of which some 2260 species are reported from the Chittagong region (Anon 1992). The major forest tree species of the country are shown in Appendix 1.

Khan (1996) reported that there are about 86 timber species, 130 species yielding fibre and 29 medicinal plant species available in the country. The Bangladesh National Herbarium (BNH) prepared a list of 500 medicinal plants. Bamboo resources of 18 taxa, both wild and planted are available in the country (Alam 1982). There are at least nine species of rattans, including a recently reported one (Alam and Basu 1988), along with 12 other palm species (Khan 1996). However, it must be noted that comprehensive information on forest genetic resources (FGR) is not available in the country. Information on species diversity in terms of (i) chromosome numbers, (ii) morphological variation, (iii) flowering and seed production habits, (iv) flowering time and (v) seed morphology and viability, etc. are available only for a few agricultural species. Forest species have been neglected in this respect (Hassan 1995).

Identification of threats

Forests in Bangladesh are declining at an alarming rate. An estimated 73 000 ha of forests were lost to encroachment for agriculture and aquaculture by the year 1980. Some species are disappearing fast and are considered as threatened. A total of 19 tree species and nine rattan species need immediate conservation measures (Khan 1996). The on-going loss of germplasm is a threat to FGR. High population pressure on land, clearing of forests, exploitation, draining and filling of wetlands, introduction of exotic species, introduction of improved genotypes, pests, improper silvicultural techniques and management and lack of public awareness are some of the major threats to FGR. Poverty and the attitude of the people towards exploitation of natural habitats of plants as free goods also contribute to the loss of germplasm in the country.

The destruction of forests by shifting cultivation is another problem in Bangladesh. The forests are cut and cultivated for a short time only, and when the residual nutrients in the soil are leached as a result of erosion removing the topsoil, the shifting cultivators move to another location.

The country has four wild gymnosperms, viz. *Cycas pectinata, Gnetum scandens, G. funiculare* and *Podocarpus nerifolia*. *C. pectinata* is regionally threatened and the two *Gnetum* species have become very rare while the populations of *P. nerifolia* are much depleted. Immediate appropriate conservation measures are needed to protect these species in the country. Khan (1996) reported that the number of plant species threatened in the country is 45. Among mammals, birds, reptiles and amphibians, 15 species have become extinct and 33 species are endangered. According to the Government of Bangladesh (GOB 1992), there are 27 threatened and 39 endangered species of wildlife in Bangladesh at present.

Links between forestry sector and FGR

Genetic resources play an important role in improving the quality and quantity of forest products. In this respect, FGR provide the source material for selection of mother trees, provisional plus trees and establishment of seed orchards. It is associated with the conservation of superior genetic materials and their subsequent improvement. Ultimately, the improved materials will be utilized in national programmes to enhance the productivity of forests, and in order to do so the following activities are undertaken by the Forest Department:

- Use of fast-growing genotypes for increasing the production
- Use of best genotype/provenance of proven trees for particular site type
- Use of best genotype to develop interim and alternate sources of improved seeds required for national plantation programme
- Use of best genotypes in tree improvement programmes

Links between agriculture and FGR

The Bangladesh Agriculture Research Institute (BARI), Bangladesh Rice Research Institute (BRRI) and Bangladesh Jute Research Institute (BJRI) initiated systematic germplasm conservation activities around the mid-70s. The assistance of Institute of Jute Organization (IJO) added extra emphasis and BJRI now has a global germplasm collection of jute and associated fibre crops. FGR have not received much attention until recently.

Although Bangladesh is a small country it has a diverse ecosystem with hills, plains, coastal areas and wetlands, and a wide variety of FGR as a result of the diverse agroecological conditions [38 agroecological zones and 88 subzones]. The landraces have survived here under the hostile climates over centuries and acquired some characteristics, which are of immense importance to the breeders for development of new cultivars, hybrids, etc, and face challenges of more violent pathogens, pests and a hostile climate (drought, salinity, temperature, etc).

With regard to tree species, collecting, conserving and utilizing fruit germplasm has received some attention. A total of 817 fruit germplasms have been collected so far. Moreover, 53 fruit species have been identified to be occurring mainly in the forests. The conservation of these fruit species is implemented by BARI, the Department of Agriculture Extension (DAE) and the Bangladesh Agriculture Development Corporation (BADC).

FGR are needed for the incorporation of genotypes into the existing agricultural production systems, reforestation programmes, agroforestry, social forestry and commercial timber estates. Agriculture utilizes FGR in selection of superior traits, selection breeding, identification of high-yielding varieties (HYV) and domestication of fruit germplasms.

Links between agroforestry and FGR

Large-scale agroforestry projects have been initiated in heavily degraded *Shorea robusta* forests of the central and northern regions of the country. A community forestry project at Dinajpur is considered a success story of the Forest Department (FD). In this area, plantations have been established in close cooperation with local people on a benefit-sharing basis. At the moment, the people are harvesting the trees. The major tree species are *Eucalyptus camaldulensis*, *Acacia auriculiformis* and *Cassia siamea*. During the first two to three years after planting, people cultivated rice, wheat and vegetables, etc.

The farmers in the northern region are also cultivating tree species along with their agricultural crops. They keep different tree species at a wide distance in their crop fields. The species used include *Acacia nilotica, A. catechu, Azadirachta indica, Eucalyptus* spp., *Dalbergia sissoo, Borassus flabellifer, Phoenix sylvestris*, etc. In some areas, they have also planted mulberry for feeding silkworms to produce silk.

There are homestead agroforestry systems all over the country. These homesteads are rich in genetic resources. Ninety tree species and 13 bamboo species are grown in homestead forests. The Bangladesh Forest Research Institute (BFRI) has started research to develop improved rubber agroforestry systems in some rubber estates and trying to find out shade tolerant genotypes of economic crops. Ginger, turmeric and *Colocasia* (Arum) have given satisfactory results when planted at the early stage of rubber plantation.

For agroforestry purposes, farmers use different forest species for soil fertility management, fodder and living fences, as well as timber. Agroforestry utilizes forest genetics resources in selection of superior trees, selection of multi-purpose tree species (MPTS) and fast-growing tree species, selection of leguminous tree species and selection of wild crops.

Past and present activities in conservation, utilization and management of FGR

Establishment of forest plantations in Bangladesh started in 1871 with teak (*Tectona grandis*) using seeds brought from Myanmar. Since then plantation forestry became a part of the overall clearfelling silvicultural systems. Teak was the main species planted because of its high value. Other species, such as *Gmelina arborea, Artocarpus integrifolius, Dipterocarpus turbinatus, Swietenia mahagoni, Lagerstroemia speciosa, Toona ciliata, Artocarpus chaplasha, Xylia kerrii* and *Syzygium grande* were introduced later. Most of the plantations were monocultures established by shifting cultivators through taungya system. Since the plantations were established through clearfelling followed by artificial regeneration, there was a severe loss of native vegetation. Moreover, with the development of mechanized logging for commercial purposes, the shifting cultivators could not cope with the extensive area cleared, which resulted in a rapid loss of FGR. In many cases plantation establishment failed. The above-mentioned species used for plantation establishment were slow-growing and long-rotation species. Plantations with these species were unable to meet the growing needs of the rapidly increasing population.

In 1974, the Forest Department (FD) began to establish plantations with fast growing species such as *Gmelina arborea, Paraserianthes falcataria* and *Anthocephalus chinensis*. During this period, plantations of industrial species such as rubber, oil palm, mulberry and cashew were established but the results were disappointing.

Presently, industrial and fuelwood plantations comprise a mixture of species with long rotation (40 years), medium rotation (12–18 years) and short rotation (5–6 years). In addition, agroforestry plantations are being raised in encroached land with the active participation of local people on a benefit-sharing basis. Encroachment is a serious problem both in sal forests and Hill Forests.

Forest plantations cannot be the substitute to natural forests. The most important reason is that plantations are severely degraded in genetic resources compared to natural forests. In fact, the forests of Bangladesh, particularly the plain land sal forests and hill forests, are severely degraded due to indiscriminate exploitation, the sal forest are even on the verge of extinction. Therefore, the GOB has taken initiatives for the conservation of ecosystems and forest gene resources in the remaining natural forests.

Conservation strategies

Major international efforts to conserve FGR began in the 1960s with the guidance and support of FAO. Conservation efforts of FGR have been implemented with the following strategies:

In situ conservation

In situ conservation is carried out in the following areas: nature reserves, national parks, wildlife sanctuaries and world heritage sites.

(a) Nature Reserves – The objectives of a nature reserve are to protect communities and species and to maintain natural processes in order to have ecologically representative examples of the natural environment. However, in Bangladesh there are no nature reserves. There are some wilderness areas in Chittagong Hill Tracts but there are no records of these areas.

(b) National Parks – There are four national parks in Bangladesh. Details of the national parks are presented in Table 1 below.

Table 1. National Parks in Bangladesh

Name & location	Area (ha)	Year est.	Purpose/Flora
Himchari National Park (Cox's Bazar)	1729	1980	To preserve the fauna and habitats as well as to provide facilities for research, education and recreation. Semi-evergreen and moist deciduous forests. *Dipterocarpus* spp., *Albizia procera*, *Artocarpus chaplasha*, *Salmalia malabarca*, *Sterculia alata*, *Quercus* spp., *Castanopsis* spp., *Eugenia* spp., *Lannea grandis*, undergrowth mixed with canes, palms, orchids and ferns and sometimes as pure stands.

Name & location	Area (ha)	Year est.	Purpose/Flora
Bhawal National Park (Gazipur)	5022	1982	To preserve and develop the habitats and provide facilities for research, education and recreation. About 90 percent of the forest cover is composed of coppice-origin sal (*Shorea robusta*) in association with *Dillenia pentagyna*, *Lagerstroemia parviflora*, *Adina cordifolia*, *Miliusa velutina*, *Lannea grandis*, *Albizia* spp., *Bauhinia variegata*, *Spondias mangifera*, *Butea frondosa*, *Barringtonia acutangula*, etc. Common undergrowths are *Eupatorium* spp., *Pennisetum setosum*, *Asparagus racemosus* and *Rauvolfia serpentia.*
Madhupur National Park (Tangail)	8436	1982	To preserve and develop the habitats and provide facilities for research, education and recreation. Flora similar to that of the Bhawal National Park. About 40% of the forest flora is composed of sal.
Ramsagar National Park (Dinajpur)	52	1974	To preserve and develop the habitats and provide facilities for research, education and recreation. The park does not contain any type of natural forest of the country but is artificially raised. The species planted consist mostly of fruit and ornamental trees.

(c) Wildlife Sanctuaries – There are 14 wildlife sanctuaries and game reserves in Bangladesh and details on these are as given in Table 2 below.

Table 2. Wildlife Sanctuaries in Bangladesh (Sarker 1989; Rahman 1996)

Name & location	Area (ha)	Year est.	Purpose/Flora
Sundarbans World Heritage Site (Khulna)	16 065	1998	To preserve breeding habitats. The Sundarbans mangrove forest is fairly evergreen with low floristic diversity. The two main dominant species are *Heritiera fomes* and *Excoecaria agallocha*. Both species are gregarious in nature but the latter is more saline tolerant and therefore, predominates in the saline zones. Other species are *Rhizophora* spp., *Ceriops* spp., *Kandelia candel*, *Sonneratia apetala*, *Avicennia* spp., *Aegiceras corniculatum*, *Bruguiera gymnorhiza, Phoenix paludosa*, *Nipa fruticans*, etc. and among grasses *Imperata cylindrica*, *Typha elephantina* and *Phragmites karka* are prominent.
Sundarbans East (Khulna)	5439	1977	To preserve the Royal Bengal Tiger (*Panthera tigris*) and its habitats. Flora similar to the Sundarbans World Heritage Site.
Sundarbans South (Khulna)	17 878	1977	To preserve the Royal Bengal Tiger (*Panthera tigris*) and its habitats. Flora similar to the Sundarbans World Heritage Site.
Sundarbans West (Khulna)	9069	1977	To preserve the Royal Bengal Tiger (*Panthera tigris*) and its habitats. Flora similar to the Sundarbans World Heritage Site.
Rema-Kalenga (Sylhet)	1095	1981	To preserve the existing fauna and flora in the area. Flora is same as in tropical evergreen and semi-evergreen forests.
Char Kukri-Mukri (Bhola)	40	1981	To preserve the existing habitat used by local and migratory birds. The sanctuary is covered very thickly by a small spiny plant locally called tambulkanta that grows up to 2.5 metres in height. There are patches of hogla (*Typha elephantina*), hargoja (*Acanthus illicifolius*) and keora (*Sonneratia apetala*) scattered throughout the sanctuary area. Khalisha (*Aegiceras malus*) is also seen.

Name & location	Area (ha)	Year est.	Purpose/Flora
Pablakhali WS (Chittagong Hill Tracts)	42 087	1983	To preserve fauna and habitat for white-winged wood duck (*Cairina scutulata*). The following types of forest cover are recognized in the sanctuary area: a) Tropical evergreen; important species are *Pterygota alata* and *Quercus* spp. b) Tropical semi-evergreen; important trees are *Dipterocarpus* spp., *Mangifera, Amoora, Cinnamomum, Syzygium, Tetrameles*, *Artocarpus, Salmalia, Albizia*, etc. c) Tropical moist deciduous; the characteristic tree species are *Albizia*, *Salmalia, Terminalia*, *Ficus* spp., etc. Bamboos grow in all the types as undergrowth.
Hail Haor (Sylhet)	1427	1983	To preserve habitats for migratory ducks. At present all the wetland areas are under management control of Haor Development Board. Their activities probably place more emphasis on paddy production and other agricultural crops. It is the most threatened habitat in the country.
Hazarikhil (Chittagong)	2909	1970	To preserve local fauna and habitats. The forest cover of the sanctuary is of evergreen/semi-evergreen type. Main species of trees are *Dipterocarpus* spp., *Artocarpus chaplasha*, *Tetrameles nudiflora*, *Cedrela toona*, *Mesua ferrea*, *Eugenia* spp., *Ficus* spp., *Albizia procera*, etc. Undergrowth consists mostly of bamboo and *Eupatorium odoratum*.
Rampahar-Sitapahar (Rangamati)	3026	1973	To preserve local fauna and habitats. Same as Hazarikhil except bamboos occur as prominent undergrowth.
Chunati (Chittagong)	7764	1986	To preserve habitats. As in the case of mixed evergreen forests, the upper storey of the sanctuary forest consists of deciduous trees such as *Dipterocarpus turbinatus* with fewer *D. pilosus* and *D. costatus*, *A. chaplasha, Salmalia insigne* and *S. malabarica, Ficus* spp., *Swintonia floribunda*, Bandarholla, etc. The second storey consists of evergreen species, such as *Quercus* spp., *Eugenia* spp., *Lannea* spp., *Lagerstroemia* spp., *Aphanomixis* spp., Hargaza, etc. The undergrowth consists mostly of smaller evergreen trees with bamboo and assamlata (*Eupatorium odoratum*).
Dulhazara Safari Park (Cox's Bazar)	1600	1995	To preserve habitats. Flora is same as in tropical semi-evergreen forests.
Khagrachari (Chittagong Hill Tracts)	n.a.	n.a.	To preserve elephants. Flora is same as in tropical wet evergreen forests.
Teknaf (Cox's Bazar)	11 615	1983	To preserve the Asian elephant (*Elphas maximus*) and its habitats. Semi-evergreen and moist deciduous forests. *Dipterocarpus* spp., *Albizia procera*, *Artocarpus chaplasha*, *Salmalia malabarica*, *Sterculia alata*, *Quercus* spp., *Castanopsis* spp. *Eugenia* spp., *Lannea grandis*, *Lagerstroemia* spp., *Amoora* spp. etc. Bamboo occurs as undergrowth mixed with canes, palms, orchids and ferns and sometimes as pure stands. This category does not fall in any of the ten categories described by the IUCN.

(d) World Heritage Site – The Sundarbans has been declared a world heritage site.

Ex situ conservation

In contrast to *in situ* conservation, *ex situ* conservation includes any practices that conserve genetic materials outside the natural habitat of the parent population. *Ex situ* conservation methods and materials include genebanks for seed or pollen as well as clonal banks, arboreta, preservation plots, sample plots, etc:

- **Preservation plots** – The BFRI has established five preservation plots at different hill forest areas and 27 at the Sundarbans (mangrove) forest.
- **Clone banks** – The BFRI has established two clonal banks, one at Hayko, Chittagong (4 ha) and another at Ukhia, Cox's Bazar (4 ha). Seven tree species (*Tectona grandis, Gmelina arborea, Bombax ceiba, Dipterocarpus turbinatus, Syzygium grande, Swietenia mahagoni and Paraserianthes falcataria*) are preserved in these two locations.
- **Botanical gardens**
  - Mirpur Botanical Garden: area 85 ha, with 255 tree species (total 28 200 plants), 310 shrub species (8400 plants), 385 herb species (10 400 plants). The total number of families of trees, herbs and shrubs is 114 (Ranjit 1997).
  - Baldha garden: area 1.15 ha with 18 000 trees, herbs and shrubs from 820 species and 92 families (Ranjit 1997).
- **BFRI Bamboo Arboretum** – The BFRI Bambusetum (1.5 ha) has been established at the BFRI campus. This arboretum contains 27 bamboo species (*Bambusa balcooa, B. bambos var. spinosa, B. burmanica, B. cacharensis, B. comillensis, B. jaintiana, B. multiplex, B. nutans, B. polymorpha, B. salarkhanii, B. tulda, B. vulgaris, B. ventricosa, Dendrocalamus giganteus, D. hamiltonii, D. longispathus, D. strictus, D. brandisii, Gigantochloa andamanica, G. atroviolacea, G. apus, Melocalamus compactiflorus, Melocanna baccifera, Schizostachyum dullooa, Thyrsostachys oliveri, T. regis* and *T. siamensis*), including six exotic species. One arboretum of medicinal plants (1 ha) has been established at the BFRI campus with a collection of 40 species. One cane arboretum (0.5 ha) of seven species has also been established (Banik 1997). Three arboreta of tree species have been established at the BFRI HQ with 56 species, Keochia Forest Research Station with 56 species and Charaljani Silviculture Research Station with 52 species.
- **Seed storage –** There is a National Forest Seed Center (NFSC) at the BFRI; however, the centre does not have any facility for long term storage of seeds.
- **Tissue culture –** Tissue culture on forest tree species has been done only at the BFRI tissue culture laboratory. The BFRI has so far developed tissue culture techniques for six tree species and seven bamboo species.

Appendices 2–4 provide information on the conservation of important tree species in Bangladesh, their use and threats.

Conservation of provenances within a species:

The BFRI has established provenance trials of *Acacia mangium, A. auriculiformis, Eucalyptus camaldulensis, E. brassiana, E. tereticornis, E. urophylla, Tectona grandis, Gmelina arborea, Pinus caribaea, P. oocarpa, Paraserianthes falcataria, Leucaena leucocephala, Melaleuca leucadendra, Gliricidia sepium* and *Populus deltoides* from 68 provenances.

Institutional framework

Roles of different institutions are crucial in guiding the course of events and ensuring the successful achievement of aims and objectives. The Forestry Master Plan considered five interrelated areas, i.e. policy, legislation, organizational structure, human resource development, research and extension.

Today the forestry and forest institutions in Bangladesh are judged in much wider context than before. The interrelated and multiple roles of forests are vital for human welfare and sustained socioeconomic development.

Bangladesh signed the convention of the Earth Summit on 5 June 1992 in Rio and subsequently ratified it on 20 March 1994. As a result, the country has certain obligations under the convention.

National forest policy

In accordance with the National Forest Policy promulgated in October 1994, the following policy objectives are set in order to eliminate any uncertainty regarding the aims of the Government:

i) To meet the basic needs of the present and future generations and also to ensure greater contribution of the forestry sector in economic development.
ii) To create employment opportunities, strengthening the rural and national economy the scope for poverty alleviation and trees and forest-based rural development sectors will be extended and consolidated.
iii) Biodiversity of the existing degraded forests will be enriched by conserving the remaining natural habitats of birds and animals.
iv) Agricultural sector will be strengthened by conserving the land and water resources.
v) National responsibilities and commitments will be fulfilled by implementing various international efforts and agreements ratified by the government relating to global warming, desertification and control of trade and commerce of wild birds and animals.
vi) Through the participation of the local people, illegal occupation of the forestlands, illegal tree felling and hunting of wild animals will be prevented.
vii) Effective use and utilization of the forest goods at various stages of processing will be encouraged.
viii) Implementation of afforestation programmes on both public and private lands will be provided with encouragement and assistance.

List of national priority species

The following species are the priority species in the Forest Department plantation programme:

Long rotation plantation species: *Tectona grandis, Dipterocarpus turbinatus, Syzygium grande, Swietenia macrophylla, Chukrasia tabularis, Michelia champaca, Hopea odorata, Xylia kerrii, Lagerstroemia flos-reginae, Shorea robusta* and *Toona ciliata*

Medium rotation species: In addition to the long rotation plantation species *Pinus caribaea, Albizia flacatana, Bombax ceiba, Gmelina arborea, Anthocephalus chinensis and Eucalyptus camaldulensis, E. tereticornis, Dalbergia sissoo, Azadirachta indica, Samanea saman, Bombax ceiba, Acacia nilotica* and *A. catechu*

Short rotation species: *Acacia auriculiformis, Acacia mangium, Eucalyptus camaldulensis, Melia azadirachta, Albizia chinensis, Leucaena leucocephala, Trewia nudiflora and Casuarina equisetifolia*

Village groves: *Artocarpus heterophyllus, Mangifera indica, Aegle mermelos, Litchi chinensis, Psidium guajava, Ziziphus spp., Syzygium, Albizia, Barringtonia, Eucalyptus, Erythea, Ficus, Albizia fuman, Anthocephalus, Tamarindus indica, Bombax ceiba, Swietenia macrophylla, Alstonia scholaris, Cocos nucifera,* palmyra palm and bamboo

On marginal lands such as roadsides: *Tectona grandis, Mangifera indices, Artocarpus heterophyllus, Dalbergia sissoo, Butea frondosa, Polyanthina longifolia, Eucalyptus camaldulensis, Acacia auriculiformis, Swietenia, Albizia, Samanea, Syzygium* and *Casuarina equisetifolia*

Multipurpose tree species for different zones:

Hillzones: *Albizia lebbeck, A. procera, Phyllanthus emblica, Eucalyptus camaldulensis, Elaeocarpus robusta, Artocarpus heterophyllus, Acacia auriculiformis* and rattans

Coastal zone: *Casuarina equisetifolia, Albizia lebbeck, Acacia procera, S. grandiflora, Cocos nucifera, Phonek sylvestria* and *Erythrina indica*

Mangrove: *Heritiera fomes, Avicennia sp., Bruguiera gymnorhiza, Ceriops decandra, Rhizophora mucronata and Sonneratia apetala*

Research on FGR

The BFRI conducts research under 12 programme areas. Each year the Institute undertakes a number of priority research studies following the suggestions of the Bangladesh Forest Department, Bangladesh Forest Industrial Development Corporation, Bangladesh Chemical Industries Corporation, Bangladesh Tea Board, Rural Electrification Board, other wood-based industries, private owners and non-government organizations. A Technical Committee scrutinizes the suggested studies. An Advisory Committee approves the selected studies.

The BFRI conducts a number studies on FGR conservation and management under the following programme areas: (i) Biodiversity and its conservation, (ii) Production of quality planting materials, (iii) Plantation techniques and forest management, (iv) Breeding and improvement, (v) Social and non-timber forest products, (v) Social forestry and farming system research and (vi) Pest and diseases. Seed Orchard Division, Silviculture Research Division, Silviculture Genetics Division, Mangrove Silviculture Division, Plantation Trial Unit Division, Minor Forest Products Division, Soil Science Division, Forest Protection Division and Farming System Research Component are involved in conducting these studies.

A total of 44 technologies have been developed and out of these, 28 technologies have been transferred to end-users. A total of 16 technologies on conservation and management of FGR have been developed and transferred to different end-users. Training programmes based on these new technologies are arranged as and when required.

Conclusion and recommendations

The natural forests of Bangladesh have been seriously degraded, resulting in serious genetic erosion of FGR. There is a critical need to develop coordinated efforts to conserve and manage FGR. Effective and hopeful efforts have been developed into conservation activities, but national and international financial and technical assistance are needed to bring about success. The following recommendations have been put forward for the conservation and sustainable utilization of FGR in Bangladesh:

- Development of a database on the present status of flora and fauna in different ecosystems of Bangladesh.
- *In situ* and *ex situ* programmes to conserve, manage and use FGR should be significantly expanded.
- Community-based resource conservation needs to be emphasized.
- Improved silvicultural methods should be applied in the management of natural and plantation forests.
- The method of clear-felling followed by burning for plantation establishment must be stopped.
- Silvicultural measures for aided natural regeneration should be followed.
- Enrichment planting should be conducted in the forest gaps with diversified genetic resources collected from natural regeneration in the forest floor.
- Establishment of preservation plots and permanent sample plots in the reserved forest.
- Establishment of a genebank for conservation of FGR.
- Logging in the remaining natural forests must be stopped.

- Creation of diversified job opportunities for the hill people through Farming System approach.
- Improvement of shifting cultivation by improved technologies like SALT, DSA, etc.
- Introduction of a forest certification system for sustainable forest resources management.
- Awareness should be developed among the shifting cultivators about the detrimental effect of shifting cultivation.
- Education and training of professionals and technicians should be given to equip them with the latest knowledge of forest genetic resource survey, management and conservation.
- Strengthening the international cooperation for FGR conservation.

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Appendix 1

Value and use of main forest species in Bangladesh

Species name	Value	Present, future or potential use											
	code	ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
1. *Acacia auriculiformis*	1	+		+		+		+	+	+			
2. *A. catechu*	1	+	+	+	+			+					
3. *A. farnesiana*	3			+	+			+					
4. *A. mangium*	1	+		+		+		+		+			pb,v
5. *A. nilotica*	1	+		+	+			+					cw,agi
6. *Acrocarpus fraxinifolius*	3	+											pw
7. *Aegiceras corniculatum*	3			+	+		+						
8. *Albizia chinensis*	1	+				+		+	+				pw
9. *A. lebbeck*	1	+		+			+	+					v
10. *A. lucidor*	3	+		+				+					
11. *A. odoratissima*	2	+		+				+				+	
12. *A. richardiana*	2	+			+		+					+	bb
13. *A. procera*	1	+		+				+					
14. *Alstonia scholaris*	1	+			+	+						+	pc,n
15. *Amoora cucullata*	3		+	+									
16. *Anacardium occidentale*	1	+			+		+						
17. *Anogeissus acuminata*	3	+		+	+							+	agi
18. *Anthocephalus chinensis*	1					+	+					+	
19. *Antidesma ghaesembilla*	3	+					+	+					
20. *Aphanamixis polystachya*	2	+			+								
21. *Aporusa dioica*	3		+		+		+						
22. *Aquilaria agallocha*	2												ab
23. *Artocarpus chama*	1	+				+	+						
24. *A. heterophyllus*	1	+			+		+	+		+		+	
25. *A. lacucha*	2	+			+		+	+					agi
26. *Avicennia alba*	2			+									pw
27. *Azadirachta indica*	1				+					+		+	
28. *Bambusa sp.*	1			+		+	+	+					pb
29. *Barringtonia acutangula*	2	+		+	+								
30. *Bauhinia purpurea*	3				+		+	+					agi

Species name	Value	Present, future or potential use											
	code	ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
31. *B. variegata*	3				+		+	+					
32. *Beilschmiedia pseudomicrocarpa*	3	+											
33. *Berrya cordifolia*	3	+										+	agi,cw
34. *Bischofia javanica*	2	+	+		+			+					agi
35. *Bombax ceiba*	1	+				+	+	+					k
36. *Bridelia retusa*	3		+		+		+	+					
37. *Bouea oppositifolia*	3	+					+						agi
38. *Bruguiera gymnorhiza*	2	+	+		+								
39. *B. sexangula*	3	+	+		+								
40. *Buchanania lanzan*	3				+		+						
41. *Butea monosperma*	2	+			+			+					
42. *Callicarpa tomentosa*	3		+	+				+					
43. *Calophyllum inophyllum*	2				+								m,bb,rs
44. *Canarium resiniferum*	3				+								v,pw
45. *Cassia fistula*	2	+			+			+				+	c
46. *C. nodosa*	2	+										+	
47. *C. siamea*	1	+		+				+				+	c
48. *Castanopsis tribuloides*	3	+					+						agi
49. *Casuarina cunninghamiana*	3								+			+	
50. *C. equisetifolia*	1	+		+	+					+		+	bb,m
51. *Ceiba pentandra*	1	+			+			+					k
52. *Ceriops decandra*	3	+	+		+								
53. *Chukrasia velutina*	1	+								+			
54. *Cinnamomum iners*	3												p
55. *Cordia dichotoma*	3	+		+	+		+	+					
56. *Crateva magna*	3	+			+		+						t,n
57. *Croton oblongifolius*	3	+		+	+								
58. *Crypteronia paniculata*	3												cw,c,rs
59. *Dalbergia sissoo*	1	+			+			+					a,v
60. *Delonix regia*	2	+		+					+			+	
61. *Dillenia indica*	3		+	+	+		+						bb
62. *D. scabrella*	3	+					+						
63. *Diospyros montana*	3	+			+								
64. *D. nigricans*	3		+										

Species name	Value	Present, future or potential use										
	code	ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
65. *D. peregrina*	3	+			+		+						ts
66. *D. toposia*	3	+					+						
67. *Dipterocarpus alatus*	2												bb,rs
68. *D. turbinatus*	1									+			bb,c
69. *Dolichandrone spathacea*	3											+	
70. *Duabanga grandiflora*	3	+				+							pw,d
71. *Dysoxylum binectariferum*	3	+			+								
72. *D. hamiltonii*	3	+			+		+						
73. *Ehretia serrata*	3	+					+	+					agi
74. *Elaeocarpus floribundus*	1	+					+						
75. *E. sphaericus*	3											+	
76. *E. varunna*	3									+			tc
77. *Engelhardtia spicata*	3	+			+								
78. *Erioglossum rubiginosum*	3	+					+						c
79. *Erythrina fusca*	3			+				+	+				
80. *E. variegata*	2			+				+	+				d,v,t
81. *E. fusea*	3												
82. *Eucalyptus alba*	3				+							+	
83. *E. camaldulensis*	1			+			+						c,v,rs,pw
84. *E. brassina*	2			+			+						
85. *E. tereticornis*	2			+			+						
86. *E. urophylla*	2			+			+						
87. *E. citriodora*	2	+			+								c, agi
88. *Excoecaria agallocha*	1					+							
89. *Ficus benghalensis*	1	+		+	+			+					
90. *F. hispida*	2			+			+	+					
91. *F. racemosa*	2	+		+	+		+	+					
92. *F. religiosa*	1			+				+				+	pc
93. *Flacourtia jangomas*	3	+			+		+						
94. *Garcinia cowa*	2	+			+		+						va
95. *Garuga pinnata*	2	+			+	+	+	+	+				
96. *Gliricidia sepium*	2			+				+	+				
97. *Gmelina arborea*	1	+			+	+		+		+			
98. *Grevillea robusta*	3	+											v,d

Species name	Value	Present, future or potential use											
	code	ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
99. *Grewia tiliaefolia*	3						+						agi,m
100. *Heritiera fomes*	1		+										bb,c
101. *Hevea brasiliensis*	1	+				+							v,r
102. *Holarrhena pubescence*	3	+			+								n
103. *Hopea odorata*	1	+	+		+					+			
104. *Hydnocarpus kurzii*	2				+								
105. *Hymenodictyon orixensis*	2	+			+			+					tc,m
106. *Jacaranda mimosifolia*	3				+							+	
107. *Kandelia candel*	3				+								
108. *Lagerstroemia macrocarpa*	2		+										c,bb
109. *L. speciosa*	1	+	+									+	bb,c
110. *Lannea coromandelica*	3	+			+	+		+					
111. *Leucaena leucocephala*	3			+				+		+			
112. *Lithocarpus elegans*	2		+	+									
113. *L. pachyphylla*	3			+									c
114. *Litsea glutinosa*	3	+		+	+								
115. *L. monopetala*	3	+			+			+				+	
116. *Madhuca indica*	3	+			+		+						
117. *Mallotus philippensis*	3				+								
118. *Mangifera indica*	1	+			+		+	+		+			
119. *Melaleuca leucadendra*	3		+	+	+	+	+						rs,bb
120. *Michelia champaca*	1	+			+		+			+		+	
121. *Olea dioica*	3			+									
122. *Oroxylum indicum*	3			+	+		+	+					
123. *Paraserianthes falcataria*	2					+							pw,m
124. *Phyllanthus emblica*	1				+		+			+			
125. *Pinus caribaea*	2					+						+	
126. *Pithecellobium dulce*	2	+		+	+		+	+					
127. *Pongamia pinnata*	2				+		+						
128. *Prosopis juliflora*	3	+		+				+					
129. *Protium serratum*	3						+						c,rs
130. *Pterospermum acerifolium*	2	+			+			+				+	agi
131. *Pterygota alata*	2	+				+	+						
132. *Rhizophora mucronata*	1		+	+	+		+						

Species name	Value	Present, future or potential use											
	code	ti	po	wo	nw	pu	fo	fd	sh	ag	so	am	xx**
133. *Samanea saman*	1	+		+				+				+	
134. *Saraca asoca*	2				+							+	
135. *Schima wallichii*	2			+									c
136. *Schleichera oleosa*	2				+		+						
137. *Sesbania grandiflora*	1			+		+	+	+		+			
138. *Semecarpus anacardium*	3				+		+						
139. *Shorea robusta*	1	+			+								c
140. *Sonneratia apetala*	1			+			+	+					
141. *Sterculia villosa*	2	+			+		+						
142. *Stereospermum suaveolens*	3	+		+									
143. *Swietenia mahagoni*	1	+										+	
144. *Syzygium grandis*	2		+							+			
145. *Tamarindus indica*	1	+		+	+		+	+					
146. *Tamarix dioica*	3			+							+		
147. *Tectona grandis*	1	+			+								c,bb
148. *Terminalia bellirica*	1	+			+		+	+					
149. *T. catappa*	2				+		+						
150. *T. chebula*	1				+		+						
151. *Toona ciliata*	1	+											bb
152. *Trema orientalis*	3	+		+				+					
153. *Vatica lanceaefolia*	3				+								rs
154. *Xanthophyllum flavescens*	3	+					+						
155. *Xylia kerrii*	2		+										c
156. *Xylocarpus granatum*	2				+								
157. *Zanthoxylum rhetsa*	3	+			+		+					+	
158. *Ziziphus mauritiana*	1	+		+			+	+					agi

VALUE: 1 = Species of current socioeconomic importance; 2= Species with clear potential of future value; 3 = Species of unknown value given present knowledge and technology

UTILIZATION: ti = timber production; po = posts, poles, roundwood; wo = fuelwood, charcoal; nw = non-wood products (gums, resins, oils, tannins, medicines, dyes, etc.); pu = pulp and paper; fo = food; fd = fodder; sh = shade, shelter; ag = agroforestry systems; so = soil and water conservators; am = amenity, antithetic, ethical values; **xx** other:** v = veneer; pw = plywood; cw = cartwheel; pb = particle board; c = construction work; k = Kapok; irs = railway sleepers; mb = mast of boat; p = planking; t = toys; n = novelties; d = decorative; tc = tea chest; va = varnish; agi = agricultural implements; bb = boat building; pc = packing cages; ab = agar batti; m = match splints and boxes; r = rubber

Appendix 2

Conservation and management of important FGR by ecogeographic zone in Bangladesh

Species in ecogeographic (or genecological) zones	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment, fields, trials
Hill Forest (Chittagong, Chittagong Hill Tracts, Sylhet)								
Artocarpus chaplasha	+	+	+		+			+
Swintonia floribunda	+	+	+					+
Dipterocarpus turbinatus	+	+	+		+			+
D. pilosus	+							
D. costatus	+							
D. gracilis	+							
Mesua ferrea							+	
Hopea odorata	+	+	+		+		+	+
Syzygium spp.		+	+		+			+
Calophyllum spp.	+							
Palaquium spp.	+							
Chukrasia tabularis	+	+	+		+			+
Ficus spp.	+							
Michelia champaca	+	+			+		+	+
Pterygota alata	+							
Lophopetalum fimbriatum	+							
Amoora spp.	+							
Dysoxylum spp.	+							
Albizia procera	+	+			+		+	+
A. lebbeck	+	+			+		+	+
A. chinensis	+	+			+		+	+
Gmelina arborea	+	+			+		+	+
Alstonia scholaris	+	+						
Toona ciliata	+	+					+	+
Quercus semiserrata	+							
Q. gomeziana	+							
Podocarpus neriloforcis	+							
Cassia fistula	+							
Phyllanthus emblica	+						+	+
Tetrameles nudiflora	+							
Bombax insigne	+							

Species in ecogeographic (or genecological) zones	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment, fields, trials
B. ceiba	+						+	
Duabanga grandiflora	+							
Lithocarpus elegans	+							
Castanopsis tribuloides	+							
Calophyllum polyanthum	+							
Macaranga spp.	+							
Terminalia bellirica	+							
Pterospermum acerifolium	+							
Diospyros embryopteris	+							
Sterculia villosa	+							
Garuga pinnata	+							
Meliosma pinnata	+							
Callicarpa macrophylla	+							
Vitex glabrata	+							
Saraca indica	+							
Elaeocarpus robustus	+							
Lagerstroemia spp.	+				+			+
Mitragyna parvifolia	+							
Calamus guruba	+				+			+
C. viminalis	+				+			+
C. latifolius	+				+			+
Daemonorops jenkinsanus	+				+			+
Melocanna baccifera	+				+			+
Dendrocalamus longispathus	+							+
D. hamiltonii	+							+
Neohouzeaua dullooa	+							+
Bambusa tulda	+							+
B. polymorpha	+							+
Melocalamus compactiforus	+							+
Oxytenanthera nigrocialata	+							+
B. vulgaris				+			+	+
Plainland Sal Forest (Comilla, Dhaka, Dinajpur)								
Shorea robusta	+							+
Terminalia bellirica	+							
T. chebula	+							

Species in ecogeographic (or genecological) zones	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment, fields, trials
Miliusa velutina	+							
Albizia procera	+				+			+
Dillenia pentagyna	+				+			+
Lagerstroemia spp.	+							
Garuga spp.	+							
Cassia fistula	+							
Phyllanthus emblica	+				+			+
Adina cordifolia	+							
Butea monosperma	+							
Careya arborea	+							
Schleichera oleosa	+							
Sterculia spp.	+							
Semecarpus anacardium	+							
Litsea polyantha	+							
Aphanamixis polystachya	+							
Microcos paniculata	+							
Littoral and Swamp Forest								
Casuarina equisetifolia					+			+
Calophyllum inophyllum	+							
Terminalia catappa	+						+	
Erythrina variegata	+							
Barringtonia spp.	+							
Hibiscus tiliaceus	+							
Thespesia populnea	+							
Vitex negundo	+							
Trewia nudiflora	+							
Dolichandrone spathacea	+							
Mangrove Forest (Sundarban and Coastal Forest)								
Heritiera fomes	+				+			+
Excoecaria agallocha	+				+			+
Sonneratia apetala	+				+			+
Avicennia officinalis	+				+			+
Xylocarpus granatum	+				+			+
Nipa fruticans	+				+			+

+ = Available

Appendix 3

Level and nature of threats to the integrity of species/populations of important tree species (Huq and Banik 1992; Khan 1991)

Species in ecogeographic (or genecological) zones	Nature reserves, prot. areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment fields, trials	Degree of threat index
1. *Aglaonema clarkei*	+								
2. *Aldrovanda vesiculosa*	+								
3. *Aquilaria agallocha*	+								
4. *Cirrhopetalum roxburghii*	+								
5. *Cymbopogon osmastonil*	+								
6. *Debregeasia dentata*	+								
7. *Elaeocarpus lucidus*	+								
8. *Hippocratea marcantha*	+								
9. *Homalium schlichil*	+								
10. *Justicia orephylla*	+								
11. *Knema benghalensis*	+								
12. *Limnophila cana* (endemic)	+								
13. *Mantisia spathutala* (endemic)	+								
14. *Marsdenia thyrsiflora*	+								
15. *Ophiorrhiza villosa*	+								
16. *Phrynium imbricum*	+								
17. *Quercus acuminata*	+								
18. *Rotala simpliciuscula* (endemic)	+								
19. *Semecarpus sulepanduriformis (endemic)*	+								
20. *Sonneratia griffithi*	+								
21. *Spatholobus listeri* (endemic)	+								
22. *Tournefortia roxburghii*	+								
23. *Typhonium listeu* (endemic)	+								
24. *Vatica scaphula* (endemic)	+								
25. *Vernonia thomsonii*	+								
26. *Adina cordifolia*	+								
27. *Aphanamixis polystachya*	+								
28. *Bassia latifolia*	+								

Species in ecogeographic (or genecological) zones	Nature reserves, prot. areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment fields, trials	Degree of threat index
29. *Bauhinia malabarica*	+								
30. *Castanopsis tribuloides*	+								
31. *Derris robusta*	+								
32. *Diospyros cordifolia*	+								
33. *Hydnocarpus kurzii*	+								
34. *Lophopetalum fimbriatum*	+								
35. *Mesua ferrea*	+								
36. *Mitragyna parvifolia*	+								
37. *Podocarpus neriifolius*	+								
38. *Pterospermum acerifolium*	+								
39. *Pterygota alata*	+								
40. *Schleichera oleosa*	+								
41. *Sterculia foetida*	+								
42. *Swintonia floribunda*	+								
43. *Tamarindus indica*	+								

+ = Available

Appendix 4

List of priority species for conservation, improvement or seed procurement, their uses and conservation activities needed

Species	End use				Operations / activities needed								REMARKS
	W	NW	FW	O	Exploration & collection		Evaluation		Conservation		Germplasm use		
	1	2	3	4	5	6	7	8	9	10	11	12	
1. *Acacia auriculiformis*	+		+					+		+		PVT	NGB
2. *A. catechu*		+		+					+	+			
3. *A. mangium*	+		+					+		+		PVT	NGB
4. *A. nilotica*	+	+	+	+					+	+			
5. *Albizia chinensis*	+		+										
6. *A. lebbeck*	+												
7. *A. procera*	+												
8. *Alstonia scholaris*				+									
9. *Anacardium occidentale*				+									
10. *Anthocephalus chinensis*	+			+									
11. *Artocarpus heterophyllus*	+		+	+					+				MPTS
12. *Azadirachta indica*	+	+	+	+					+				MPTS
13. *Bombax ceiba*				+									
14. *Cassia siamea*			+										
15. *Casuarina equisetifolia*			+										
16. *Ceiba pentandra*				+									
17. *Chukrasia velutina*	+		+										
18. *Dalbergia sissoo*	+		+	+									NGB
19. *Dipterocarpus turbinatus*	+	+											
20. *Elaeocarpus floribundus*				+									
21. *Eucalyptus alba*	+		+										
22. *E. camaldulensis*	+		+										
23. *E. brassina*	+		+									PVT	NGB
24. *E. tereticornis*	+		+									PVT	NGB
25. *E. urophylla*	+		+									PVT	NGB
26. *E. citriodora*	+		+									PVT	NGB
27. *Excoecaria agallocha*	+		+	+									
28. *Ficus benghalensis*			+	+									
29. *F. religiosa*			+	+									
30. *Gliricidia sepium*			+	+									
31. *Gmelina arborea*	+		+	+									
32. *Heritiera fomes*	+		+										

Species	End use				Operations / activities needed								REMARKS
	W	NW	FW	O	Exploration & collection		Evaluation		Conservation		Germplasm use		
	1	2	3	4	5	6	7	8	9	10	11	12	
33. *Hevea brasiliensis*	+	+	+										
34. *Hopea odorata*	+		+										
35. *Hydnocarpus kurzii*			+	+									
36. *Lagerstroemia speciosa*	+		+										
37. *Leucaena leucocephala*			+	+									
38. *Madhuca indica*	+	+	+	+									
39. *Mangifera indica*	+		+	+									
40. *Michelia champaca*	+		+										
41. *Paraserianthes falcataria*	+		+										
42. *Phyllanthus emblica*			+	+									
43. *Pinus caribaea*	+	+	+										
44. *Rhizophora mucronata*	+		+										
45. *Samanea saman*	+		+	+									
46. *Saraca asoca*			+	+									
47. *Sesbania grandiflora*			+	+									
48. *Shorea robusta*	+		+										
49. *Sonneratia apetala*	+		+										
50. *Swietenia mahagoni*	+		+										
51. *Syzygium grande*	+		+										
52. *Tamarindus indica*			+	+									
53. *Tectona grandis*	+												
54. *Terminalia bellirica*	+		+	+									
55. *T. chebula*	+		+	+									
56. *Toona ciliata*	+		+										
57. *Xylia kerrii*	+												
58. *Xylocarpus granatum*	+		+										
59. *Ziziphus mauritiana*			+	+									

End uses: 1 = Industrial wood products (logs, sawtimber, construction wood, plywood, chip and particle board, wood pulp etc.); **2 =** Industrial non-wood products (gums, resin, oils, tannins); **3 =** Fuelwood, posts, poles (firewood, charcoal, roundwood used on-farm, wood for carving); **4 =** Other uses, goods and services (food, medicinal use, fodder, land stabilization/amelioration, shade, shelter, environmental values).

Exploration & collection: 5 = Biological information (natural distribution, taxonomy, genecology, phenology etc.); **6 =** Collection of germplasm for evaluation

Evaluation: 7 = *In situ* (population studies); **8 =** *Ex situ* (provenance and progeny tests)

Conservation: 9 = *In situ*; **10 =** *Ex situ*

Reproductive use/germplasm use: 11 = Semi-bulk/bulk seedlots, reproductive materials; **12 =** Selection and improvement

Remarks (13): PVT = provenance trials; E = endangered at species or provenance level; PGT = progeny trials; MPTS = multi-purpose tree species; CLT = clonal trials; SO = seed orchard; NGB = narrow genetic base

Status of forest genetic resources conservation and management in India

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Introduction

Forests are the world's most important and most valuable renewable natural resource and also repositories of terrestrial biological diversity. This resource is in imminent danger due to adverse abiotic and biotic stresses resulting from urban expansion, infrastructural development, agriculture and global warming (Bawa and Dayanandan 1998; Brown and Pearce 1994; Stedman-Edwards 1998). Since forests are long-living, out-breeding, generally highly heterogeneous and found in variable environments, they have developed complex mechanisms to maintain high intraspecific diversity. It is well recognized that genetic variation is essential for species to evolve and adapt to changing environmental conditions. The sustained ability of forest trees to provide goods and services thus depends on the maintenance and management of forest genetic resources (FGR). Despite the enormous threats, there have been limited concentrated efforts to address the conservation concerns of forest trees. India, for example, though being an acknowledged leader in conservation of crop genetic resources, has no systematic programme for conservation of FGR. Among others, critical information on the status, threats and extent and distribution of genetic diversity are required for planning effective conservation strategies. Though the basic principles of conservation of FGR are conceptually rooted in our understanding of crop genetic resources, the challenge lies in breaking free from this legacy and formulation of specific protocols that suit tree species.

Status of forest genetic resources in India

India is one of the 12 centres of biological diversity in the world and the origin of several cultivated plants. It is estimated that about 45 000 species of plants occur in India, of which flowering plants account for 15 000 species. About 5000 of the flowering plants are endemic. The wild relatives of crop plants, together with other economically important species (about 150 species) are rich sources of many important and desirable characters and constitute a gene pool of potential use. The term FGR is used variedly and encloses a range of components from intraspecific diversity to inter-specific genetic diversity among a set of taxonomically and/or ecologically related species, to the entire range of forest species that are economically important and/or potentially useful (Young *et al.* 1999). It has been reported that in India there are about 6270 economically important species (Table 1).

Table 1. Economically important plant diversity in India as identified in the IV International Congress of Ethnobiology, Lucknow, India, 1994 (ICE 1994)

Economic uses	Number of species
Food	1200
Fodder	2200
Fuel and timber	1000
Medicines	1500
Fibre	150
Spices	120
Oil	100

N.B. It is likely that some of the species are being used for more than one purpose.

The rich traditions of modern scientific forest management began in 1864 under the British administration with the establishment of the Indian Forest Department. Since then, new forest policies have been issued in 1894, 1952, and 1988. In India the protection and improvement of the environment and the safeguarding of forest and wildlife is ensured under the directive of state policy Articles 48 A and 51 A (g), Part IV of the Constitution. The Constitution directs citizens to protect nature and also provides for forests and wildlife as concurrent subjects under Schedule 8, List III, and Entry 17-A and 17-B.

A large segment of India's population depends on forests for energy, housing materials, timber and fodder. The demand for forest products and services in the country is increasing with the rapid economic growth and increase in population whereas the forested area in the country is declining (Myers *et al.* 2000). According to the projections of the United Nations, India is expected to be the most populous country in the world by 2020. Both urban and rural population will continue to grow, this factor will be important from the point of view of forestry and genetic conservation. India has 2% of the world's land area, 1% of its forests and 0.5% of its rangelands but supports 16% of the human population and 15% of world's cattle population (Ahmed 1997). The increased demand for forest products, along with population growth and poverty is putting a great pressure on all natural resources, including forests.

In the economic sphere, India is undergoing a profound change. It has moved from a slow-growing to a very dynamic economy. By 2020, the per capita income in South Asia is expected to rise from US$350 in 1995 to US$830. This will greatly change the demand for all products, including forest products and services. India is short of forest resources and the current roundwood supply shortfall of 26 million m^3 annually is expected to remain in the foreseeable future (Ganguli 2000).

According to Ahmed (1997), the total annual value of India's forest products is estimated to be Rs 300 000 million (about US$ 6662 million) compared to the meagre investments of Rs 8000 million (US$ 176 million) in this sector. Indian forests contribute significantly to meet the demand for fuelwood, fodder and non-wood forest products and the major portion of all wood harvested (92%) is for fuelwood for cooking.

The non-timber forest products (NTFPs) play a very important role in the country's economy. They form the basic raw material for phytopharmaceuticals and various other industries. Herbal medicines in use today are derived from nearly 8200 species of medicinal plants. In the developing countries, more than 80% of the population depends on traditional plant-based medicines, and even in the USA, 25% of the prescription drugs are still based on phytochemicals. NTFPs offer an excellent potential for international trade. Ahmed (1997) reported eight different categories of NTFPs; some are important for tribal indigenous groups. For example, in West Bengal tribal groups collect 27 plants for commercial products, 39 plants for food, and 47 for medicines. NTFPs account for 70% of India's forest product exports and the demand for phytochemicals is expected to increase in the future. NTFPs could become a new frontier for trade and sustainable commercialization of biological resources at the international level if intellectual property rights are secured.

National conservation programmes and management of FGR

Many countries have national policies or special programmes for the conservation of biological diversity, including forest biological diversity and FGR. 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 (CBD), 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 them in a sustainable manner. The CBD relates to 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 protection of rare and endangered species and populations, as well as regulations governing seed collection and transfer in socioeconomically important tree species to comprehensive approaches to the management of landscapes, ecosystems and FGR. 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 (Biodiversity Bill 2002).

The management of an appropriate combination of genetic resources in various locations under diverse environmental and silvicultural practices, such as provenance trails and progeny trials, is considered to be the most efficient way to conserve various levels of genetic variation to increase the productivity. However, it takes relatively long time to evaluate and identify the provenances suitable for conservation. However, most often genetic conservation has to be carried out without a real understanding of the genetic background of the populations and depends on population genetic models. In Indian forest ecosystems, some economically important forest tree species have been conserved in genebanks, *in situ* and *ex situ* conservation sites with wide networking between the state forest departments. National parks (87) and other protected areas in the form of biosphere reserves (12) and wildlife sanctuaries (421), which have been regarded as *in situ* conservation and management of FGR at the species level (Tables 2 and 3).

Table 2. Biosphere reserves in India (FSI 2001)

Name of Biosphere reserve	State/Union Territory	Area (km^2)
Great Nicobar	Andaman Nicobar (A&N)	885.0
Manas	Assam	2837.0
Nanda Devi	Uttaranchal	2236.7
Nilgiri	Tamil Nadu, Kerala and Karnataka	5520.0
Nokrek	Meghalaya	820.0
Sunderbans	West Bengal	9630.0
Dibru-Saikhowa	Assam	765.0
Dehang-Debang	Arunachal Pradesh	5111.5
Gulf of Mannar	Tamil Nadu	10500.0
Pachmarhi	Madhya Pradesh	4926.3
Simlipal	Orissa	4374.0
Khangchendzonga (proposed)	Sikkim	2655.3
Agasthyamalai	Kerala	1701.0

Table 3. National parks and wildlife sanctuaries in India (FSI 2001; Rodegers and Panwar 1986)

States	National parks		Wildlife sanctuaries		Total area (km^2)
	Number	Area (km^2)	Number	Area (km^2)	
Andhra Pradesh	4	3314.5	21	12 530.1	15 844.6
Arunachal Pradesh	2	2468.2	10	7114.5	9582.7
Assam	3	1173.7	13	939.9	2113.6
Bihar	2	567.3	21	3890.3	4457.6
Chattisgarh	3	n.a.	n.a.	n.a.	n.a.
Delhi	0	0	1	27.6	27.6
Goa	1	107.0	6	648.0	755.0
Gujarat	4	479.7	21	16 422.7	16 902.4
Haryana	1	1.4	9	278.3	279.8
Himachal Pradesh	2	1429.4	32	5736.9	7166.3
Jammu & Kashmir	4	4650.1	16	10 172.2	14 822.2
Jharkahnd	1	n.a.	n.a.	n.a.	n.a.
Karnataka	5	2472.2	20	3930.6	6402.8
Kerala	3	536.5	12	2143.4	2679.9
Madhya Pradesh	11	6474.7	35	10 704.1	17 178.7
Maharashtra	5	955.9	33	14 387.8	15 343.7
Manipur	2	81.8	1	184.9	266.6
Meghalaya	2	267.5	3	34.2	301.7
Mizoram	2	250.0	4	634.0	884.0

States	National parks		Wildlife sanctuaries		Total area (km^2)
	Number	Area (km^2)	Number	Area (km^2)	
Nagaland	1	202.0	3	24.4	226.4
Orissa	2	990.7	18	6971.2	7961.9
Punjab	n.a.	0	11	317.8	317.8
Rajasthan	4	3856.5	24	5712.8	9569.4
Sikkim	1	1784.0	5	265.1	2049.1
Tamil Nadu	5	307.9	20	2602.1	2909.9
Tripura	n.a.	0	4	603.6	603.6
Uttranchal	6	n.a.	n.a.	n.a.	n.a.
Uttar Pradesh	7	5410.8	29	7594.5	13 005.4
West Bengal	5	1692.7	16	1103.5	2796.1
A&N Islands	9	1157.1	94	372.1	1 529.3
Chandigarh	0	0	2	26.0	26.0
Dadra & Nagar Haveli	0	0	0	0	0
Daman & Diu	0	0	1	2.2	2.2
Lakshadweep	0	0	0	0	0
Pondicherry	0	0	0	0	0
Total	**87**	**40 631.6**	**485**	**115 374.4**	**156 006.1**

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

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

The National Bureau of Plant Genetic Resources (an independent national institute) has been working to introduce, collect and conserve plant genetic resources of mainly agricultural and horticultural species in India since 1976. Taking into consideration legal, political, economic and social issues, management of PGR has to be stratified, as these resources are imperative to sustainable development globally. 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. ICFRE caters to the needs of different biogeographical regions of the nation to increase the productivity through genetic and silvicultural improvement, treatment of wasteland and conservation of forest ecosystems. ICFRE has expertise and research collaboration with Danida and collaborative ventures with various international organizations, such as FAO, FORTIP (UNDP/FAO Regional Forest Tree Improvement Project), UNDP and World Bank on economically important species. ICFRE established a National Bureau of Forest Genetic Resources (NBFGR) with a wide network of regional institutes situated at various agroecological zones for germplasm collection, *ex situ* and *in situ* conservation as well as introduction and evaluation.

To reach the desired goals, the following priority areas for research have been identified (NFRP 2001):

- Develop mitigation strategies in forestry sector to reduce and store green house gases
- Research on upland watershed management (integrated soil and water conservation to check siltation and water scarcity and to boost afforestation)
- Research on reforestation of degraded lands and problematic soils (barren, mined, waste, water-logged and salt-affected lands, etc)
- Research on conservation, protection and sustainable development of existing forests to conserve biodiversity

- Increasing productivity of existing forests and future plantations through:
- High quality seed production
- Production and multiplication of site matched planting stock
- Improvement of species and varieties using traditional breeding methods and biotechnology
- Biological rejuvenation of lands using mycorrhizae and other useful microorganisms
- Research on multipurpose trees in farming systems
- Research on improved utilization of traditional wood and paper products, including improved recovery and processing
- Research on non-wood forest products, which provide sustenance to people and supply raw materials to a large number of forest-based industries
- Research on modern tools, equipment, techniques and operations for afforestation, logging and extraction of forest products
- Protection of forest from entomological and pathological problems
- Socioeconomic research for motivating farmers/land owners to adopt tree farming in a manner similar to crop-based farming

Research on policy strategies and combination of measures desired for enlarging the area under forest has included studies on property rights and land tenure, culture and gender issues involved in 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.

International Forest Genetic Resource Programme

ICFRE has established a National Bureau of Forest Genetic Resources (NBFGR) under its International Genetic Resource Programme, along the lines of the National Bureau of Plant Genetics Resources (NBPGR). ICFRE is managing the collection, documentation, evaluation and use of tree genetic resources available in India. ICFRE has established a similar line of action as established by the NBPGR, FAO, CIRAD, Danida, DFSC, FRED, FORTIP, World Bank-project and UNDP in promoting FGR research activities in India. ICFRE is interacting with various international organizations, such as the International Plant Genetic Resources Institute (IPGRI) on specific issues related to FGR conservation.

Present level of production and use of genetically superior propagules

Though various tree species are planted every year, 90% of the plantation programmes consist of bamboos, *Eucalyptus, Acacia, Albizia, Prosopis juliflora, P. cineraria, Dalbergia sissoo*, conifers and teak. During the late eighties and early nineties, $3x10^9$ plants were planted annually. Of these, a certain percentage of seeds were obtained from seed production areas (SPAs). There are 3100 ha of SPAs for teak and an additional 900 ha of clonal seed orchard (CSOs) for teak. The seeds from these can supply 30–35% of the demand.

Similarly, nearly 8000 ha of conifer seed stands have been identified (not seed production areas). There are 24.6 ha of SPAs for *Dalbergia sissoo* available and 91 ha for eucalypts. For various other species, for which there is only limited local demand, seeds are collected from respective SPAs. An estimated 155 000 kg of teak seeds are available from the 3100 ha SPA for teak annually. With germination of 35% and survival of 60%, a little over 16 000 ha can be planted with these seeds. The CSOs produce much less than the expected amount per tree. Often many clones flower at different times resulting in poor seed set. On average, 30 kg of seeds are collected per ha. From the 900 ha of CSOs of teak in the country, 27 000 kg of seeds are collected which are sufficient for planting of 3000 ha with 30% germination and 60% survival. While establishing CSOs, it is essential to consider the need for synchronous flowering.

For *Dalbergia sissoo*, around 300 kg of seeds can be obtained from the 24 ha of SPAs, which is sufficient to plant 9000 ha. There are 90 ha of SPAs for eucalypts providing 450kg of seeds sufficient to plant 40 000 ha. The work done on conifers is not reliable as most of the areas classified as seed stands are unculled. The seed yield varies highly from tree to tree. In the case of bamboo, a large amount of seeds is collected, but these cannot be classified as superior seeds. They are collected in bulk when the entire plantation flowers, as for many years there may not be any collections at all.

It is obvious from the above that teak is the single most important species collected from SPAs. Significant quantities of eucalypts and *Dalbergia sissoo* are also available. The annual planting of tree seedlings in the country exceeds 3020 million seedlings with 180 million seedlings originating from SPAs; majority of the planted species being teak, *Dalbergia sissoo* and eucalypts.

Future requirements for superior propagules

Being a vast country with varying climatic and edaphic conditions, India has a variety of vegetation types. The cultural diversity coupled with traditional practices has made the people highly dependent on various types of local vegetation. Therefore, preferences for different species vary considerably. This results in a dilemma in the species choice, especially when the sociological aspects are taken into consideration. Various state forest departments have developed strategies to grow species taking into consideration local requirements, in addition to other species that are required in large amount. The current annual rate of planting of social forestry species is around 1.5 million ha and the number of seedlings planted is approximately 3000 million. The future annual planting target is expected to be little over 3 million ha, consisting mainly of bamboos, *Eucalyptus, Acacia, Albizia, Prosopis, Casuarina, Dalbergia,* conifers and teak. The projected annual requirement of tree seedlings is 6160 million, of which around 23.5% is expected to be raised from SPAs of certified seed sources and around 15% is expected to be raised from genetically improved sources. Fifty per cent of the teak seeds will be coming from SPAs and 25% from genetically improved stock. Likewise, about 25% of future *Eucalyptus* seeds is expected to be provided as genetically improved stock. In the case of *Acacias* and *Albizia*, not less than 30% of seeds will be collected from identified/certified seed sources. In the case of *Casuarina* and *Dalbergia sissoo*, 20 and 10%, respectively, will be made available from genetically improved plants. It is possible that the amount of seeds of these two species available from the genetically improved plants may be doubled as a result of a tree improvement programme. In the case of conifers, however, only 20% of the seeds would be collected from the SPAs and the supply of genetically improved seeds may not be more than 2% (Table 4).

Table 4. Projected quantity of seeds needed for tree planting activities in India, including improved seeds (all figures in kilograms, percentages are in parentheses)

Species	Seeds from SPA	Genetically improved seeds	Seeds by conventional practice	Total seeds
Eucalyptus spp.	650 (18.5%)	875 (25%)	1975 (56.5%)	3500
Acacias	88 800 (30%)	29 600 (10%)	177 600 (60%)	296 000
Albizia spp.	48 860 (30%)	15 620 (10%)	93 720 (60%)	156 200
Casuarina equisetifolia	114 (20%)	114 (20%)	342 (60%)	570
Dalbergia sissoo	412 (10%)	412 (10%)	3 303 (80%)	4 1276
Conifers	16 660 (20%)	1670 (2%)	64 970 (78%)	83 300
Tectona grandis	228 570 (50%)	114 285 (25%)	114 285 (25%)	457 140

Research and development in genetic resources

With a view to improve the productivity and profitability of planting forest species and offering an attractive land use option, many State Forest Departments have established SPAs, CSOs, seedling seed orchards (SSOs), vegetative multiplication gardens (VMGs) and modern nurseries in consultation with ICFRE for production of quality planting stock material. For example, Andhra Pradesh Forest Department has raised 10 438.8 ha of *Eucalyptus* plantations in different districts using superior quality clones.

ICFRE has also implemented a major research and development project to improve the productivity of *Casuarina*, poplar, teak and eucalypts in a short time span through the application of vegetative propagation and cloning techniques with the existing useful variation as well as development and deployment of locality-specific, high-yielding, forest-growing and disease-resistant clones (Sharma *et al.* 2002). The adopted methodology includes selection of candidate plus trees (CPTs) with most desirable qualities and cloning of the CPTs through rooting of juvenile coppice shoots under controlled environment in the green house.

In order to develop better clones than what is available presently 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. These include:

- Selection of candidate plus trees for cloning, for development and deployment of new clones for various species.
- Development of intra–specific hybrids through controlled pollination between clones.
- Development of clonal seed orchards for production of improved genetically superior seed for future plantations.
- Further improvement of technical packages of practices for field plantations and clonal nurseries.

Tree improvement work in India began as early as in the 1960s. It got an impetus with the formation of ICFRE. One of the mandates of the Council is to increase the productivity of forests from 0.7 $m^3 ha^{-1}a^{-1}$ to at least 2.5 $m^3 ha^{-1}a^{-1}$. The ICFRE institutes have defined suitable species and strategies in collaboration with State Forest Departments and State Forest Research Wings for various states (Table 5).

Table 5. Priority species for different states for the Planting Stock Improvement Programme

State	Coordinating institute	Priority species for the establishment of...			
		Seed production areas (SPA)	Clonal seed orchards	Seedling seed orchards	Vegetative multiplication gardens
UP, Haryana & Punjab	FRI, Dehra Dun	*Dalbergia sissoo* *Eucalyptus tereticornis* *Pinus roxburghii*	*D. sissoo* *E. tereticornis* *P. roxburghii*	*D. sissoo* *E. tereticornis* *P. roxburghii*	*E. tereticornis* *P. roxburghii*
TN, Kerala, A. & Nicobar	IFGTB, Coimbatore	*Eucalyptus* spp. *Acacia* spp. *Tectona grandis*	*Eucalyptus* spp. *Casuarina* spp. *T. grandis*	*Eucalyptus* spp. *Casuarina* spp. *T. grandis*	*Eucalyptus* spp. *Casuarina* spp. *T. grandis*
Karnataka & Andhra Pradesh	IWST, Bangalore	*T. grandis* *Eucalyptus camaldulensis* *Casuarina* spp.	*Eucalyptus* spp. *T. grandis* *Casuarina* spp.	*Eucalyptus* spp. *T. grandis* *Casuarina* spp.	*T. grandis* Bamboo
MP, Maharashtra & Orissa	TFRI, Jabalpur	*T. grandis* *Casuarina equisetifolia*	*T. grandis* *Casuarina* spp. *Albizia procera* Bamboo	*T. grandis* *Casuarina* spp. *Albizia procera* Bamboo	*T. grandis* *Casuarina* spp. *Albizia procera* Bamboo
Rajasthan Gujarat	AFRI, Jodhpur	*T. grandis* *D. sissoo* *Acacia nilotica* *Eucalyptus* spp.	*T. grandis* *D. sissoo* *Acacia nilotica* *Eucalyptus* spp.	*D. sissoo* *Acacia nilotica* *Eucalyptus* spp.	*D. sissoo* *Eucalyptus* spp.
J&K Himachal Pradesh	HFRI, Shimla	*Pinus roxburghii*	*D. sissoo* *Pinus* spp.	*D. sissoo* *Pinus* spp.	*D. sissoo* *Populus* spp.
UP	ISF&ER, Allahabad	*D. sissoo*	*Eucalyptus* spp.	*Acacia* spp. *D. sissoo*	*T. grandis* *Eucalyptus* spp.
Bihar, Orissa W.B.	IFP, Ranchi	*Acacia auriculiformis*	*Eucalyptus* spp.	*Acacia* spp. *Eucalyptus* spp. *D. sissoo* *Gmelina arborea*	*Eucalyptus* spp. *Paulownia* spp. *Gmelina arborea* Bamboo

ICFRE has established the following SPAs, CSOs, SSOs and VMGs of various species in different parts of the country (Table 6).

Table 6. State-wise planting stock improvement areas for priority species under ICFRE (areas in hectares)

State	Coordinating institute	Seed production areas (SPA)	Clonal seed orchards (CSO)	Seedling seed orchards (SSO)	Vegetative multiplication gardens (VMG)
UP, Haryana & Punjab	FRI, Dehra Dun	181.8	28.0	25.2	4.1
TN, Kerala, A. & Nicobar	IFGTB, Coimbatore	82.3	27.7	38.3	13.0
Karnataka & Andhra Pradesh	IWST, Bangalore	120.0	12.0	34.0	6.0
MP, Maharashtra & Orissa	TFRI, Jabalpur	425.0	41.0	83.5	10.0
Rajasthan, Gujarat	AFRI, Jodhpur	200.0	29.0	55.0	5.0
States of N-E	IRMDFR, Jorhat	24.0	5.0	60.0	10.0
J&K Himachal Pradesh	HFRI, Shimla	32.5	12.8	6.0	6.0
UP	ISFER, Allahabad	60.0	8.0	12.0	2.0
Bihar, Orissa W.B.	IFP, Ranchi	100.0	3.0	30.5	0.0

Provenance trials

The first provenance trials for two important native species *viz. Tectona grandis* and *Pinus roxburghii* were initiated by Prof. M. L. Laurie and Sir Harry Champion, respectively, during the time when they were silviculturists at the FRI, Dehradun. Provenance trials of teak were established during 1928–30 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,* etc. 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 systematised during the last five years by ICFRE. Different institutes conducted both national and international provenance trials in collaboration with the State Forest Departments and international agencies. The details are given in Table 7.

Table 7. Provenance trials established by ICFRE

Species	States of India					
	U.P., Punjab & Haryana	T.N., Kerala & A&N Land	M.P., Maharashtra, Orissa & Goa	Rajasthan, Gujarat, & D&N	Karnataka, A.P., A&N	Bihar, W.B. & Orissa
Acacia nilotica	27	34	46	14	–	–
Azadirachta indica	–	–	26	19	–	–
Pinus roxburghii	23	–	–	–	–	–
Dalbergia sissoo	31	–	10	10	–	–
Prosopis cineraria	6	–	–	–	–	–
Casuarina equisetifolia	–	40	–	–	–	–
Eucalyptus grandis	–	17	–	–	–	10
E. tereticornis	–	5	4	–	–	–
E. camaldulensis	–	13	16	–	–	15
E. microtheca	–	20	–	–	–	–
Albizia lebbeck	–	13	–	–	–	–
Acacia mangium	–	–	13	–	–	–
Santalum album	–	–	9	–	–	–
Acacia procera	–	–	11	–	–	–
Pongamia pinnata	–	–	7	–	–	–
Jatropha curcus	–	–	25	–	–	–
Dendrocalamus strictus	–	–	11	–	–	–
Tecomella undulata	–	–	–	13	–	–
Gmelina arborea	32	–	–	13	–	–

Plus trees

The selection of plus trees was done with the help of the State Forest Departments. The ICFRE institutes maintain plus tree registers for different species. The largest number of plus trees was for teak followed by *D. sissoo, P. roxburghii*, *C. equisetifolia* and *A. indica* (neem) (Table 8).

Table 8. Details of plus trees selected in various states

Species	States of India				
	U.P., Punjab & Harayana	T.N., Kerala & A&N Land	M.P., Maharashtra Orissa & Goa	Rajasthan Gujarat & D&N	Karnataka, A.P., A&N
Azadirachta indica	47	40	–	–	–
Dalbergia sissoo	130	–	43	–	–
Casuarina equisetifolia		91	–	–	–
Tectona grandis	–	53	330	–	50
Eucalyptus tereticornis	–	42	–	–	–
Dalbergia latifolia	–	–	15	–	–
Tecomella undulata	–	–	–	15	–
Acacia nilotica	–	–	–	4	–
Prosopis cineraria	–	–	–	6	–
Acacia tortilis	–	–	–	8	–
Pinus roxburghii	97	–	–	–	–

Seed orchards

Seed orchards contribute greatly to the production of quality planting stock of the desired species. A clonal teak seed orchard established at Walayar, Kerala consists of 20 superior genotypes from Tamil Nadu, Kerala and Andra Pradesh, and is providing superior seeds for improvement programmes. Similarly, a clonal seed orchard of *Tectona grandis* consisting of 80 clones collected from superior genotypes from different states and seed orchards of *Bombax ceiba*, *Casuarina equisetifolia* and bamboos have been established at the Tropical Forest Research Institute (TFRI), Jabalpur. An excellent clonal seed orchard for sandal (*Santalum album*) has been established at Gottipura by the Institute of Wood Science & Technology (IWST), Bangalore. The seeds are made available to progressive planters and also used for development of demonstration plantation of sandal. Seed orchards established in different states are shown in Table 6.

Seed production areas

Much of the work with seed production areas is on teak with over 3000 ha established by the close collaboration between different State Forest Departments and ICFRE institutions. Different institutions have developed methods for demarcation and selection of trees in the SPAs so that trees with desirable characteristics are retained. The method for establishment of SPAs has been developed by ICFRE and the details provided to the State Forest Departments. State-wise information about seed production areas is given in Table 6 and Appendix 1.

Vegetative propagation and establishment of clonal banks

Vegetative propagation is an effective method for tree improvement as it could capture both additive and non-additive genetic variances. By using vegetative propagation techniques, it is possible to produce plants and quickly establish clonal banks, provided the plants are not recalcitrant to rooting and plageotropism in growth. Use of juvenile material or inducing juvenility in adult material greatly contributes to the success of establishing clonal lines. Different ICFRE institutes have developed a vegetative propagation technique for a number of economically important species for establishment of a clonal bank and for mass multiplication. The details of species have been presented in Table 5. Currently, ICFRE is able to produce and supply good quality planting stock of *D. sissoo*, *E. tereticornis*, *E. camaldulensis*, *C. equisetifolia*, poplars and *Tectona grandis.* In addition, ICFRE is continuously adding more and more clones with defined characteristics and is also exchanging clonal material with various State Forest Departments.

Tissue culture for mass propagation

Research on tissue culture of trees was initiated in late 1970s with emphasis on teak and eucalypts for which protocols were developed. The institutes under ICFRE have taken up a number of species for mass multiplication through tissue culture, to produce adequate number of good quality planting stock material. Studies were also conducted on mass multiplication of different bamboos, including edible bamboos, and several thousands of plantlets have been transferred to the field. The technique is used in conjunction with selection strategies so that the material produced is of high quality.

Seed bank and seed exchange

The programme for the production of quality planting stock involved tree selection, seed collecting, storage and distribution, not only within the region but also to other regions where the species was of interest. Seed exchange is already in progress for neem, *Casuarina*, eucalypts and bamboos. ICFRE institutes have developed modern techniques for genetic conservation to improve the planting stock, such as storage of seeds, pollen, storage by *in-vitro* methods, growth limitation, cryopreservation and use of molecular biological methods. Seed certification is done for transportation of seeds within and outside the country. Seed certification is designed to ensure that the seed for sale is of the right variety and of good quality. Thus, legislation on seed certification has been adopted, however mostly for agriculture seeds. There is a need to develop such mechanism for forestry seeds.

Access to genetic resources

Plant Breeders' rights

In India, Plant Breeders' rights legislation that rewards the providers of genetic resources is being implemented in agriculture. India has phytosanitary regulations only for PGRFA (Plant genetic resources for food and agriculture), which are often poorly understood, inadequately developed and implemented or non-existent for forestry related activities. There is a general need to review and assess existing laws and adapt them or to develop new ones in line with specific needs. There is also a general need to harmonize the national legislation, especially concerning access to FGR and intellectual property rights (IPR). International legal assistance is required to draft suitable legislation covering IPR for forestry varieties in line with international agreements and national needs.

With its expertise and as a notified agency for seed, ICFRE could link phytosanitary certification with other aspects of legal regulations related to FGR. ICFRE may also deal with seed quarantine, seed technology, seed movement regulation and legal aspects. It may also be vital to develop a Forest Tree Seed Corporation (FTSC), which will not only help producing large quantities of improved seed material but also systemise the forest tree seed production, collection, handling, storage and export in large scale, and also conserve the biological diversity of the genetic resources.

Acts of the Government

Based on the recommendations of the 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 regulate the natural resources:

Forest Acts

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

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 87 national parks and 421 wildlife sanctuaries, wetlands and a network of biosphere reserves.

Status of medicinal plants in India

In India, medicinal plants are widely used by all sections of the population and it has been estimated that, in total 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 forest product exports and the demand for phytochemicals is expected to increase in 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 9).

Table 9. Medicinal plants: species diversity and representative species of different biogeographic zones of India (Ved *et al.* 2001)

Biogeographic region	Estimated no. of medicinal plants	Examples of some typical medicinal species
Trans-Himalayas	700	*Ephedra geradiana*, *Hippophae rhamnoides*, *Arnebia euchroma*
Himalayan	2500	*Aconitum heterophyllum, Ferula jaeshkeana, Saussurea costus*, *Nardostachys grandiflora*, *Taxus wallichiana*, *Rhododendron anthopogon* and *Ponax pseudoginseng*
Desert	500	*Convolvulus microphyllus*, *Tecomella undulata*, *Citrulus colocynthis* and *Cressa crertica*
Semi-arid	1000	*Commiphora wightii*, *Caesalpinia bonduc*, *Balanites aegyptiaca* and *Tribulus rajasthanensis*
Western Ghats	2000	*Myristica malabarica*, *Garcinia indica*, *Utleria salicifolia* and *Vateria indica*
Deccan Peninsula	3000	*Pterocarpus santalinus*, *Decalepis hamiltonii*, *Terminalia pallida* and *Shorea tumbuggaia*
Gangetic Plain	1000	*Holarrhenaq pubescens*, *Mallotus philippensis*, *Pluchea lanceolata* and *Peganum harmala*
Northeast India	2000	*Aquilaria malaccensis*, *Smilax glabra*, *Ambroma augusts* and *Hydnocarpus hurzii*
Islands	1000	*Claophyllum inophyllum, Adnanthera pavonina*, *Barringtonia asiatica* and *Aisandra butyracea*
Coasts	500	*Rhizophora mucronata*, *Acanthus ilicifolius*, *Avicennia marina* and *Sonneratia caseolaris*

Exploration for 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 a very small number of species are cultivated. According to the data compiled by the International Trade Centre, Geneva, India is ranked second amongst the exporting countries, after China, with an annual export of 326 000 tonnes with a value of Rs 45.95 million (about US$ 1.4 million) during 1992–95. 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 (Ved 1997; Ved *et al*. 2001) has projected the turnover of the herbal industry in India to be Rs 4000 million (about US$ 88 million) for the year 2000. 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 from the wild. To meet the demands of the Indian herbal industry, which has an annual turnover of about US$ 300 million medicinal plants are being harvested every year from some of 165 000 ha of forests (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, Dendrobium 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 kurroa, Costus speciosus, Berberis aristata, Gloriosa superba*, etc.

The Medicinal Plant Specialist Group met in September 1996 in Nairobi and resolved to identify the 'Top 50' medicinal plant species for conservation. The Group listed five steps to identify both global and regional priority species. The Indian Subcontinent Plant

Specialist Group that met in January 1998 identified the following species of medicinal plants for detailed study and protection: *Abrus precatorius, Adhatoda vasica, Centella asiatica, Costus speciosus, Gloriosa superba, Rauvolfia serpentina, Saraca asoca, Streblus asper, Tribulus terrestris* and *Withania somnifera*.

State Forest Departments (SFDs) of Andhra Pradesh, Karnataka, Kerala, Tamil Nadu and Maharashtra, in consultation with the Foundation for Revitalisation of Local Health Traditions (FRLHT) and with the support of Danida and UNDP have established 54 forest genebank sites called Medicinal Plant Conservation Areas (MPCA). The network of 54 MPCAs, measuring 200 ha to 500 ha each, has been established gradually since 1993 and represents all forest types with large bio-climatic and soil regime variation. These gene banks harbour 45% of recorded populations of flowering and medicinal plants of Peninsular India, including 70% of the red-listed. The intra-specific diversity, i.e. germplasm conserved in the MPCA network can be used to provide authenticated quality planting material for commercial cultivation to meet rising demands of the herbal industry. MPCAs also constitute 'study sites' for threatened species recovery research. MPCAs have proved crucial in capacity building of forestry staff, local communities and researchers in the conservation of medicinal plants for sustainable use and equitable benefit sharing. This experience can help in implementing plans and programmes under the Biological Diversity Act 2002, National Biodiversity Strategy and Action Plan (NBSAP) and Medicinal Plants Board. Various states have established Medicinal Plants Boards to improve the status of existing medicinal plants in their respective areas either by *in situ* or *ex situ* conservation.

Conservation and cultivation strategies for medicinal plants

Since the beginning of this century, more than half of the world's tropical forest area has 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. Institutes of ICFRE have established herbaria and medicinal plant gardens and developed packages for 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 of India, the country needs to establish a network of forest sites across the biogeographic regions of the country. However, a network of *in situ* (field) genebanks, in the forest habitats is the most cost-effective way to manage the intra- and interspecific diversity. Various institutes under ICFRE are working on specific species for the conservation of germplasm.

Bamboo diversity in India

India is the second richest country in bamboo genetic resources after China. These two countries together have more than half the total bamboo resources globally. Sharma (1987) reported 136 species of bamboos occurring in India. Fifty-eight species of bamboo belonging to 10 genera are distributed in the northeastern states alone. The forest area, over which bamboos occur in India, on a conservative estimate, is 9.57 million ha, which constitutes about 12.8% of the total area under forests (Bahadur and Verma 1980). Out of the 22 genera in India, 19 are indigenous and three exotic. The annual production of bamboo in India is about 4.6 million tonnes; about 1.9 million tonnes is used by the pulp industries. The annual yield of bamboo per hectare varies between 0.2 and 0.4 tonnes with an average of 0.33 tonnes per hectare, depending upon the intensity of stocking and biotic interferences. The economic impact of the agroforestry-based bamboo system may influence general economic development considerably. On average, 250 air-dried culms weigh one tonne and the price per tonne of dry bamboo is Rs 1000 (auction rate) (about US$ 22).

Need for collection and conservation of germplasm

With the increasing population pressure, natural stands of bamboo are being indiscriminately cut for fuelwood and furniture. The common practice of 'jhum' (a form of shifting cultivation) cultivation in the northeastern states has resulted in genetic erosion of several bamboo species; overexploitation of some species for fuelwood and for the cottage industry has endangered others. Since natural variation is the genetic resource base required for selection and improvement, conservation of available genetic resource needs to be accorded the highest priority (Rao and Ramanatha Rao 2000). Efforts have been taken by the NBPGR, New Delhi and its stations in Trichur, Shillong and Ranchi, ICFRE and ICAR (Indian Council of Agricultural Research) to collect and build up genetic diversity of bamboo for evaluation and maintenance.

Strategies for conservation

Large areas where bamboos occur have been declared as National Bamboo Reserve areas and provenances in the natural habitats are being maintained. Considering the limitation in seed supply, vegetative methods for *ex situ* conservation and tissue culture work have been started in Asian countries. The excellent work on bamboo micropropagation by Mehta *et al.* (1982) in Delhi University using seeds of *Bambusa arundinacea* resulted in callus, which differentiated into many embryiods. These regenerated into plantlets *in vitro*. This has laid the foundation for bamboo micropropagation and *in vitro* conservation, as it is a quick method with high multiplication rate. ICFRE has perfected the macropropagation techniques for bamboo and transferred them to users for mass multiplication. The Kerala Forest Research Institute (KFRI) at Kerala has established a Bamboo Information Centre (BIC) for disseminating all relevant information on 137 species Indian bamboo. State-wise growing stock, area and distribution of bamboo are given in Tables 10, 11 and 12.

ICFRE has taken up the systematic research on bamboo under its various research institutes at different agroecological regions of the country. The work is coordinated by the Chief Technical Adviser with the main objective to work on quick-growing annual, biennial and perennial bamboos suitable for the cottage and paper industries.

Table 10. State-wise bamboo growing stock and potential yield (FSI 1995)

States/ Union territories	Bamboo crop ('000 m^3)	Bamboos (no.) 1994–95	1995–96
Andhra Pradesh	652	143 573	83 732
Assam	6 558	409 877	n.a.
Bihar *	1 621	6 691	8 125
Goa	–	21 000	10 000
Gujarat	–	50 006	12 636
Haryana	–	678 125	1 423 590
Karnataka	49	33 618	59 504
Kerala	–	1 596 297	1 339 741
Madhya Pradesh	–	284 143	–
Maharastra	5156	300 989	245 910
Manipur	3081	810 950	900 865
Meghalaya	11 795	–	–
Nagaland	1 077	–	–
Mizoram	2 452	1 097 344	1 277 525
Orissa	6 574	–	217 802
Punjab	–	165 743	151 357
Rajasthan	–	165 743	151 357
Tamil Nadu	n.a.	1 410	1 154
Tripura	510	544	695
Uttar Pradesh	579	208 675	185 851
West Bengal	n.a.	9 950	10 550
A&N Islands	n.a.	1 661 665	2 068 352

* Bamboos in metric tonnes

Table 11. Area under bamboo in India (FSI 2001)

States/Union territories (year of inventory)	Bamboo area (km^2)
Andhra Pradesh (1968–74)	6598
Arunachal Pradesh (1985–90)	4590
Assam (1988–90)	8213
Bihar (1971–74)	795
Goa, Daman & Diu	249
Gujarat (1977–78)	2806
Haryana	42
Himachal Pradesh (1974–76)	60
Jammu & Kashmir	15
Karnataka (1983–94)	4925
Kerala	517
Madhya Pradesh (1970–86)	18124
Maharashtra	8893
Manipur (1986–88)	3692
Meghalaya (1986–88)	3102
Mizoram (1988–89)	9210
Nagaland (1984–87)	758
Orissa (1976–84)	7822
*Punjab	50
Rajasthan (1984–86)	529
*Tamil Nadu	3101
Tripura (1989-90)	939
Uttar Pradesh (1981–85)	2010
*West Bengal	1751
Andaman & Nicobar Islands	784
Total	**89575**

* = Estimate based on forest types

Table 12. Distribution of main bamboo species in India (ICFRE 2001)

Species	States/UTs
Bambusa arundinacea	Arunachal Pradesh, Karnataka, Orissa, Maharashtra, Himachal Pradesh, Andhra Pradesh and Gujarat
B. balcooa	Arunachal Pradesh, Mizoram
B. pallida	Arunachal Pradesh, Nagaland, Mizoram, Tripura
B. tulda	Arunachal Pradesh, Assam, Mizoram, Nagaland, Tripura
B. polymorpha	Tripura
Dendrocalamus hamiltonii	Arunachal Pradesh, Assam,Mizoram, Nagaland
D. longispathus	Mizoram
D. strictus	Andhra Pradesh, Assam, Gujarat, Maharashtra, Himachal Pradesh, Madhya Pradesh, Manipur, Orissa, Karnatak, Uttar Pradesh, Rajasthan
Melocanna bambusoides	Assam, Mizoram, Nagaland, Tripura, Manipur, Meghalaya
Neebenzia balcooa	Nagaland
Oxytenanthera nigrociliata	Tripura, Assam
O. parviflora	Assam
Pseudostachyus polymorphium	Arunachal Pradesh
Polystachia pargracile	Orissa

Bamboos are aptly called the poor man's timber and are found in great abundance. Their strength, straightness and lightness combined with extraordinary hardness, range in sizes, abundance, easy propagation and the short period in which they attain maturity make them suitable for a variety of purposes. The diversity of this fascinating plant has to be conserved, not just for financial reasons, but also more importantly in the revitalization of traditional sciences and technologies.

Forestry extension

The forestry extension programme of ICFRE plays a vital role in connecting research institutes with the end users through transfer of technology and extension support to State Forest Departments, non-governmental organizations (NGOs), etc. The Programme also facilitates research collaboration with various organizations and establishment of synergic linkage with user groups.

Extension is carried out in a two-way process. On one hand, tested technologies and scientific information are transferred to the users and, on the other hand, requirements of the users are ascertained for evolving research priorities and researchers are kept abreast with the realities in the field. The extension methodologies presently adopted are demonstrations on the field and the use of extension materials such as films, videos, brochures, hand arts, and exhibitions, workshops, seminars and conferences, as well as by personnel contracts.

Training

To provide up-to-date training and educational exposures to foresters and scientists, arrangements were made for visits abroad for short and long term training courses, meetings, symposia and workshops. Financial assistance was provided by World Bank, UNDP, British Council, IPRC, FAO, INBAR and USDA under various forestry research and educational support programmes. In order to strengthen education in forestry disciplines, technical and financial assistance were also extended to various universities. Many students, industry representatives, teachers and various user groups, including farmers, were also trained on advanced technologies developed by ICFRE institutes.

Constraints to forestry research

Lack of funding for tree improvement programmes

Tree improvement is an activity that requires adequate input and gestation period. Therefore, various user agencies should be provided with external funding for the establishment of clonal seed orchards, seed production areas, tissue culture techniques, establishment of trial plots for clonal forestry using rooted cuttings as well as plants raised by tissue culture. In addition, funds are also needed to upgrade the existing seed storage facilities: mist chambers and tissue culture laboratories in order to mass-produce quality planting stocks for large scale planting programmes.

Mobilization of funds in the past

Since the commencement of the First Five Year Plan (FYP) in 1951, in total Rs 85 billion have been spent by the end of the Eighth FYP in 1996–97 on forestry development planning activities. During this period, afforestation of about 26.9 million ha has been carried out. Financial allocation to the forestry sector has increased from Rs 76 million in the First FYP to Rs 40 818 million in the Eighth FYP, but is has always been less than 1% of the total plan outlay of the country. This is one of the main reasons for the continuous deterioration of forest resources (Table 13).

A provision of Rs 68 billion has been made for the Ninth Plan. During 1997–98, afforestation of 1.48 million ha was completed which involved the distribution of 1033 million seedlings. Thus, up to 1997–98, the total area afforested is 28.38 million ha, which includes a national target of 4.65 million ha (equivalent of 9309 million seedlings distributed).

The average annual plan outlay for the forestry sector during the Eighth FYP was about Rs 8.16 billion (approx. US$ 240 million) whereas the estimated annual value of harvests (recorded and unrecorded) from the forests was worth Rs 300 billion during the same period, which is about 36 times more than the planned investment.

Table 13. A glimpse of budget allocation for forestry under the Five Year Plans, 1951–2002 (million RS)

Plan/Year	Total plan		Agriculture plan		Forest and wildlife plan		Forest outlay
	Outlay	Actual	Outlay	Actual	Outlay	Actual	(% of total)
First Plan (1951–1956)	23 780	19 600	3 540	2 900	76	85	0.32
Second Plan (1956–1961)	45 000	46 720	5 100	5 490	212	212	0.47
Third Plan (1961–1966)	75 000	8 577	10 860	10 890	458	459	0.61
Annual Plan (1966–1969)	66 250	66 225	10 370	11 070	419	421	0.63
Fourth Plan (1969–1974)	159 020	157 790	27 280	23 200	894	938	0.56
Fifth Plan (1974–1979)	393 220	394 260	47 660	48 650	2 088	2 088	0.53
Annual Plan (1979–1980)	126 010	121 760	18 150	19 960	683	683	0.54
Sixth Plan (1980–1985)	975 000	1 092920	125 390	152 010	6 924	n.a.	0.71
Seventh Plan (1985–1990)	1 800 000	2 187 300	222 330	315 090	18 519	19 759	1.09
Annual Plan (1990–1991)	647 170	583 690	91 420	85 420	6 299	5 764	0.97
Annual Plan (1991–1992)	723 170	647 500	100 580	90 600	7 831	7 153	1.08
Eight Plan (1992–1997)	4 341 000	–	636 420	–	40 820	39 930	0.94
Ninth Plan (1997–2002)		–	–	–	–	68 228	
Total up to 8th FYP	**9 374 620**		**1 299 100**		**85 295**		**0.90**

Tables 14 and 15 provide information on the planned investments in forestry activities. Proposed investments have been estimated on the basis of the requirements of the sector irrespective of the source of funding.

Table 14. Summary of investment estimates for the country (State and Central Sectors) by programme (million Rs)

S. no.	Programme	First 5-year	Second 5-year	Third 5-year	Fourth 5-year	Total for 20 years
I.	Improve forest productivity	82 252.3	100 761.3	110 349.0	119 554.9	412 917.5
II.	Expand forest area	88 928.4	103 634.0	1 054 812.4	113 344.2	411 719.0

Table 15. Summary of investment estimates for 20 years by programme (million Rs)

Programme	State Sector	Central Sector	Total	Area to be regenerated / planted (million ha)
Improve Forest Productivity	391479.9	21 437.6	412 917.5	26.43
Expand Forest Area	405 605.5	6 113.6	411 719.1	21.80

Conclusions

Forest genetic resources are facing multiple threats from habitat loss, forest fires, climate change and from the invasion of exotic species. Conservation is compounded by the number of species that require protection. Some priority species for India are listed in appendices 2–6. Plant resources, many of which come from forests, are the biological basis of the world security and directly or indirectly support the livelihoods of every person on earth by providing food, feed for domestic animals, fibre, clothing, shelter, wood, timber, medicine, energy, etc. These resources are also the raw material used in the production of new plant varieties through traditional plant breeding or through biotechnology. The erosion of these resources poses a severe threat to the world's food security in the long term. Thus, there is an urgent need to conserve and utilize the genetic resources as a safeguard against an unpredictable future.

Today, increasing direct and indirect access to the benefits created by forests is causing damage to the ecosystem as a whole as well as loss of biodiversity in particular. Reliable and sustainable improvements in plantation yield are necessary to meet the growing demand and to protect the natural forests from pressures. The conservation and sustainable utilization of PGR is the key to improving the productivity and sustainability of forests, thus contributing to national development, food security and the alleviation of poverty. A multifaceted approach to biodiversity conservation is needed at this junction. We should not allow a single species to depart from us.

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Appendix 1

State-wise seed production areas of various species (Forest Statistics India 2001)

States/Union territories	Species	No. of locations	Area (ha)
Andhra Pradesh	*Tectona grandis* (teak)	76	811.1
	Anogeissus latifolia	4	25
	Terminalia alata	5	36
	Pterocarpus santalinus (red sanders)	1	12.4
	P. marsupium	2	15
Arunachal Pradesh	n.a.	n.a.	n.a.
Assam	Teak	5	64
	Chukrasia tabularis	4	29
	Artocarpus chaplasha	1	2
	Gmelina arborea	2	16
	Acacia catechu	1	4
	Bombax ceiba	2	22
	Shorea robusta	3	11
	Dipterocarpus turbinatus	1	2
	Dalbergia sissoo	2	4
	Dipterocarpus macrocarpus	5	39
	Phoebe cooperiana	1	4
	P. goalparens	1	14
	Amoora wallichi	1	11
	Lagerstroemia reginae	2	3
	Canarium resiniferum	1	5
	Morus laevigata	1	1
	Sterculia villosa	1	4
	Terminalia myriocarpa	2	4
Bihar	n.a.	n.a.	n.a.
Delhi	n.a.	n.a.	n.a.
Goa	Nil	Nil	Nil
Gujarat	*Acacia nilotica*	2	40
	Tectona grandis	6	100
Haryana	*Eucalyptus tereticornis*	1	2.1
Himachal Pradesh	n.a.	n.a.	n.a.
Jammu & Kashmir	*Pinus wallichiana* (kail)	4	77
	Cedrus deodara (deodar)	4	51.8
	Robinia pseudoacacia (robinia)	4	53
	Pinus roxburghii (chir)	3	43.5
	Abies pindroa	1	13.2
Karnataka	*Acacia auriculiformis*	3	182
	Anogeissus latifolia	1	25
	Cassia siamea	1	1
	Casuarina equisetifolia	2	50
	Eucalyptus camaldulensis	5	70
	Hardwickia binata	3	60
	Hopea parviflora	3	20
	H. wightiana	1	4
	Annona squamosa	2	10
	Emblica officinalis	2	10
	Feronia elephantum	2	3.5
	Gmelina arborea	1	1.5
	Leucaena leucocephala	2	20
	Morinda tinctoria	1	10
	Pterocarpus marsupium	2	15

States/Union territories	Species	No. of locations	Area (ha)
	Borassus flabellifer	1	15
	Buchanania lanzan	1	12
	Chloroxylon swietenia	1	8
	Dalbergia sissoo	1	8
	Madhuca latifolia	1	10
	Acacia catechu	1	10
	Calamus travancoricus	1	10
	Grevillea robusta	1	8
	Lagerstroemia lanceolata	1	2
	Pinus caribaea	1	4
	Acacia mangium	1	50
	Adina cordifolia	1	150
	Calophyllum inophyllum	1	200
	Dalbergia latifolia	1	10
	Garcinia indica	1	40
	Eucalyptus citriodora	2	40
	Eucalyptus hybrid	2	25
	Pterocarpus santalinus	1	20
	Samanea saman	1	1
	Santalum album	1	5
	Sapindus trifoliatus	1	200
	Semecarpus anacardium	1	130
	Syzygium jambos	1	3
	Tamarindus indica	1	5
	Tectona grandis	3	464
	Terminalia bellirica	1	35
	Terminalia tomentosa	1	448
	Vateria indica	1	4
	Xylia xylocarpa	1	16
	Ziziphus jujuba	2	14.5
Kerala	Teak	6	1337.4
	Eucalyptus spp.	2	5
	Bombax ceiba	2	12.5
	Santalum album (sandal)	1	23
	Venteak	1	6.6
	Terminalia alata (laurel)	1	16
	Dalbergia latifolia (rosewood)	1	5
	Swietenia spp. (mahogany)	1	10
	Ailanthus triphysa	1	7
	Emblica officinalis	1	10
Madhya Pradesh	Teak	47	1360
	Eucalyptus spp.	2	8
	Gmelina arborea (khamar)	2	24
	Ougeinia oojeinensis (tinsa)	1	10
	Emblica officinalis (aonla)	1	10
	Anogeissus pendula (kardhai)	1	24
	Acacia catechu (khair)	3	153
	Leucaena leucocephala (subabul)	1	10
	Prosopis juliflora	1	10
	Miscellaneous	9	220
Maharashtra	Teak	17	749
	Cenchrus ciliaris (anjan)	3	20
	Cleistanthus collinus (garadi)	1	10
	Pterocarpus marsupium (bija)	1	10
	Acacia catechu (khair)	4	35

States/Union territories	Species	No. of locations	Area (ha)
	Bombax ceiba (semal)	1	5
	Surya	1	5
	Diospyros melanoxylon (tendu)	1	5
	Mitragyna parvifolia (kalam)	1	5
	Casuarina equisetifolia	2	6
	Eucalyptus grandis	2	4.5
	Acacia auriculiformis	1	2
	Shivan	2	10
	Pinus caribaea	1	2
	Terminalia chebula (hirda)	1	5
	Acacia nilotica ssp. *indica* (babul)	1	10
	Dalbergia sissoo (sissoo)	1	10
	Schleichera oleosa (kusum)	1	5
	mixed	1	2
	Ficus carica (ain)	2	8
	Cleistanthus collinus	1	5
Meghalaya	n.a.	n.a.	n.a.
Manipur	n.a.	n.a.	n.a.
Mizoram	Teak	3	20
Nagaland	Nil	Nil	Nil
Orissa	*Casuarina equisetifolia*	2	61
	Teak	3	218
Rajasthan	*Acacia nilotica* ssp. *indica*	2	35
	Dalbergia sissoo	2	30
	Eucalyptus camaldulensis	1	10
	Prosopis cineraria	1	10
	Acacia senegal	1	10
	Acacia catechu	1	10
	Acacia tortilis	1	10
	Ailanthus excelsa	1	1
	Salvadora oleiodes	1	10
Sikkim	Teak	1	1.5
	Shorea robusta (sal)	1	1
	Michelia spp. (rani champ)	1	0.5
	Pinus roxburghii (chir pine)	1	1.5
	Tsuga dumosa (hemlock)	1	2.5
	Michelia champaca (champ & okhar)	1	1
	Rhododendron arboreum	1	0.5
	Pinus patula	1	1.5
Tamil Nadu	*Acacia mearnsii*	1	4.5
	Acacia planifrons	1	10
	Anacardium occidentale	1	21
	Eucalyptus tereticornis	1	9
	Hardwickia binata	1	0.4
	Tectona grandis	1	53
Tripura	Nil	Nil	Nil
Uttar Pradesh	*Eucalyptus* hybrid	3	12
	Dalbergia sissoo (shisham)	9	110
	Teak	1	10
West Bengal	Misc.	3	641
A&N Island	Nil	–	Nil
D& N Haveli	Nil	–	Nil
Chandigarh	Nil	–	Nil
Lakshadweep	n.a.	n.a.	n.a.
Pondicherry	n.a.	n.a.	n.a.

Appendix 2

List of priority species for conservation, improvement or seed procurement (FAO-coordinated activities) (Sharma *et al*. 2002)

Species	End users of species				Operations/activities needed: Exploration & collection		Evaluation		Conservation		Germplasm uses	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Acacia catechu	–	+	–	–	2	2	–	3	2	2	2	2
A. nilotica	–	+	+	+	2	2	2	2	2	2	2	2
A tortilis	–	–	+	+	–	3	–	3	–	3	–	–
Albizia procera	+	–	+	+	1	1	2	2	2	2	3	2
Azadirachta indica	+	+	+	+	1	1	2	1	1	1	1	1
Bamboo	–	+	+	+	1	1	–	1	1	1	1	1
Rattans	–	+	–	–	2	2	2	2	2	2	3	3
Casuarina equisetifolia	–	+	+	+	–	2	2	2	2	2	1	2
Cedrus deodara	+	+	+	+	2	2	2	2	2	2	2	2
Dalbergia sissoo	+	+	+	+	1	2	1	1	1	1	2	1
Eucalyptus spp.	+	+	+	–	2	3	–	3	–	3	3	2
Pinus roxburghii	+	+	+	+	1	2	–	2	1	2	2	1
Populus ciliata	+	–	+	+	1	1	1	1	1	1	1	1
P. euphratica	+	–	+	+	1	1	1	1	1	1	1	1

End uses: 1 = Industrial wood products (logs, sawtimber, construction wood, plywood, chip and particle board, wood pulp etc.); **2** = Industrial non-wood products (gums, resin, oils, tannins); **3** = Fuelwood, posts, poles (firewood, charcoal, roundwood used on-farm, wood for carving); **4** = Other uses, goods and services (food, medicinal use, fodder, land stabilization/amelioration, shade, shelter, environmental values).

Exploration & collection: 5 = Biological information (natural distribution, taxonomy, genecology, phenology etc.); **6** = Collection of germplasm for evaluation

Evaluation: 7 = *In situ* (population studies); **8** = *Ex situ* (provenance and progeny tests)

Conservation: 9 = *In situ*; **10** = *Ex situ*

Reproductive use/germplasm use: 11 = Semi-bulk/bulk seedlots, reproductive materials; **12** = Selection and improvement

Remarks (13): Specific uses not obvious from columns 1-4 are mentioned. Also, work in progress is reported in this column.

Priority ranking for columns 5-12: **1** = Highest priority; **2** = Prompt action recommended; **3** = Action is important, but of less urgency than that for species

Appendix 3

List of priority species identified at national level in India (FAO 2002)

Species	End users of species				Operations/activities needed							
					Exploration & collection		Evaluation		Conservation		Germplasm uses	
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**
Acacia pindraw	+	–	–	+	2	3	3	3	2	–	–	3
A. nilotica	+	+	+	+	1	1	–	2	2	2	2	2
A. catechu	–	+	–	–	–	–	–	–	–	–	–	–
Ailanthus excelsa	+	+	–	–	2	2	2	2	2	2	2	2
A. grandis	+	+	+	+	2	2	2	2	2	2	2	2
Albizia procera	+	–	+	+	1	1	–	3	1	1	–	1
Annona squamosa	+	–	–	+	3	3	3	3	3	3	3	3
Artocarpus heterophyllus	–	+	–	+	3	3	3	3	3	3	3	3
Azadirachta indica	+	+	+	+	1	1	1	1	1	1	1	1
Bamboo	–	+	+	+	1	1	1	1	1	1	1	1
Bombax ceiba	+	+	+	–	3	1	–	1	1	1	1	1
Casuarina equisetifolia	+	–	+	–	–	–	2	2	2	2	2	2
Cedrus deodara	+	–	–	+	1	1	–	1	1	1	1	1
Cinnamomum camphora	+	+	+	+	2	2	–	2	–	–	–	–
Dalbergia latifolia	+	–	–	–	1	1	–	1	1	1	1	1
D. sissoo	+	+	+	+	1	1	1	1	1	1	1	1
Dipterocarpus spp.	+	–	–	–	1	1	–	2	1	1	1	1
Emblica officinalis	–	+	–	+	3	3	3	3	3	3	3	3
Eucalyptus spp.	+	+	+	-	2	3	–	3	–	3	3	2
Gliricidia sepium	–	+	–	+	3	3	3	3	3	3	3	3
Gmelina arborea	+	–	+	+	–	1	1	1	1	1	1	1
Hardwickia binata	+	–	+	-	1	1	–	2	1	1	1	1
Paulownia fargesii	+	–	–	+	1	1	–	1	–	–	–	–
P. spp.	+	–	–	+	1	1	1	1	2	2	2	2
Moringa oleifera	–	+	–	+	1	1	–	–	–	1	–	1
Melia azedarach	+	–	+	+	1	1	–	–	–	1	–	1
Madhuca indica	–	–	–	+	–	–	–	–	–	–	–	–

Species	End users of species				Operations/activities needed							
					Exploration & collection		Evaluation		Conservation		Germplasm uses	
Lagerstroemia lanciolotor	–	+	–	+	3	3	3	3	3	3	3	3
Juglans regia	+	+	+	+	1	–	1	–	1	–	–	1
Paulownia kawakami	+	–	–	–	2	2	–	2	–	–	–	–
P. smithania	+	–	–	–	1	1	–	1	–	1	1	1
Pinus caribaea	+	+	+	–	–	–	1	–	1	–	1	–
P. gerardiana	–	+	–	+	1	1	–	–	1	1	1	1
P. kesiya	+	–	–	+	1	1	–	1	1	1	1	1
P. patula	+	–	–	–	2	2	–	2	2	–	–	–
P. oocarpa	+	–	–	+	1	1	–	–	1	–	3	–
P. roxburghii	+	+	+	+	1	1	1	1	2	2	1	1
P. wallichiana	+	–	–	+	3	1	–	3	1	1	1	1
Populus deltoides	+	–	+	+	2	1	–	1	–-	1	1	1
P. ciliata	+	–	–	–	2	2	–	2	–	–	–	–
P. euphratica	+	–	+	+	1	1	–	1	1	1	1	1
P. yunnanensis	+	–	+	–	3	1	–	1	–	–	1	1
Prosopis cineraria	+	+	+	+	1	1	1	1	1	1	1	1
P. juliflora	+	+	+	+	1	1	1	1	1	1	1	1
Rattan	–	+	+	+	1	1	1	1	2	2	2	2
Salix alba	+	–	–	–	2	2	–	2	–	–	–	–
S. babylonica	+	–	–	+	2	2	–	2	–	–	–	–
Santalum album	+	–	–	+	1	1	–	–	1	1	1	1

For denotes, please refer to Appendix 2 above.

Appendix 4

Priority species for different agro-climatic regions in India (FSI 2001)

Agro-climatic region	Priority				
	1	**2**	**3**	**4**	**5**
Western Himalayan	*Grewia optiva*	*Populus ciliata*	Toona ciliata	*Casuarina australis*	*Acacia catechu, Robinia pseudoacacia*
Eastern Himalayan	*Michelia champaca*	*Alnus nepalensis*	*Gmelina arborea*	*Morus laevigata*	*Pinus kesiya*
Lower Gangetic Plains	*Populus deltoides*	*Anthocephalus auriculiformis*	*Gmelina arborea*	*Acacia nilotica*	*Azadirachta indica*
Middle Gangetic plains	*Populus deltoides*	*Anthocephalus cadamba*	*Eucalyptus hybrid*	*Dalbergia sissoo*	*Acacia nilotica*, bamboo
Upper Gangetic plains	*Populus deltoides*	*Eucalyptus* hybrid	*Dalbergia sissoo*	*Anthocephalus cadamba*	*Leucaena leucocephala*
Trans-Gangetic plains	*Populus deltoides*	*Eucalyptus* hybrid	*Dalbergia sissoo*	*Melia azadirachta*	*Acacia nilotica*
Eastern Plateau and Hills	*Gmelina arborea*	*Tectona grandis*	*Eucalyptus* hybrid	*Casuarina equisetifolia*	*Leucaena leucocephala*
Central Plateau and Hills	*Azadirachta indica*	*Eucalyptus* hybrid	*Tectona grandis*	Acacia nilotica	*Leucaena leucocephala, Hardwickia binata*
Western Plateau and Hills	*Azadirachta indica*	*Acacia nilotica*	*Eucalyptus* hybrid	*Leucaena leucocephala*	*Tectona grandis*
Southern Plateau and Hills	*Ailanthus excelsa*	*Eucalyptus camaldulensis*	*Tamarindus indica*	*Ceiba pentandra*	*Casuarina equisetifolia*
East coast Plains and Hills	*Casuarina equisetifolia*	*Gmelina arborea*	*Acacia mangium*	*Terminalia tomentosa*	*Dalbergia sissoo*
West coast Plains and Ghats	*Casuarina equisetifolia*	*Eucalyptus* hybrid	*Acacia mangium*	*Terminalia tomentosa*	*Artocarpus heterophyllus*, bamboo
Gujarat Plains and Hills	*Prosopis cineraria*	*Eucalyptus* hybrid	*Ailanthus excelsa*	*Dalbergia sissoo*	*Leucaena leucocephala*
Western dry	*Prosopis cineraria*	*Acacia nilotica*	*Azadirachta indica*	*Ailanthus excelsa*	*Dalbergia sissoo*
The islands	*Casuarina equisetifolia*	*Gmelina arborea*	*Gliricidia sepium*	*Samanea saman*	*Terminalia catappa*

Appendix 5

Priority species for different zones / regions in India (FSI 2001)

Zone / Region	Preferred species
Submontane low hills	*Grewia optiva, Albizia chinesis, Bauhinia variegata, Celtis australis,*
Subtropical	Bamboo species*, Morus alba, Bombax ceiba, Anogeissus latifolia, Acacia catechu, Toona ciliata*
Mid-hillsSubhumid	*Grewia optiva, Celtis australis, Quercus leucotricophora, Bauhinia variegata, Ficus* spp.*, Albizia chinensis, Acacia catechu, Anogeissus latifolia*
High hillsTemperate wet	*Quercus* spp.*, Morus* spp*, Robinia pseudoacacia, Celtis australis, Alnus nitida, Populus* spp.
High hillsTemperate dry	*Robinia pseudoacacia, Salix* spp.*, Quercus* spp.*, Fraxinus* spp.
Punjab lower hill zone	*Acacia nilotica, Dalbergia sissoo, Acacia catechu, Ziziphus* spp,. *Butea*
(Kandi)	*monosperma, Grewia optiva, Anogeissus latifolia*
Alluvial zone	*Populus deltoides, Eucalyptus* spp.
Hayarana	*Populus deltoides, Eucalyptus* hybrid*, Prosopis cineraria, A. nilotica, A. tortilis, Dalbergia sissoo*
Western Uttar Pradesh	*Dalbergia sissoo, A. nilotica, Populus deltoides, Eucalyptus* hybrid, *Albizia lebbeck, Morus alba, Syzygium cumini*
Central Uttar Pradesh	*Dalbergia sissoo, A. nilotica, A. catechu, Eucalyptus, Prosopis* spp., bamboo*, Madhuca latifolia, Ficus religiosa, Derris indica*
Eastern Uttar Pradesh	*Dalbergia sissoo, Eucalyptus* spp.*, bamboo, neem, Madhuca latifolia, Syzygium cumini, Ficus* spp.
Bihar (NW Dist.)	*Dalbergia sissoo, Morus alba, A. nilotica, Bombax ceiba, Tectona grandis, Cassia fistula, Azadirachta indica, Emblica, Dendrocalamus strictus, Wendlandia exserta*
West Bengal	*A. nilotica, Dalbergia sissoo, Azadirachta indica, Terminalia arjuna, Butea monosperma, Leucaena leucocephala*
Arid	*Prosopis cineraria, P. juliflora, Tecomella undulata*
Semi-arid	*A. nilotica, Dalbergia sissoo, Azadirachta indica, Prosopis cineraria* Bundel khand (including *Azadirachta indica, Madhuca latifolia, Acacia leucophloea, Butea*
Central Plateau region)	*monosperma, Anogeissus pendula, Albizia lebbeck*
Deccan Plateau	*Albizia lebbeck, A nilotica, P. juliflora, A. leucophloea, Hardwickia binata, A. ferruginea*
Tropical highlands	Jackfruit, drumstick, tamarind, teak, *Sesbania grandiflora, Lawsonia inermis*
Tropical plains	Neem, *Acacia nilotica, A. leucophloea, A. planiformis, Casuarina, Ailanthus excelsa*
Coastal	*Casuarina, A. planiformis, P. juliflora, E. tereticornis*
Humid (rainfall > 2500 mm)	Silver oak*, Casuarina* spp.
Rainfall 1500-2500 mm	Teak, jackfruit, curry leaf*, Casuarina* spp., *Ceiba pentandra, Bombax ceiba*
Rainfall < 1500 mm	*Acacia nilotica, Ceiba pentandra, Ailanthus excelsa*
Bihar (NW Dist.)	*Dalbergia sissoo, Morus alba, A. nilotica, Bombax ceiba, Tectona grandis, Cassia fistula, Azadirachta indica, Emblica, Dendrocalamus strictus, Wendlandia exserta*

Appendix 6

Level and nature of threats to the integrity of populations of important tree species in India

Species in ecogeographic zones (geo-ecological)	Reserves, natural areas	*In situ* conservation stand	Managed forest	Unmanaged forest	Plantation/ cultivated	*Ex situ* cons. stand, naturalized from cultivation	Villages, fields, homesteads	Experimental fields, trials index	Degree of threat
1. *Abies delavayi* (EH)	–	–	–	+	–	–	–	–	5, High
2. *Acer caesium* (WH)	–	–	–	+	–	–	–	–	3, Medium
3. *Actinodaphne lanata* (WG)	+	–	–	+	–	–	–	–	2, Low
4. *Ailanthus kurzii* (A.Is.)	+	–	–	+	–	–	–	–	3, Medium
5. *Albizia gamblei* (EH)	–	–	–	+	–	–	–	–	5, High
6. *Amentotaxus assamica* (EH)	–	–	–	+	–	–	–	–	5, High
7. *Aquilaria malaccensis* (EH & NEI)	+	–	–	+	+	–	–	–	4–5, Medium-High
8. *Artocarpus hirsutus* (EG & SI)	+	–	–	+	–	–	–	–	3–4, Medium
9. *Bentinckia coddapanna* (EG & WG)	–	–	–	+	–	–	–	–	3–4, Medium
10.*Boswellia ovalifoliolata* (EG)	–	–	–	+	–	–	–	–	3, Medium
11.*Cephalotaxus griffithi* (NEI)	–	–	–	+	–	–	–	–	4–5, Medium-High
12.*Commiphora wightii* (GP & WI)	–	–	–	–	+	–	–	–	3–4 Medium
13.*Cochlospermum religiosum* (N & SI)	–	–	–	+	+	–	–	–	2–3 Low-Medium
14.*Dalbergia lanceolaria* (NWI)	–	–	–	+	–	–	–	–	3–4 Medium
15.*Dipterocarpus kerrii* (A & N)	+	–	–	–	–	–	–	–	4–5 Medium-High
16.*Gleditsia assamica* (NEI)	–	–	–	–	+	–	–	–	3–4, Medium
17.*Gmelina arborea* var. *canescens* (GP)	–	–	–	–	–	–	+	–	5, High
18.*Hopea jacobi* (WG)	+	–	–	–	–	–	–	–	2–3, Low-Medium
19.*Kingiodendron pinnatum* (SWG)	+	–	–	+	–	–	–	–	2–3, Low-Medium
20.*Lagerstroemia hypoleuca* (A. Is.)	–	–	–	+	–	–	–	–	1–2, Low
21.*Madhuca bourdillonii* (SWG)	–	–	–	+	–	–	–	–	2–3, Low-Medium
22.*Mangifera andamanica* (A. Is.)	+	–	–	+	–	–	–	–	1–2, Low
23.*Mesua manii* (A. Is.)	–	–	–	+	–	–	–	–	2–3, Low-Medium
24.*Michelia punduana* (NEI)	–	–	–	+	–	–	–	–	3–4, Medium
25.*Picea spinulosa* (E H)	–	–	–	+	–	–	–	–	4–5, Medium-High
26.*Podocarpus neriifolius* (A. Is., NEI)	+	–	–	+	+	+	–	–	2–3, Low-Medium
27.*Populus gamblii* (EH)	+	–	+	–	+	–	–	+	1, Low

Species in ecogeographic zones (geo-ecological)	Reserves, natural areas	*In situ* conservation stand	Managed forest	Unmanaged forest	Plantation/ cultivated	*Ex situ* cons. stand, naturalized from cultivation	Villages, fields, homesteads	Experimental fields, trials index	Degree of threat
28.*Pterocarpus santalinus* (EP)	+	–	–	–	+	+	–	+	1, Low
29.*Rhododendron johnstoneanum* (NEI)	–	–	–	+	–	–	–	–	4–5, Medium-High
30.*Shorea thumbaggaia* (EG)	+	–	–	+	–	–	–	–	5, High
31.*Syzygium bourdillonii* (SI)	–	–	–	+	–	–	–	–	4–5, Medium-High
32.*S. palghatensis* (WG)	+	–	–	+	–	–	–	–	2–3, Low -Medium
33.*Taxus baccata* ssp. *wallichiana* (NW & EH)	+	–	+	+	–	–	–	–	3–4, Medium-High
34.*Trachycarpus takil* (WH)	+	–	–	+	–	+	–	–	4–5, Medium -High
35.*Vateria macrocarpa* (EP & WG)	+	–	–	+	–	–	–	–	2–3, Low Medium

Direct causes of threats may include Unmanaged use and harvesting; unmanaged grazing/browsing (domestic animals, wildlife); wildfires, environmental biotic/abiotic factors (drought, pests, diseases, floods, pollution); clearing for agriculture and pasture land; infrastructure development (dams, mining, urban expansion); biological incompatibility for reproduction/interdependence for dispersal and regeneration; monotypic taxa

Degree of threat index (1–5):

1 = Implementation/enforcement of regulations probable and regulations scientifically sound. Low level of threat.

5 = Implementation/enforcement of regulations unlikely; or threat severe with high probability of genetic degradation or loss. High level of threat.

2–4 = Intermediate between 1 and 5.

Abbreviations:

A.Is. = Andaman Islands; **A & N** = Andaman & Nicobar Islands; **DP** = Deccan Peninsula; **EG** = Eastern Ghats; **EH** = Eastern Himalaya; **EP** = Eastern Peninsula; **GP** = Gangetic Plains; **NEI** = North East India; **SI** = South India; **SWG** = South Western Ghats; **WC** = Western Coast; **WH** = Western Himalaya; **WI** = Western India; **WP** = Western Peninsula

Status of forest genetic resources conservation and management in Nepal

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Introduction

Conservation is the management of genetic resources so that they can provide the greatest sustainable yield to benefit the present generations while preserving their potential to meet the needs and aspirations of future generations (IUCN 1980). More than 70% of the people of Nepal still depend largely on forests for medicines and other products. Thus, conservation and sustainable utilization of forest genetic resources (FGR) is very important for Nepal, for the present as well as for the future.

Status of forest resources in Nepal

Nepal is a land-locked, mountainous country, located along the southern slope of the Himalayas between India and China, situated at the junction of the Indo-Malayan and Palaearctic Biogeographic Realms. Within a distance of less than 150 km, the land rises dramatically from less than 100 m asl. in the tropical Terai in the south to the highest point in the world (8848 m), on the edge of the Tibetan plateau. Nepal has an area of 147 18 km^2, of which the forest area covers 55 180 km^2, approximately 37% of the total area. According to the 1991 census, the total population of the country was 18.5 million, with an annual growth rate of 2.17%. The economy is still largely rural and agrarian.

Based on aerial photographs taken during 1992-1996, forest cover of Nepal was estimated to be 29%. In addition, 10.6% of the area was found to be degraded shrubland; thus 39.6% of the country's land is under forests (DFRS 1999).

Nepal is a small country but rich in biological diversity. It has 5400 species of vascular plants, including over 254 endemic plant species and 700 species of medicinal plants. In addition, over 175 species of mammals, 850 species of birds, 600 species of butterflies, 50 species of moths, 180 species of dragonflies, 170 species of fish, and other animals inhabit this country. With only 0.15% of the world's forest, Nepal has 2.2% of all known plants and 9.4% of all known bird species. Many valuable genetic resources are conserved in the protected areas for their potential use in the future.

Nepal has 16% of its area protected to conserve wildlife, FGR and ecosystems. However, research and management activities mostly concentrate to conserve wildlife alone. Many valuable tree species are growing inside conservation areas, but scientific studies on their identification, validation, conservation and management are yet to be initiated.

Utilization of trees

Forest trees are an integral part of rural livelihoods in Nepal (Figure 1). They dominate not only the landscape but also the way people live. Forests provide 75% of the total energy consumed in the country (fuelwood) and more than 40% of fodder for livestock is extracted from forests (MPFS 1988). Besides, they play a dynamic role in protecting the fragile mountain ecosystems and maintaining diverse and complex ecosystems of the country (Thomson 1995).

Identification of threats

Hill forests are a key resource in the Nepalese economy, providing fodder, timber and fuelwood. Their degradation has long been a concern. IDA's Forestry Sector Review of 1978 identified two major problems, which are still relevant today: the rural energy crisis and the environment deterioration caused by over-utilization of forests.

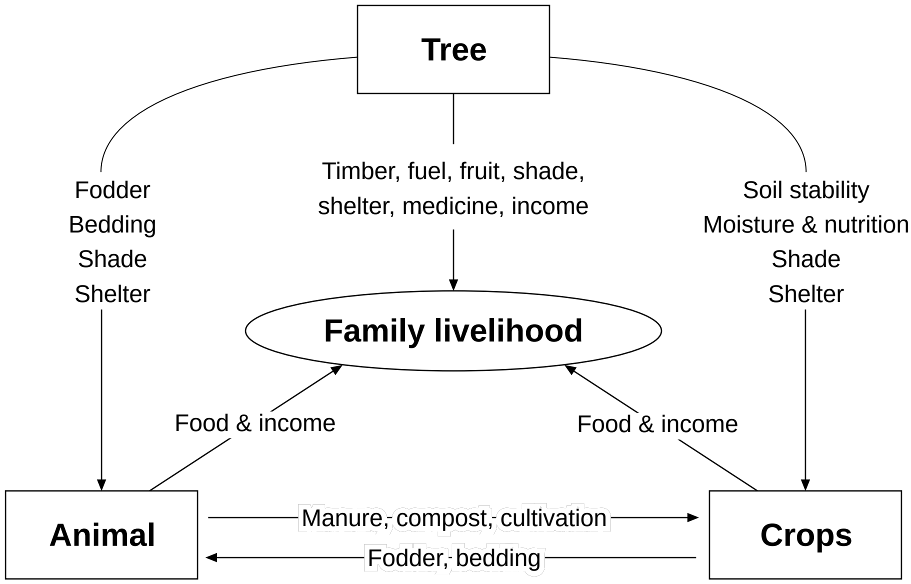

Figure 1. Nepal's tree-animal-crop farming system

Due to increasing population, there is a heavy pressure on the forest of Nepal for material needed for subsistence, such as fuelwood and fodder, as well as landuse changes. It was estimated that 10.6% of Nepal's forests degraded to shrubland in 12 years, whereas the population has been increasing at a rate of 2.1 % annually (Table 1) (DFRS 1999). Declarations on conservation of biodiversity during the Rio conference in 1992 could remain on paper alone if immediate action is not taken to stop the growth of human population.

Table 1. Forest area decline and population growth in Nepal during the last two decades (HMGN 1968, 1974, 1998a and 1998b)

	Year		
	1979	**1986**	**1998**
Forest area	43%	37.4%	29%
Population	13.7 million	15 million	21.8 million

Increase in the population, together with illegal felling and forest encroachment is the main reasons for forest degradation. If this trend continues, the condition of the forests in the country and species diversity of valuable tree species will be adversely affected.

Overexploitation of forest trees

Nepal is rich in species diversity of forest trees; physiographic and climatic variations have created habitats for various forest tree species. There are still many forest species that are not yet identified. However, many forest tree species are providing food and services to the rural communities. Due to over-exploitation, important and valuable species, such as *Dalbergia latifolia*, *D. sissoo*, *Pterocarpus marsupium, Azadirachta indica* and *Taxus baccata* are becoming rare and even under threat of extinction. All the merchantable size forest trees have been logged illegally.

Lack of forest management

From the management perspective, Nepal's forests are divided into: Government-managed forest (GMF, national forest), community forest (CF), leasehold forest (LF), religious forest (RF) and national parks and reserves (NPR, protection forest). Large parts of the forests of the Terai are categorised as GMF. Forests of 22 Terai districts are considered as productive forests. Operational Forest Management Plan (OFMP) has been developed for 18 Terai districts, but yet to be implemented.

Hill forests are managed through the Community Forestry Programme (CFP). The CFP is the highest priority programme in the forestry sector and was initiated in 1978 (MPFS 1988). The main objective of the CFP is to manage all the accessible forests through active participation of the local people. By July 2003, 12 584 forest-user groups (FUGs) have been formed to manage more than 999 951 ha of forests. There are 1 406 947 households involved in this programme. The programme is successful in protecting and rehabilitating the forests. In this programme, users have the right to protect, harvest and manage the forest after it is handed over to them. However, all the District Forest Offices (DFOs) responsible to hand over the community forests have individual approaches and understanding of community forests though there are common guidelines and regulations. Despite these guidelines and regulations, managerial decisions might be needed to suit the local environment due to the localised nature of the FUGs. Presently, the FUGs are seeking technical assistance to manage and conserve forests.

It can be concluded that any single conservation programme is not sufficient to preserve all representative species and genetic diversity. An integrated conservation programme including *in situ* and *ex situ* conservation, community forestry and domestication is urgently needed to conserve the plant genetic resources of Nepal for their sustainable use in future.

Past and present activities in conservation, utilization and management of genetic resources

Many valuable tree species in Nepal are under threat of extinction. For better conserving these species, there is a need for a long-term commitment, strong economic base and trained manpower. In the absence of these resources, conservation of endangered and threatened forest tree species cannot move ahead as it should. It is urgent to stop the genetic depletion of forest trees to preserve future opportunities. Identification of endangered tree species, establishment of genebanks and development of appropriate propagation techniques are urgently needed to initiate conservation programme.

A practical way to preserve the valuable tree species is not only to conserve but also to utilize at the same time. Therefore, it is necessary to estimate the present status of tree species and to develop and implement a conservation and utilization programme. This would assist in supplying the needed forest products, help in carrying out management of the environment and improve the economic condition of people.

Increasing pressure on land could be minimised by making efficient use of land resources to produce more wood from the same area. In the context of forestry, it could be possibly done through a tree improvement programme (TIP), which aims to improve productivity of forests through the application of technological advances in tree breeding and propagation. In addition, TIP plays a role in conserving the genetic diversity of forest trees through the selection of plus trees from different parts of the country and establishment of a genebank.

TIP is a good option for the improvement of productivity and genetic conservation of forest trees simultaneously. The TIP in Nepal is in its infancy and is seeking a long-term commitment of the government and other assisting bodies. There are various scattered activities and coordination of these could enhance the TIP. This classical model of TIP (Figure 2) can contribute to the genetic conservation of forest trees through the establishment of a genebank and provenance trial.

Agroforestry, plantations and afforestation programme

The Department of Forest Research and Survey (DFRS) has a history of forestry research in Nepal since 1965. Forestry research has focused largely on plantation forestry. Taking note of a World Bank report in 1970 that "all the hill forests will be wiped out in 20 years time and Terai forests in 15 years", plantation forestry became the major activity of the forestry sector. Majority of the activities conducted were provenance and progeny trials. All the donors contributing in forestry sector had plantation programmes.

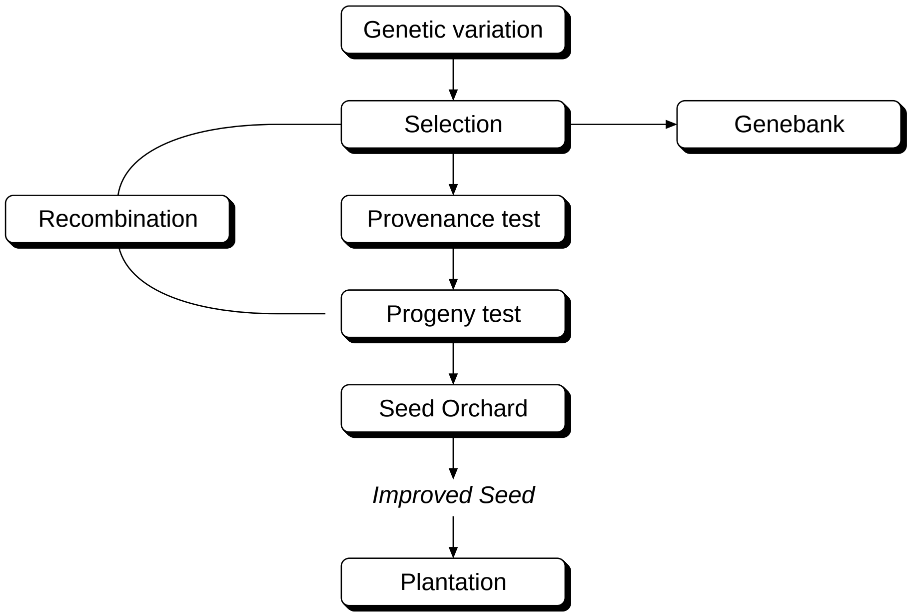

Figure 2. Classical model of a tree improvement programme

The DFRS (then Forest Survey and Research Office, later Forest Research Division) has been supported by the DFID (then ODA) to carry out research activities. Silvicultural Research Project (which was later followed by Forestry Research Projects I and II) had a main thrust on plantation research. During 1979 to 1996, a number of plantation and tree improvement studies were conducted; some 159 studies focusing on the aspects of seed, seedlings and plantations are documented in Appendix 1. There is still a substantial number of plantation and tree improvement studies, which have not been reported and are still ongoing. Appendix 2 provides a summary of the most important reports and publications in these fields.

Demand and supply of tree seed

There are two institutions active in tree domestication within the Ministry of Forest and Soil Conservation. These are the DFRS and the Tree Improvement and Silviculture Component (TISC, previously Tree Improvement Programme). There have been discussions to create an understanding between the DFRS and TISC as to which activities of tree improvement should each organization carry out to avoid duplication.

TISC is mandated to supply seed required for plantation activities in the country. TISC carries out identification, registration and management of natural seed stands of important tree species; establishment of breeding seed orchards has been initiated in different parts of the country. Detailed information on the seed stands is not available. The major goal of the programme is to conserve genetic diversity of forest trees and to supply quality seeds on a reliable basis.

The demand of farmers for fodder and fruit species in Nepal is met by many different species in small quantities from each species. Due to the scattered nature of farmers' locations, the demand could be best met through a decentralised distribution of seed carried out by farmers' associations, cooperatives and private suppliers. TISC has initiated decentralised distribution of seed through seed cooperatives. Seed cooperatives were established with the aim to collect and supply all the common seeds required for plantations. At the same time, TISC encourages and assists the cooperatives to collect and distribute more specialized seed, such as medicinal plants, important fodder trees, etc. In recent years, TISC has initiated more specialized activities in seed collecting, storage and distribution (NTFP, medicinal herbs, fodder seed, etc). Information on seed and seedling distribution by TISC is listed in Table 2 below. It can be seen that 17 166 kg of seed was distributed within a period of six years, in addition to many millions seedlings.

Table 2. Distribution of seeds and seedlings by TISC between 1992 and 1998

Species	Total seed distributed (kg)	Total no. of seedlings
Alnus nepalensis	52	1 548 000
Albizia lebbeck	802	6 416 000
Bauhinia spp.	404	469 375
Bassia butyracea	300	75 000
Choerospondias axillaris	3339	4 006 680
Cedrus deodara	48	268 800
Dalbergia latifolia	64	448 000
Dalbergia sissoo	7513	33 808 950
Eucalyptus camaldulensis	69	13 840 000
Grevillea robusta	3	15 000
Hippophae spp.	13	123 000
Juglans regia	797	15 940
Juniperus spp.	4	6300
Leucaena spp.	178	4 096 300
Michelia champaca	744	1 488 000
Pinus spp.	1874	20 581 500
Prunus cerasoides	254	304 200
Sesbania spp	14	216 000
Tectona grandis	694	346 750
Total	**17 166**	**88 073 795**

In situ conservation

In situ conservation of plant genetic resources is more effective and realistic than *ex situ*. Plant species grow and regenerate in native environment. *In situ* conservation protects the reservoir of genes for potential use in future. FGR of Nepal are preserved in national parks, and wildlife and hunting reserves. This activity started in the early 1970s aiming to conserve a representative sample of ecosystems. Currently, Nepal has eight national parks, four wildlife reserves, three conservation areas and one hunting reserve. Preserved areas cover 16.5% of total area of the country. The Department of National Parks and Wildlife Reserves is the primary agency managing these conservation areas.

These protected areas do not adequately represent all the ecosystems of the country. Most of the protected areas are located in the lowland Terai and high Himalayas. There is a major gap in the reserve system in the middle hills (500m to 3500m altitude); only 10% of the existing reserves are located in this range. The omission is significant because the middle hill zone contains 61% of Nepal's forest, out of which 57% is shrublands that are important breeding habitats for many bird species (Hunter and Yonzon 1993). Middle hill forests also consist of many valuable tree species. The potential of many forest tree species is yet to be identified, validated and scientifically managed.

A major problem with *in situ* conservation is the conflict between reserves and local people. Hence, involving local communities in conservation efforts becomes important. However, interests of local people and the conservation authorities managing these areas could be different. The sources of conflicts are forest resource use, crop damage and livestock depredation (Studsord and Wegge 1995**)**. Efficient management of the buffer-zone areas could be a possible solution to preserve genetic resources of conservation area.

Forest User Groups (FUGs) are formed to protect, manage and utilize the forest outside the reserve areas. Similarly, conservation groups are formed in the fringes of these areas. Projects active in these areas are providing training on income generation to these groups to uplift their economic conditions.

Ex situ conservation

Threatened and endangered species require some protective measures to maintain a genetically viable population in the wild. It is impractical to design an *in situ* conservation programme based on individual species. So, it is necessary to design a complementary *ex situ* conservation programme.

Community forestry is a viable alternative approach for *in situ* conservation of forest trees outside the protected areas. However, a major problem is the motivation of the FUGs in conservation of genetic resources. The FUGs are more interested in utilization of forest resources than in conservation of biodiversity. Occasionally there could be some conflict due to differences in motivation of the FUGs and conservationists. Hence, some level of *ex* situ conservation becomes important. This is especially true in the case of rare and endangered species and valuable species used in tree improvement programmes. The Government of Nepal has adopted a policy to hand over all the accessible forests to the local communities in lots that they are willing and able to manage. About 61% of the total forest area of Nepal is potential community forest area.

The DFRS and TISC are the two organizations under the Ministry of Forest and Soil Conservation responsible to carry out *ex situ* conservation of forest trees in the country. Their major activities include identification, registration and management of natural seed stands of important tree species and establishment of breeding seed orchards in different parts of the country. The major goal of the programme is to conserve the genetic diversity of forest trees and to supply quality seeds on a reliable basis for the success of plantation programmes.

TISC has established breeding seed orchards to conserve the genetic resources of *Dalbergia sissoo* and *D. latifolia*. Each of these orchards is expected to yield about 400 kg of seeds annually. The seed produced in the orchards should be at least 20% more productive (Thomson 1995). TISC is also promoting the identification, registration and management of local seed sources. The main aim is to make each district self-sufficient in seed supply of highly demanded species and to conserve plant genetic resources.

For the conservation of threatened and endangered species, *ex situ* conservation is more practical than *in situ*, because these species require more protective measures. This method is more costly to operate, though. In developing countries like Nepal, where poverty-related issues are more important, policy makers could rarely be convinced to finance *ex situ* conservation of plant genetic resources.

Tree improvement

The DFRS and TISC are responsible in carrying out tree improvement studies in the country. Studies carried out by these organizations focus on identification and registration of natural stands of commercially important species as well as on genetic improvement.

Major tree improvement activities conducted by TISC

Identification of seed stands

During the identification process, registration and management of natural seed stands of important tree species are done. A total of 116 seed stands of 20 different species have been surveyed in 33 districts, out of which 54 seed stands have been registered in 28 districts. The main aims of this programme are to make each district self-sufficient in seed supply of highly demanded species and to conserve genetic resources.

Establishment of breeding seed orchards

Breeding seed orchards (BSO) of *Albizia lebbeck, Azadirachta indica, Bauhinia purpurea, Choerospondias axillaris, Dalbergia latifolia, D. sissoo* and *Michelia champaca* have been established in different parts of the country. A minimum of 25 plus trees of each species were selected from the natural stands to minimize the risk of inbreeding depression. A BSO for *D. sissoo* was the first one to be established in the country; the species has been the most popular plantation species in the Terai. The BSO for *D. sissoo* is replicated in three districts, Chitwan, Sunsari and Banke districts in successive years representing three development regions, that is, East, West and Mid-west.

Major tree improvement activities conducted by DFRS

Genetic improvement of chir pine

For the genetic improvement of chir pine, the DFRS has identified 115 plus trees from eight districts and is in the process to initiate their multiplication. The DFRS is planning to establish BSOs in different parts of the country to ensure the production of quality seeds. For more information see Appendix 3.

Provenance trials

The Forest Research and Survey Centre (FORESC) has conducted a provenance test of the two most popular species of the country, namely *Dalbergia sissoo* and chir pine on different sites of the country. In addition, provenance tests of other important species, such as *Eucalyptus camaldulensis*, *Azadirachta indica*, *Alnus nitida*, *Pinus caribaea* and *Gliricidia sepium* have also been carried out.

Mass multiplication of *Eucalyptus*

The DFRS has established a clonal bank in Sunsari District in the Eastern Region for mass multiplication of *Eucalyptus camaldulensis* to meet the growing demand of FUGs and private farmers. Some 30 plus trees of *Eucalyptus* spp. have been selected in Sagarnath Forest Development Area. Scaring was conducted at the base of the selected plus trees to allow juvenile growth. Cuttings of this juvenile growth were used to establish a clone bank. Regular cuttings from the clone bank will be taken out to produce seedlings.

Domestication

Domestication of fodder, fruit, timber and fuelwood trees and growing them in marginal agricultural lands has been practised by farmers using their indigenous knowledge. In many parts of the country, farming consists of tree-crop-animal systems (Figure 1). The success of farming system depends on the contribution of these three elements and the dynamic interplay between them (Thomson 1995). Most farmers understand this very well and plant trees on their farmlands. Many tree species found in farmland are either lost or rarely found in their natural habitats. Germplasm of these tree species have been preserved in the farming system and the farmers are regularly watching and learning the dynamism of the species.

Community Forestry Programme

To date, more than 7000 FUGs have been formed and more than 999 951 ha of forests has been handed over. The programme has been successful in involving a total of 1 406 947 households in managing the forests. The programme is found to be effective to rehabilitate the forest cover and improve the forest condition. However, limitations that need to be addressed have been observed:

1. Human resources available at the Department of Forest are not sufficient to train the FUGs in the aspects of technical skills, institutional development and self-reliance.
2. Due to the increase in population, demand for forest products in many areas has grown significantly. Because of this, forest management planning has been unable to meet the increased demand, and community forests do not produce enough to fulfil the need of users. It is questionable how long the people would accept this situation, before over-extraction becomes routine.
3. Participation of women and minority groups in decision-making, together with the dominant elite needs to be improved for equitable sharing.
4. Boundary conflicts between the FUGs and equitable sharing of benefits among the users.

Institutional framework

His Majesty's Government of Nepal has developed a 20-year Master Plan for the forestry sector in 1988. It has identified conservation of ecosystems and genetic resources as a primary programme to protect special areas.

The Forestry Sector Master Plan (MPFS 1988) put people at the centre of conservation and development process. By giving adequate priority to the Community Forestry Programme and developing subsequent programmes to cover a major part of the renewable natural resources, it has empowered people for the conservation and sustainable utilization of the resources. Likewise, the Nepal Agricultural Perspective Plan (APP 1995) has realised the significant role of agrobiodiversity and also envisaged the linkages between forestry and agricultural sectors. The Tenth Five-Year Plan (2002–2007) continues the past programmes and puts emphasis on the preparation and implementation of the National Biodiversity Strategy that covers all aspects of biodiversity conservation, sustainable utilization and fair and equitable sharing of the benefits from the conservation efforts.

Nepal signed the Convention on Biological Diversity (CBD) during the Earth Summit, 1992 and ratified it on 21 February 1994. Thus, the CBD has become the guidepost for biodiversity conservation efforts in Nepal. The World Trade Organization (WTO) through its Trade-Related Aspects of Intellectual Property Rights (TRIPS) agreement urges to register and patent biological diversity and associated property rights in order to fully obtain benefits in near future.

The Ministry of Forests and Soil Conservation in Nepal has been designated as the national focal point for the CBD. In order to successfully implement the CBD and to meet the requirements of the WTO, Nepal has initiated certain policy measures and started to implement them.

Accordingly, the National Biodiversity Steering Committee (NBSC) was formed in 1997 under the chairmanship of the Secretary, Ministry of Forest and Soil Conservation (MFSC). Representatives from various ministries (including the Ministry of Agriculture and Co-operatives, and the Ministry of Population), the National Planning Commission and NGOs (IUCN and WWF) were among the members of this committee. A National Biodiversity Unit (NBU) was formulated within the MFSC as a secretariat to the NBSC. A total of six meetings were recorded by the end of 2001.

Similarly, the Ministry of Agriculture and Co-operatives has established a National Agrobiodiversity Conservation Committee. The National Planning Commission (NPC) has also formed a National Coordination Committee for Biodiversity Conservation (NCCBC) in 2000 under the coordination of the NPC Vice-Chairman and a Biodiversity Registration Coordination Committee was formed under the coordination of the NPC Member for Agriculture. As an outcome of all these efforts, Nepal Biodiversity Strategy (NBS) has been prepared and recently approved by the government, a draft bill and policy on Access to Genetic Resources and Benefit Sharing has also been prepared and the Implementation Plan for the NBS is being prepared at the present.

National forest policy and institutional issues

As has been indicated in the previous chapters, some activities have already been initiated on biodiversity conservation. A policy has been formulated to facilitate the formulation and implementation of biodiversity conservation. However, conserving alone is not enough. There is a need for well-balanced planning to promote the concept of *use and improve*. The concept is very important in the context of this country. Nepal has successfully formed 12 584 FUGs and more are in the process. More forest area will be handed over and more households will be involved in the future. The government plans to hand over all the assessable forest if the communities demand and if they are able to manage the area. Therefore, a national forest policy should not be formulated to implement the CBD and meet requirements of the WTO alone, but it should also consider the context of development of forest management by the people of Nepal. Policy should be made to enhance the productivity of forests both qualitatively and quantitatively as circumstances demand.

Identification of national priorities

List of priority species

A seminar of the International Board for Plants Genetic Resources (currently IPGRI), held 23-25 September 1981 in Kathmandu, listed 25 tree species of Nepal as threatened and vanishing (Table 3). It was noted that a more subtle loss of biological diversity was occurring through the loss of genetic variation within species. The possible reasons may be the outright destruction of tree populations, reduction in range and fragmentation of populations into isolated units that are so small that inbreeding becomes a significant factor in survival.

Table 3. List of threatened and vanishing forest tree species of Nepal (Anon 1982)

Scientific name	Scientific name
1. *Abies pindrow*	14. *Larix griffithii*
2. *Abies smithiana*	15. *Michelia champaca*
3. *Acacia catechu*	16. *Myrica nagi*
4. *Adina cordifolia*	17. *Pinus roxburghii*
5. *Alnus nepalensis*	18. *Pinus wallichiana*
6. *Boehmeria rugulosa*	19. *Pterocarpus marsupium*
7. *Bombax ceiba*	20. *Quercus semecarpifolia*
8. *Bassia butyracea*	21. *Quercus species*
9. *Cedrela toona*	22. *Rhododendron arboreum*
10. *Choerospondias axillaris*	23. *Shorea robusta*
11. *Dalbergia latifolia*	24. *Terminalia species*
12. *Dalbergia sissoo*	25. *Tsuga dumosa*
13. *Gmelina arborea*	

In addition, some tree species from Terai, the Middle Hills and Himalayan forests were identified to be threatened and vanishing (Table 4).

Table 4. List of species identified as threatened and vanishing in Terai, Middle Hills and Himalayan forests.

Terai		Middle hills	Himalayan forest
1	*Shorea robusta* (in danger of extinction)	*Bassia butyracea*	*Pinus wallichiana*
2	*Dalbergia latifolia* (vanishing fast)	*Pinus roxburghii*	*Tsuga dumosa*
3	*Bombax ceiba*	*Alnus nepalensis*	*Larix griffithii*
4	*Gmelina arborea*	*Choerospondias axillaris*	*Quercus semecarpifolia*
5	*Terminalia* spp.	*Pinus wallichiana*	*Abies smithiana*
6	*Michelia champaca*	*Rhododendron arboreum*	*Abies pindrow*
7	*Pterocarpus marsupium*	*Quercus* spp.	
8	*Adina cordifolia*	*Boehmeria rugulosa*	
9	*Cedrela toona*	*Myrica nagi*	
10	*Acacia catechu* (disappearing from the natural habitat)		
11	*Dalbergia sissoo*		

The first meeting of the TIP was held at the DFRS in 1992. Many professionals from different departments under the Ministry of Forest and Soil Conservation, and the Forest Tree Improvement Project (FORTIP) representative attended the meeting. This meeting listed ten nationally important forest tree species that require breeding and propagation research (Table 5).

Table 5. Ten important tree species identified at the first meeting of the Tree improvement programme in 1992

	Scientific name	Vernacular name
1	*Acacia auriculiformis*	(exotic species)
2	*Acacia nilotica*	Babul
3	*Alnus nepalensis*	Utis
4	Bamboos	Bans
5	*Dalbergia sissoo*	Sissoo
6	*Eucalyptus camaldulensis*	Masala
7	*Ficus* spp	—
8	*Pinus patula*	Patle salla
9	*Pinus roxburghii*	Khote salla
10	*Tectona grandis*	Teak, Sagawan

After the discussion it was agreed at the meeting that, to avoid duplication, each institution would carry out a specified activity. The list of species allotted for the DFRS to conduct tree breeding and propagation activities included:

- *Alnus nepalensis*
- *Eucalyptus camaldulensis*
- *Artocarpus lakoocha*
- *Pinus roxburghii*

In addition, the DRFS would also establish a potted seed orchard of *Dalbergia sissoo* from the juvenile cuttings. See Appendix 4 for more details.

Support activities

Training and capacity building

There is a need for a long-term commitment, strong economic base and trained human resources to improve the conservation and sustainable use of threatened species in Nepal. Human resources across the departments should be trained and awareness created. In the absence of these resources, conservation of endangered and threatened forest trees will not get any momentum. Along with the development of a national database on extant forest tree species, studies are needed to identify and document any unidentified tree species.

Research

The DFRS and TISC are conducting tree improvement studies of a few vanishing tree species through *in situ* and *ex situ* conservation activities. Similarly, the CFP is also contributing to the genetic conservation of forest trees. FUGs are seeking for assistance from forest technicians for better conservation and utilization. Many valuable forest tree species are preserved through domestication on private lands of the farmers.

The DFRS is actively working on *Eucalyptus* spp., *Azadirachta indica*, *Schima wallichii* and also conducts provenance tests of these species. TISC is active in establishing seed stands in the natural forests, plantations, farmlands and studying species such as *Albizia lebbeck*, *A. procera*, *Artocarpus heterophyllus*, *Azadirachta indica*, *Cassia siamea*, *Casuarina equisetifolia*, *Lagerstroemia ovalifolia*, *Schima wallichii*, *Tectona grandis* and *Terminalia chebula.*

Regional and international collaboration

In 1995, the DFRS initiated a contractual agreement for improved research in tree improvement. Several activities were planned and executed. However, due to unfortunate situations and circumstances the project was stopped. For more details on international projects, see Appendices 1, 2 and 4. Nevertheless, the infrastructure and provenance trials are still intact and reporting is yet to be made. The DFRS therefore has a lot of potential in the field of tree improvement.

Recommendations

Establishment of national parks and reserves to represent all ecosystems

The existing network of national parks and wildlife reserves is not representative of all the different ecosystems in the country. These are concentrated in the high Himalayas and lower Terai. National parks and reserves need to be established in the Middle Mountain regions to conserve all representative ecosystems.

Tree Improvement Network

Financial assistance for the TIP should be increased and more partners for technical enhancement should be searched. The TIP should be reviewed and improved. Involvement in the programme should not be limited to the DFRS and TISC alone but be extended to Department of National Parks and Wildlife, Department of Plant Resources and other concerned institutions in the country. A coordinated Tree Improvement Network should be formed and include these institutions. Depending upon the mandate, specialised activities should be developed and implemented through this network. This network could work as a separate office with the experts from all the member institutions. Some suggested activities for the network include:

1. Identification of species diversity

More than 10 000 plant species are reported in Nepal but only 5400 plant species have been identified so far. There is a need to clearly identify and list out all rare, endangered and priority species.

2. *In situ* and *ex situ* conservation programme

In situ and *ex situ* approaches to conservation have significant roles in conserving and managing species genetic diversity. A clear policy and strategy should be developed for *in situ* and *ex situ* conservation.

3. Buffer zone management

Buffer zones in all national parks and wildlife reserves need to be managed to protect the core areas from population pressure.

4. Motivation of forest user groups

Forest users need to be motivated to conserve species and genetic diversity for their use in future generation.

5. Conservation through domestication

- Encourage farmers to domesticate and multiply rare, endangered and valuable species with appropriate technology.
- Identify other threatened species and develop technologies for domestication.
- Natural regeneration practices should be focused on Tree Improvement Programme.
- Management of community forests need to be improved as the Community Forest Operational Plan of the FUGs allow removal of single species in an operation based on use.

Since tree improvement studies are time-consuming, other priorities such as conservation of genes and biodiversity and the trend of returning to natural regeneration practices are taking over. Tree improvement research does not get the funding as it did in the past. Provenance trials established in the past under the tree improvement programme could, however, be used for *ex situ* conservation. They could function as gene reservoirs for populations that are either already extinct or are endangered in their natural habitat.

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Appendix 1

List of publications on seed, seedling, nursery and plantation research in Nepal

Year	Topic/title	Author(s)	Journal/Source
Seed scarification, storage and pre-germination treatment techniques			
1981	Provenance collection of *Alnus nepalensis* D. Don. (utis) seed	Lamichhaney, B. P.	NIFTIB 3
1981	The seed collection and propagation of oaks (*Quercus*) and chestnuts (*Castanopsis*)	Sharpe, A.L.	NIFTIB 4
1987	Pre-germination treatment of *Cassia siamea* and *Leucaena leucocephala* seed	Napier, I.	Banko Janakari 1(3)
1987	Seed storage in the nursery (*Prunus, Alnus*, and *Pinus* spp.)	Napier, I. and Robbins, A.M.J.	Banko Janakari 1(1)
1989	Limitations to the Seed Scarification on *Cinnamomum camphora*	Bruslem, D.F.R.P.	FRIC
Forest nursery research			
1980	Distribution seedlings and method of propagation of forest trees of Nepal	Lamichhaney, B. P. and Joshi, R. B.	FSRO Publication No. 3.
1981	Nursery notes- Damping off and root rots	Sharpe, A.L.	NIFTIB 3
1982	Nursery questionnaire: results of the 1980-81 survey	Sharpe, A.L.	NIFTIB 6
1984	Nursery research (1981-1984). End of assignment report	Sharpe, A.L.	SRP
1984	The use of mineral fertilizers in Nepal forest nurseries	Sharpe, A.L.	FSRO Publication No. 40
1985	The silvicultural trial unit nursery nutrition experiments 1982-1984	Westwood, S.	SRP
1986	Results of experiments conducted at Hetauda Forest Research Nursery 1984-1985	Westwood, S.	FSRO Publication No. 45
1989	Forest Seed and Nursery Practice in Nepal	Napier, I. and Robbins, A.M.J.	FRD
1989	Forest Seed and Nursery Practice in Nepal (*Nepalma ban biu tatha nursery prabidhi*)	Napier, I. and Robbins, M.	FRD
Propagation and germination techniques			
1983	Nursery growth problems		NIFTIB 9
1983	*Shorea robusta* - germination		NIFTIB 9
1982	Short Notes on Various Methods of Pre-treatment of Teak Seed	Lamichhaney, B.P.	FRIC
1982	Notes on germination of *Alnus nepalensis* (utis)	Lamichhaney, B.P.	NIFTIB 6
1982	Simple Techniques for the propagation of Stem-cuttings in Various Plants	Amatya, P.M.	FRIC
1983	The propagation of poplar and willow cuttings	Sharpe, A.L.	NIFTIB 8
1983	Seedbed protection against rodent and insect damage	Sharpe, A.L.	NIFTIB 9
1983	The production of naked root stock. A provisional recommendation	Sharpe, A.L.	FSRO Publication No. 37
1984	Optimum sowing times for important forest tree species in Nepal	Sharpe, A.L.	FSRO Publication No. 39
1984	Seedbed protection against rodent and insect damage	Sharpe, A.L.	FSRO
1988	Germination techniques for small seeded species in forest nurseries	Burslem, D.F.R.P.	FRIC
1988	Vegetative propagation of fodder trees. Preliminary research results and practical recommendations	Napier, I.	Banko Janakari 2(1)

Year	Topic/title	Author(s)	Journal/Source
1988	Initiation and development of roots in cuttings of three fodder tree species in Nepal	Parajuli, A. V.	Wolfson College, Oxford University, UK
1989	Germination techniques for small seeded species in forest nurseries in Nepal	Burslem, D.F.R.P.	Banko Janakari 2(2)
1989	Factors controlling the germination of *Grewia optiva*	Burslem, D.F.R.P.	Banko Janakari 2(2)
1989	Limitations to the use of seed scarification of *Cinnamomum camphora*	Burslem, D.F.R.P.	Banko Janakari 2(2)
1989	Germination of *Celtis australis*	Burslem, D.F.R.P.	Banko Janakari 2(2)
1990	In *Vitro* Propagation of *Ficus lacor* Buch. – Ham	Amatya, N. and Rajbhandary, S.B.	FORESC
1995	Optimum insertion times for vegetative propagation of *Ficus nerifolia* and *Saurauia napaulensis*	Thapa, H. B. and Burslem, D.F.R.P.	Banko Janakari 5(2)
1996	Optimum insertion times for vegetative propagation of *Ficus auriculata*, *Ficus semicordata* and *Artocarpus lakoocha*	Parajuli, A. V. and Flower, C.	Banko Janakari 6(1)
1996	Optimum insertion time for rooting of split and whole cuttings of *Saurauia napaulensis* and *Ficus nerifolia*	Thapa, H. B.	Banko Janakari 6(2)
Seedlings			
1976	Growth and development of chirpine seedlings in relation to nutrition, temperature and light.	Prajapati, K. P.	ANU, Canberra.
1978	Growth and development of chir pine seedlings in relation to nutrition, temperature and light.	Prajapati, K. P.	Nepal Journal of Forestry 1(4)
1987	Large plants for farmers.	Napier, I.	Banko Janakari 1(2)
1987	Early growth of some fodder trees at Hetauda and in the Kathmandu valley.	Napier, I. and Parajuli, A.V.	Banko Janakari 1(3)
1987	The optimum growing period in the nursery for six important tree species in lowland Nepal.	Westwood, S.	Banko Janakari 1(1)
1991	Large transplants ("large seedlings") or stumps?	Paudel, H. L.	Banko Janakari 2(3)
1992	Bare rooted planting of *Alnus nepalensis* D. Don. in Nepal.	Lamichhaney, B. P.	Banko Janakari 3(2)
1996	Effect of root pruning and spacing on seedling growth of *Ficus semicordata* and *Bauhinia purpurea*	Parajuli, A. V. and Flower, C.	Banko Janakari 6(2)
1999	Yield of *Morus alba* cutting under different stool-bed regimes at Chalnakhel nursery.	Thapa, H. B.	Banko Janakari 9(1)
Seedling supply strategy and nursery management			
1993	Development of Seedling Supply Strategy to Meet the Needs of the Community and Private Forestry Program	Epstein, D.M., *et al*.	FORESC
Agroforestry and tree fodder research			
1990	A case study on Lending Policies geared to sustainable agriculture and forestry in Nepal	Amatya S M	A paper presented to FAO
1991	Raising fodder trees on the farmland: a preliminary study of farmers' attitude	Amatya, S M	UK agroforestry discussion forum, Bangor
1992	Problems of Raising Fodder Trees: A study of Farmer's concept	Amatya, S.M.	NFA
1993	Design of agroforestry research trial on the Terai	Amatya, S.M. and Kiff, E.	Proceedings of Regional Seminar

Year	Topic/title	Author(s)	Journal/Source
1993	In the process of fodder research: Guajuma ulmifolia [in nepali]	Amatya, S.M.	Kalpabrikha 3 (31)
1993	Tree fodder establishment trials in the Middle Hills of Nepal	Amatya, S.M.	Forests, trees and people newsletter No. 22.
	Fodder trees		
1985	Trees as fodder crops	Robinson P.J.	NIFTIB 11
1989	Research needs in fodder trees	Robinson P.J. and Thompson I.S.	Proceedings of the workshop on research needs in livestock production and animal health in Nepal, Kathmandu Nepal
1990	Spotlight on species: *Ficus semicordata*	Amatya, S.M.	Farm Forestry News 4 (1):6
1990	Collecting Khanyu (*F. semicordata*) figs for seeds: a practical application	Amatya, S.M.	Proceedings of the third meeting of the working group on fodder trees, forest fodder and leaf litter
1990	Summary of results of a survey on vegetative propagation of fodder trees by farmers	Robinson P.J. and KC, S.	Proceedings of the third meeting of the working group on fodder trees, forest fodder and leaf litter
1990	Some results of the Dolakha Privat tree survey	Robinson P.J.	Proceedings of the third meeting of the working group on fodder trees, forest fodder and leaf litter
1991	Focus on Oak Forest	Mathema, P.	Banko Jankari 3(1)
1991	*Ficus semicordata:* a multipurpose tree species for the lower hills of Nepal	Amatya, S.M.	Proceedings of Multipurpose tree species in Asia and Pacific, Los Banos, Philippines
1992	Spot light on species *Sapindus mukorassii*	Amatya, S M	Farm Forestry News 6(2)
1993	Agroforestry in Nepal: Research and practices	Amatya S.M. and Newman, S.	Agroforestry systems 21(3)
1994	Agroforestry Systems and Practice in Nepal	Amatya, S.M.	Department of Forest
1994	Intra specific variation in *Ficus semicordata* in Nepal	Amatya S.M.	Banko Janakari 4(2)
	Planning fodder management		
1983	Farm Fodder trees in Nepal: patterns of ownership and use	Hawkins, T.	NIFITIB 9
1986	Provisional guide to site-species matching for Nepal	Teare J.A. and Howell, J.H.	FSRO Soil Technical Note No 8

Year	Topic/title	Author(s)	Journal/Source
1986	Fodder Tree Research in Nepal: A brief review of past work and future needs	Robinson P.J.	Proceedings First Farming Systems Workshop
1986	Investigations of tree use in Farm: An example from the Tamang Community at Gairigaon	Thompson, I.S., Robinson P.J. and Shakya R.	Proceedings Third Farming Systems Workshop
1987	Proceedings of the First Meeting of the Working Group on fodder trees, forest fodder and leaf litter	Robinson, P.J.	FRIC Occasional Paper No 3/87
1988	Proceeding of the second meeting of the working group on fodder, fodder trees, forest fodder and leaf litter	Robinson, P.J.	FRIC Occasional Paper 2/88
1988	FRP activities related to fodder trees and forest fodder	Robinson, P.J.	In FRIC Occasional Paper 2/88
1988	Fodder tree survey in South Lalitpur	Upton, P. and Robinson, P.J.	In FRIC Occasional Paper 2/88
1989	Fodder trees research needs	Robinson, P.J. and Thompson, I.S.	Proceeding of 2nd NARSC, FSRDD
1990	Effect of Altitude, Aspect and Season on the Use of Fodder Tree Species in South Lalitpur District	Upton, P.	Banko Jankari 2(2)
1991	Country-wide survey of farmer's knowledge and perception about tree fodder – 1990	Upadhyay, L. R.	FRD Occasional Paper No 1/91
1991	Fodder trees and their lopping cycle in Nepal.	Amatya, S.M.	Janmabhumi Press
1991	Grazing impact on forest resource	Amatya, S.M.	NFA 6 (2)
1991	Tree crop interaction	Robinson, P.J., Amatya, S.M. and Philip, M.S.	Fifth Farming systems working Group meeting
1992	Use of tree fodder in Jhapa and Sunsari Districts in the eastern Terai	Upadhyay, L.R.	Banko Jankari 3(3)
1993	Regional Seminar on fodder trees, forest fodder and leaf litter	Mathema, P. (ed)	DFRS
1993	Study on fodder tree establishment in Central Hill Region	Amatya, S.M.	Kalpabriksha Vol 2 No 21
1993	Study on growth rate of *Acacia catechu*	Amatya, S.M.	Kalpabriksha Vol 3 No 25
1994	Growth and Production Figures for *Leucaena leucocephala* and *Ficus nerifolia* Grown on Terrace Riser	Amatya, S.M. and Kiff, E.	Banko Janakari. 4(2)
1996	Financial returns in the Nepali agroforestry Models	Amatya, S.M.	Banko Jankari 6(2)
	Managing fodder trees		
1984	Fodder Tree Seedling Survival Rate	Hopkins, C.C.G.	FRIC
1987	Evaluation for multipurpose tree growth, yield and value: issues in methodology	Robinson P.J. and Thompson I.S.	Multipurpose Tree species for small farm use workshop November 1987

Year	Topic/title	Author(s)	Journal/Source
1989	Variation of *Ficus semicordata* Buch. Ham. Ex. Smith *sensu lato* – Its Taxonomy, Distribution and Use as a fodder tree in Nepal	Amatya, S.M.	Oxford University
1993	Tools and Techniques used in Agroforestry: an overview		NFA VII (2)
1994	Management Options for *Ficus subincisa*	Amatya, S.M., Bowen, M.R. and Harvey, S.	FORESC
1984	Trees as Fodder Crops	Mathema, P.	FORESC
Plantation and plantation management research			
	Selecting species		
1982	Provenance variation of *Alnus nepalensis*	Lamichaney, B. P.	Unpublished
1983	*Pinus caribaea*: Early provenance trial results	Joshi, M. R.	NIFITIB 9
1985	Variation of *Alnus nepalensis* D. Don. in Nepal. Summer trial at Pakhribas (Dhankuta)	Lamichhaney, B. P.	NIFITIB 11.
1987	Choice of species for afforestation in the mountains of Nepal	Howell, J. H.	Banko Janakari 1(3):7-14
1988	The Species Site Requirements for Nepal	Howell, J.H.	FRSO
1989	Six Nepal Provenance of *Dalbergia sissoo* Roxb	Neil, P.E.	FRIC
1989	Preliminary provenance testing of *Dalbergia sissoo*	Neil, P.	Banko Janakari 2(2):113-114
1989	Eucalyptus, or other exotics, or indigenous species?	Neil, P.	Banko Janakari 2(2):109-112
1990	Preliminary results from trials of exotic acacias	Neil, P.	Banko Janakari 2(3):213-219
1990	Some promising early species results from the Bhabar Terai	Neil, P.	Banko Janakari 2(3):279-280
1990	*Gliricidia sepium* provenance testing in Nepal	Neil, P.	Banko Janakari 2(4):399-402
1990	*Indigofera teysmannii* – a species for the Terai and Bhabar Terai	Neil, P.	Banko Janakari 2(4):403-405
1990	*Leucaena leucocephala* variety trial in Nepal	Shakya, R.	Nitrogen Fixing Tree Research Reports 11:84-85
1990	*Dalbergia sissoo* provenance testing in Nepal	Neil, P.	Nitrogen Fixing Tree Research Reports 8:130-132
1991	Preliminary results of broadleaved species in the Middle Hills of Nepal	Shakya, R.	Banko Janakari 3(1)
1992	Provenance trial of *Gliricidia sepium* in Dhankuta District	Sherpa, S.L.; Joshi, L. and Shakya, R.	Banko Janakari 3(3)
1997	Appropriate Tree Species for Plantation in Waterlogged Sites in Terai Region Of Nepal	DFRS	DFRS
2001	Preliminary findings on provenance trial of *Azadirachta indica* in western Terai, Nepal	Thapa, H. B.	Banko Janakari 11(1):39-43
	Plantation research		
1976	Planting tropical pines in Nepal	Amatya, D. B.	FRSO Publication No. 27
1980	Silvicultural Trials Unit. Research Report. Planting Programme –1980 Report	FSRO	
1981	Silvicultural Trials Unit. Research Report. Planting Programme –1981 Report	FSRO	
1982	*Eucalyptus* species for energy production	Amatya, S.M.	Tribhuwan University
1982	Silvicultural Trials Unit. Research Report. Planting Programme –1982	FSRO	FRIC

Year	Topic/title	Author(s)	Journal/Source
1983	Silvicultural Trials Unit 1983. Planting Programmes Report	FSRO	
1983	The potential role of *Leucaena leucocephala* in forestry in Nepal	Hawkins, T.	NIFITIB 8
1985	An interim report on tree species trials in Resource Conservation and Utilisation Project (RCUP) area	Joshi, R. B.	Unpublished report.
1985	Tistung Trial Sites. Silvicultural Trials	FSRO	
1985	Planting Summary. Silvicultural Trials Unit	FSRO	
1986	Adabhar trial research results	Hawkins, T.	
1987	Forestry Research Compendium – to 1986	Hudson, J. M.	FRIC Occasional Paper No. 1/87.
1987	Forestry Research in Nepal up to 1986	Hudson, J. M.	Banko Janakari 1(2):3-14
1987	New Forestry Research in Nepal, 1987	Hudson, J. M	FRIC Occasional Paper No. 1/88.
1989	New Forestry Research in Nepal -1988	FRD	Unpublished
1989	Research Experience with pines in Nepal	Neil, P.	Banko Janakari 2(2):103-107
1990	Early performance of *Paulownia* species	Neil, P.	Banko Janakari 2(3):220-222
1990	Establishment techniques for broadleaved tree species in the middle hills of the central region of Nepal	Shakya, R.	Unpublished
1990	Research trends and the forestry research database for Nepal	Neil, P.	FRIC Occasional Paper 1/90.
1990	Plantation establishment pattern for community forestry plantation in the Bhabar Terai	Shakya, R.	Banko Janakari 2(4):407-409
1990	Experience with Australian acacias in Nepal	Neil, P.	Nitrogen Fixing Tree Research Reports.
1990	Possible techniques for raising and planting sandalwood in Nepal.	Neil, P.	Banko Janakari 2(3):223-228
1991	A role for *Pinus maximinoi* and *Pinus greggii* in Nepal's afforestation efforts.	Neil, P.	Commonwealth Forestry Review 70 (40):191-200
1994	Effect of Application of Compost, Fertilizer and Plastic Mulching on the establishment and growth of *Prunus cerasoides*, *Ficus auriculata, Ficus semicordata* var. *montana Amatya,* and *Ficus nerifolia*	Suwal, M.R., Shrestha, R.K. and Thapa, H.B.	Lumle Agricultural Centre
1994	Manual of afforestation in Nepal (two volumes)	Jackson, J. K.	FRD
1994	Forest Research in Nepal - Contribution towards environment conservation	Joshi R.B. and Amatya, S.M.	Regional Conference on Environment and Biodiversity
	Growth and productivity of plantations		
1982	Some preliminary estimate of the productivity of plantation grown *Tectona grandis* and *Dalbergia sissoo* at Sagarnath, Nepal	Joshi, M.R	FRSO Publication No. 35
1992	A comparison of growth rates and development of some fuel wood tree species in the eastern Terai of Nepal	Thapa, H.B.	Unpublished

Year	Topic/title	Author(s)	Journal/Source
1994	Growth performance of *Dalbergia sissoo* as fuel wood species in lowland of Nepal	Joshi, R.B.	Banko Janakari 4(2):154-156
1997	Early growth performance of some tree species on waterlogged sites in Nepal's Terai	Joshi, R.B.; Thapa, H.B. and Oli, B.N.	Banko Janakari 7(1):10-14
1997	Growth performance of *Dalbergia sissoo* provenances of Nepal and Pakistan	Joshi, R.B. and Thapa, H.B.	Banko Janakari 7(2): 27-31
1998	Growth of five fast growing tree species in the Terai of Eastern Region of Nepal	Thapa, H.B.	Banko Janakari 8(2): 14-22
1998	Early selection in tree breeding programme: a review	Dinesh Karki and S.J. Lee	Banko Jankari 8(2)
2001	Growth and fuel wood production of *Cassia siamea* and *Eucalyptus camaldulensis* under short rotation in the eastern Terai of Nepal	Thapa, H.B. and Subedi, N.	Banko Janakari 11 (2): 34-41
	Plantation management		
1982	Some preliminary indicators from research for forest management guidance in the hills of central Nepal	Joshi, M.R. and Wyatt-Smith, J.	NFTIB. 7
1982	Planting with naked-root stock (preliminary results)	Joshi, M.R.	NFTIB. 7
1987	A greater role for broadleaved species in the mid-hills	Shakya, R. and Thompson, I.	Banko Janakari 1(2): 18-20
1987	Tree planting and natural succession at Pipal Chaur, Sankhu	Thapa, H.B. and Budhathoki, S.K.	Banko Janakari 1(3): 15-16
1987	Early thinning and pruning yields from *Pinus patula*	Thapa, H.B.	Banko Janakari 1(3): 17-20
1988	Invasion of pine plantation by broadleaved species	Thompson, I.	Banko Janakari 2(1): 66-67
	Species/Plantation Silviculture Research		
1982	*Pinus patula*	Neville, G.A.	FRIC
1988	Eucalypt provenience research in Nepal	Neil, P.E.	IUFRO meeting, Pattya, Thailand
1989	Variation of *Ficus semicordata* Buch. Ham. Ex. Smith *sensu lato* – Its Taxonomy, Distribution and Use as a fodder tree in Nepal	Amatya, S.M.	Oxford University
1989	*Ficus semicordata* Buch. Ham. Ex Sm. and Its Taxonomy	Amatya, S.M.	FRSD
1990	Notes on *Acrocarpus fraxinifolius*	Neil, P.	Banko Janakari 2(4): 391-393
1992	Notes on carob tree (*Ceratonia siliqua*)	Amatya S.M.	Banko Janakari 3(4)
1992	Sissoo	Mathema, P.	FORESC
1993	*Dalbergia sissoo*: A Compilation of Papers Published in Nepal	Forest Research Division	FORESC
1995	*Alnus nepalensis* D. Don. (A detailed study).	Lamichhaney, B.P.	FORESC Monograph 1/95.
1998	Neem: Parichaya Tatha Ek Prarambhik Adhyayanko Natija (Neem: Introduction and results of one preliminary study)	Thapa, H.B.	Abhiyan 1(2):12-18. Balkot Development Society. September 1998.
1998	Teak	Thapa, H.B.	FORESC
1993	Ritha: A cash earning tree	Amatya S.M. and Chapa D.R.	Nepal Journal of Forestry 21 (3)
	Special research		
	Economics of conventional and taungya fuelwood plantations	Hawkins T., Hocking D.	

Appendix 2

Summary of major publications and reports in forestry research

Subject area of documentation	No. of documents
1. Soil survey and analytical laboratory research	**65**
Supporting soil management	13
Supporting planning of plantation activities	22
Supporting plantation management	18
Other soil activities	12
2. Seed, seedling and nursery techniques research	**45**
Seed scarification, storage and pre-germination treatment techniques	5
Forest nursery research	9
Propagation and germination techniques	21
Seedlings	9
Seedling supply strategy and nursery management	1
3. Agroforestry and tree fodder research	**30**
Agroforestry and fodder research	5
Fodder trees	7
Planning fodder management	14
Managing fodder trees	4
4. Plantation and plantation management research	**66**
Selecting species	18
Plantation research	24
Growth and productivity of plantations	8
Plantation management	6
Species/plantation silviculture research	10
5. Bamboo research	**13**
Growth research	1
Utilization research	2
Bamboo ecology and distribution	3
Propagation	3
Special research in Bamboo	4
6. Natural forest silviculture and management research	**14**
Growth studies	2
Regeneration management	1
Research on techniques of natural forest management	9
Soil conservation	2
7. Researching techniques of quantification and qualifying forests	**24**
Developing mensuration tools	12
Biomass and volume relations	3
Site Index research	1
Measuring trees and forests	8
8. Researching tree and forest health	**28**
Nursery	4
Plantations	15
Bamboo	1
Natural forests	4
Causal elements in Nepal	4
9. Forest policy and plans	**3**
10. Extension techniques research	**17**
11. Special research	**11**
12. Forest products research	**4**
13. Community/participatory and private forestry studies	**18**
14. Non-timber forest products research	**10**
Silvicultural considerations	1
Survey and inventory techniques	3
Management plans for NTFP management	1
Marketing	1
Special studies	4
TOTAL	**359**

Appendix 3

Provenance trial of chir pine (Pinus roxburghii) and its scope in Nepal

Chir pine (*Pinus roxburghii*) is an important native conifer tree species in Nepal. It has dominated the coniferous forests of the country, which comprise 17% of the total forest area. There has been a great interest during the 1980s in chir pine plantation because of the high survival rate and ease of establishment of the species. In 1981 and 1982, 57% of all trees planted by the Community Forestry Development Project were chir pine. It was considered a suitable pioneer species for the rehabilitation of severely degraded exposed sites of the hill.

Community forestry is a major activity in the hills of Nepal. It mainly focuses on the fulfilment of immediate needs of farmers for fuelwood and fodder. Since pine needles have no use as fodder and is also less preferred by the local people for fuelwood, chir pine plantations have generated considerable debate among the public. Thus, forestry personnel have been compelled to start planting more socially acceptable broadleaf tree species on degraded sites regardless of their ecological adaptability. The consequence is a large-scale mortality in many community forestry plantations such as in Sindhu Palchowk and Kavre Palanchowk districts of Nepal.

Chir pine is used for various purposes. It is serving as a major construction timber in hilly areas and even in cities like Kathmandu it is the best alternative construction timber. It is also widely used for making furniture. There are hundreds of furniture factories operating in Nepal, many of which are unable to operate at full capacity due to the shortage of raw materials. Similarly, two plywood mills have been operating at 52% capacity due to the shortage of raw material. Sustainable management of the chir pine forests could contribute to the alleviation of these shortages. In addition, resin from chir pine trees is used to manufacture turpentine, rosin and other products. In many inaccessible forest patches of the country, where timber production is not practicable, chir pine forest could be used solely for resin collection. HMG, ADB and FINNIDA estimated in 1988 that the requirements of existing rosin and turpentine industries would be 6600 metric tonnes by 2010–2011.

Chir pine has a potential to uplift the rural economy through the establishment of industries and opportunities employment. Chir pine-based industries could be a viable option to mitigate the domestic demand and earn foreign currency by exporting required products to international markets.

The Forest Research and Survey Centre (FORESC) has established a chir pine provenance trial in Syanja district. Eight provenances of Nepal are being tested.

Appendix 4

DFRS/FORTIP collaboration (Dinesh Karki 1997, unpublished)

What is FORTIP?

FORTIP is the abbreviated title of the UNDP/FAO Regional Project on "Improved Productivity of Man-Made Forests through Application of Technological Advances in Tree Breeding and Propagation". It is one of the leading UNDP/FAO supported forestry programmes in the Asia and Pacific region aimed at improving forest productivity through genetic enhancement of forest trees.

Tree improvement programme and FORTIP's support to Nepal

The first meeting of Tree Improvement Programme was held at DFRS in 1992. Together with the FORTIP representative Mr N.Q. Zabala, many forestry professionals from different departments attended the meeting. The meeting listed ten important forest tree species in Nepal for tree breeding and propagation research (for results, see Table 5).

As regards the aspects of national tree breeding and propagation, TISC and the DFRS discussed and agreed on the activities that each agency would undertake. The main goal of this meeting/discussion was to avoid duplication of work and reinforce each other's efforts. On that basis, the DFRS had a mandate to conduct tree breeding and propagation activity on four species (*Alnus nepalensis, Eucalyptus camaldulensis, Artocarpus lakoocha* and *Pinus roxburghii).*

In addition, the DFRS has initiated the establishment of a potted seed orchard for *D. sissoo* and *Eucalyptus camaldulensis* from juvenile cuttings. The construction of a greenhouse at Butwal was initiated in 1995 with financial support from FORTIP. This was a three-year cooperation between the DFRS and FORTIP, which provided financial and technical assistance. However, the DFRS did not receive further financial support from FORTIP after one year, as a result, construction of the greenhouse at Butwal has been halted.

With the existing greenhouse facilities, basic research such as germination and propagation tests are conducted. However, for the establishment of a potted seed orchard it would be necessary to construct and improve the conditions of this greenhouse. Basic requirements of the Butwal greenhouse at present are glass covering all around the greenhouse and installation and maintenance of a water supply system. Another important need is the establishment of a humidity and temperature control system.

Status of forest genetic resources conservation and management in Pakistan

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Introduction

Forest genetic resources (FGR) play an important role in offering numerous goods and services to mankind and also in mitigation pollution and providing a good source of revenue to national governments. Pakistan has about 4.8% of forest cover. Forests help to monitor the flow of rivers in the north and regulate siltation in two important dams. Forest trees also meet the demand of small scale farmers for fodder, timber and fuelwood as almost 90% of the firewood requirements are met from trees grown on farmlands. With an annual increase of 3%, the total population would reach 150 million by the end of 2003 and then the demand for timber and fodder would increase along with an increase in livestock especially among the poor rural communities who depend on these forests. The natural forests also provide good shelter for important medicinal herbs as well as suitable habitats for wildlife. Although the forest area is small, all forest types occur in Pakistan ranging from arid zones to dry/wet temperate ecosystems. Forests of Pakistan are spread over 4 263 000 ha. Based on altitude and rainfall pattern, forests can be broadly classified into the following four categories:

i) High altitude coniferous forests

The high altitude coniferous forests lie between 1200 to 3200 m asl. with a small percentage (<25%) of broad-leaved species. Important coniferous genera include *Abies, Pinus, Cedrus* and *Picea*. The few major broad-leaved genera include *Acer*, *Betula*, *Fraxinus* and *Taxus*. The total area of such forests is 1 928 000 ha, which constitutes about 45.2% of the total forest area. These forests provide an array of products as shown in Table 1 below:

Table 1. Multiple uses of high altitude coniferous forests in Pakistan

Use	No of species	Use	No of species
Timber	15	Fodder	20
Medicine	28	Fruit/Food	18
Fuelwood	14	Small wood	12
Ornamental	6	Resin etc.	2
Soap	2	Honey harvesting	4

ii) Low altitude (<1200 m) broad-leaved species forests

These forests cover an area of 520 000 ha of irrigated and foot hill plantations in Punjab and Sindh consisting of *Populus* sp. (poplar), *Dalbergia sissoo* (shisham), *Bombax ceiba* (semal), bakain, *Morus* sp. (mulberry) and *Eucalyptus*. The aridity is mostly compensated by irrigation.

iii) Agroforestry plantations

Farmers have been planting trees on their lands for centuries. Recently, these activities have been accelerated by the Forestry Planning and Development Project (1985–1996) and are now continued under forestry sector projects in each province. The most common species are eucalypts, bakain, semal, poplars, acacias, *Prosopis*, shisham and mulberry. The local requirements of farmers for fodder, fuelwood and poles are readily met from trees planted singly or in rows or in block plantations. A modified form of agroforestry system called "Hurry" is also practised in Sindh where 2–4 acres of land have been set aside to raise plantations of *Acacia nilotica* only. These plantations cover an area of about 200 000 ha. Farmers have also started to establish their own nurseries about two decades ago to increase tree cover especially on marginal lands.

iv) Coastal and riverine forests:

Located in the extreme southern part of Pakistan as well as along the banks of rivers *viz.* Indus, Chenab and Ravi, these tracts are rich in species like poplar and acacias. The coastal areas consist of valuable species of *Ceriops tagal*, *Aviecienia officinalis* and *Rhizophora mucronata,* which had been badly affected by river pollution in the recent past. A survey has indicated that nearly 21% of the coastal forests have been degraded and has adversely affected regeneration and growth of these species. The scarcity of water as well as the diversion of river flow due to construction of dams have degenerated *Populus euphratica* forests along riverbanks. There is a need to conserve this valuable genetic resource immediately. Such forests are spread over 345 000 ha.

Shelterwood system is generally used to manage natural stands of coniferous and broad-leaved species while irrigated plantations are managed through clear-cut felling by the provincial forest departments. Permission has to be obtained from the Forest Manager to fell a tree on a farmland by any farmer. Trees planted by the sides of roads and canals are also looked after and managed by the Forest Department. Currently national afforestation programmes are in operation to encourage tree cover on private lands through community participation. The scrub forests with sparse vegetation cover of about 1 271 000 ha mainly constitute scattered arid zone species like *Zizyphus*, *Acacia*, *Prosopis* and *Olea*. These plantations have undoubtedly reduced demand pressure of timber (as poles) and fuelwood from state forests.

Conservation of FGR

In the past, forests have been managed by the Provincial Forest Departments mainly for protection. It was only during the last three decades that production through involvement of local communities, had been given due consideration. As the FGR are mainly confined to mountainous areas of northern Pakistan, afforestation of logged over areas has been exclusively carried out by the Provincial Forest Departments sponsored by foreign aid agencies such as the World Food Programme (WFP), ADB, UNHCR, Swiss Development Agency, GTZ and FAO/UNDP. Indigenous species have been used with little consideration for conservation or use of quality planting stock. Stand conservation in the sub-continent has been practised since the mid-1940s in the form of "Preservation Plots" wherein the original flora of a compartment were maintained and preserved on scientific lines. However, no efforts were made during the last four decades to continue this system. By and large, as the human population pressure and livestock increased, the natural forests were not given due attention that they would have deserved. The genetic origin of the planting stock was of poor quality; seeds were collected from genetically inferior stands, which later on resulted in low survival and productivity in plantations. As for artificial regeneration, planting of less important species e.g. *Ailanthus* and *Robinia* in *Pinus roxburghii* (chir pine) stands has not only upset the natural ecosystem but also further masked FGR conservation efforts. These operations were supplemented by constructing check dams to improve water catchment areas, which resulted in degradation in the coniferous forests.

There is still a need to support such activities by establishing *ex situ* and *in situ* conservation stands. On account of the lack of proper FGR conservation measures, *Rhododendron*, an important native species associated with chir pine, is almost extinct and steps for *in situ* conservation of this species should be undertaken to rehabilitate and restore the ecosystem. There are also several other forest species that require special conservation efforts as these have several uses besides land stabilization and amelioration of the environment. These species are listed in Appendix 1. However, the species listed in Appendix 1 are not included in large-scale afforestation/artificial regeneration programmes but are important components of the ecosystems. The associated multipurpose tree food species (MPTFS) occurring in different ecological zones are also important for food security and many of these are either extinct or endangered in their native habitats (Shams R. Khan 1998).

Since seeds have often been collected from inferior trees/stands, the health status of plantations raised from such genetically poor sources may not be satisfactory (Blake 1991). There have been severe attacks of *Pinus wallichiana* (kail, blue pine) defoliators in the blue pine forests, which were later controlled by biological means. Low seeding in chir pine is a problem for the establishment of conservation stands. Provincial forest departments are not working on any FGR conservation activities. The Pakistan Forest Institute, Peshawar (PFI) did establish some species/provenance/progeny trials of over 12 ha to improve the coniferous forests of Pakistan. The study on isozymes has helped to identify highly diverse populations of chir pine to establish seed stands. Little or no research work has been done on *Abies, Picea, Cedrus, Acer, Taxus* or A*lnus* growing in coniferous forests in Himalayas. Plantations of major species in the natural stands of coniferous forests have been established in the recent past, but the provincial forest departments have ignored aspects of conservation of rare FGR. A separate R&D Directorate in the NWFP Forest Department has been created only a couple of years ago. This institute will hopefully undertake conservation and management activities in the future.

Similarly, several broad-leaved species in the plains are also either extinct or endangered as these have not been included in afforestation programmes. In order to improve seed collection and storage conditions, a seed centre has also been established in Azad Jammu & Kashmir to undertake preliminary seed testing programmes (Roshetko 1995).

Past and present research activities in conservation, utilization and management of FGR

The Pakistan Forest Institute, Peshawar (PFI) and Punjab Forestry Research Institute, Faisalabad (PFRI) are the only institutes working on forestry research at national level. The former is federally administered while the latter is a provincial organization. Under this set-up, there are little or no coordinated efforts between the two organizations for conservation and management of FGR. Located in two distinct ecological zones, the PFI has been handling genetic improvement work in the natural coniferous forests while the PFRI had undertaken studies in irrigated as well as farmland plantations. The activities of both institutes have been mainly confined to collecting and supplying quality seeds from plus trees and stands with little efforts towards conservation and management of rare and endangered species. A genebank with a storage capacity of 20 000 kg seed has been established at the PFI during early 1990s wherein *ex situ* conservation of target species has been undertaken. However, this facility could not be utilized to its full capacity due to lack of interest and knowledge of stakeholders in the conservation of FGR. Until and unless these activities are included in the national forest policy, conservation of FGR cannot be increased to the desired level. Establishment of seed stands as *in situ* conservation stands over an area of 8 ha is one step towards this direction. These stands are also ideal sites for conserving several other endangered associated species.

Conservation and use of *Pinus wallichiana*

Detailed ecogeographic studies in the natural forests of *Pinus wallichiana* suggest strict avoidance of transfer of germplasm from xeric to mesic habitats and vice versa. In addition, one ecotype (*Pinus wallichiana* var. *karakorama* Khan) has been found resistant to blister rust (Shams R. Khan 2001). This information could be effectively used to establish rust free *ex situ* conservation stands in Europe and America. However, due to geographically isolated small stands of this variety in Pakistan, there is a dire need to establish *in situ* and *ex situ* conservation stands. Besides these efforts, an area of 1000 ha (10.2% of the total area of occurrence of the species) has been declared as "protected areas" in some ecological zones, which could be used to restore this variety. *In situ* conservation studies are exclusively handled by the Provincial Wildlife Department with little coordination among field foresters and researchers. Such coordination needs to be further strengthened.

In vitro studies and micropropagation

Attempts on micropropagation (*in vitro* studies) of endangered species have not been undertaken so far on any tree species of economic importance in Pakistan. However, in case of dieback of *Dalbergia sissoo* (prevalent in Nepal and India also), use of biotechnological techniques might bring about desired results to control the disease. Similarly, such studies might be useful in the conservation of *Populus euphratica,* which is an industrially important endangered riverine tree species in the plains of Pakistan.

Choice of species for conservation

Considering, the efforts made in the past to restore important biomes and the multiple uses of several species, a number of exotic and indigenous species could be used so that the endangered native species are conserved. Proper and timely conservation measures are required for this purpose (Appendix 2). Most of the exotics have been successfully introduced recently and large-scale establishment of conservation cum demonstration plots is therefore recommended to rehabilitate the fragile ecosystem in the country. This is not an exhaustive list and could be updated at a national workshop on the conservation and management of FGR through participation and involvement of several stakeholders. Appendix 2 also indicates that so far no *in situ* conservation stands of any endangered indigenous species have been established and the number of individual tree species could still diminish unless protective measures are taken.

Natural forests in Pakistan represent a mixture of native coniferous and broad-leaved species and therefore, an ecological balance must be maintained through an appropriate mix of *ex situ* and *in situ* conservation stands. Several timber species, e.g. *Ulmus, Quercus, Fraxinus, Taxus* and *Picea* are endangered or vulnerable. Most of the fodder species like *Ficus, Prunus, Grewia* in the sub-tropical zone, and *Acer, Aelagnus* and *Quercus* in the temperate forests are disappearing at a very fast rate. These are considered low priority species by field foresters and are not included in any artificial regeneration programmes. Similarly, the inhabitants in hilly areas use the valuable wood of *Cedrus deodara* as firewood because of ignorance and easy accessibility. The pressure on these forests could be reduced if some alternatives for cooking and for heating were provided to the local people. Forest and soil degradation could be reduced if the original native flora was restored. Some surveys and regeneration studies on non-timber species have been undertaken by the PFI in the past on limited scale but these could not be developed and included in large-scale afforestation programmes at provincial level (Anwar A. Khan 1990). These native woody herbaceous and non-herbaceous genetic resources not only fulfil the basic needs of the local communities but also stabilize the eroded areas in the Himalayas, as they are the important components of the whole ecosystem.

Since species like *Quercus*, walnut, *Aesculus*, etc. are recalcitrant *ex situ* conservation as seeds is not possible. However, the establishment of *in situ* conservation areas and use of biotechnological techniques in certain species may help to promote and improve the status of FGR in the country. Conservation and management of coastal forest tree species is a challenging job because of difficulties in storage of seeds. Availability of firewood is another problem in the area as no other energy source is available.

In addition to the problems mentioned above, several biotic and abiotic factors (over-grazing, clearing of land for agriculture), pollution and construction of dams are some of the major direct causes for the genetic erosion of valuable FGR in Pakistan (Appendix 3).

In the past the PFI has successfully introduced some exotics to improve the biodiversity in different ecosystems in the country. In some cases they outperformed the native species in terms of survival and growth. If introduced species are found better and are posing no threat to the natives, they may be continued to be tested and included in tree improvement programmes and rehabilitation of degraded lands which in turn can help to reduce the pressure on natural forests. Being less aggressive, none of the above species have posed any threat so far, but rather enhanced net productivity, as these were found better than native ones (Pakistan Forest Institute's Annual Progress Reports 1980–2002).

Socioeconomic conditions and issues related to conservation, utilization and management of FGR

The activities of forest genetic resources conservation should be based upon the following three objectives for the benefit of the people:

1. Conservation efforts to meet the demand for timber for house construction
2. Conservation and management of fuelwood plantations to ensure sustainable supply of firewood especially in winter
3. Conservation and management of rangelands to ensure constant supply of endangered fodder trees to feed livestock in winter when the grasses are not available

Numerous protected areas have been established but they still do not represent and cover all forest types. So far, species/stands of high diversity have not been identified except in chir and blue pine forests. Similarly, forest habitats of rare or endangered species have not been conserved due to the weak link between field staff of forestry sector and professionals of FGR. There is also very little coordination between different sectors such as the Food, Agriculture and Livestock Department and wood-based industries. For example, an industrial woody species, *Dalbergia sissoo* has been severely attacked by dieback in the recent past, to which no concrete control measures have been developed so far. A few species occurring in riverine areas like *Tamarix aphylla* and *Populus euphratica* are excellent species for wood carving and can easily be utilized when the trees are around 10 years age. *Populus euphratica* is being threatened and needs immediate concrete steps for *in situ* or *ex situ* conservation. If a sustainable conservation and utilization effort could be put in place, the socioeconomic conditions of the rural poor could be improved, as *Populus euphratica* is the best species to develop cottage industry at village level in certain parts of Pakistan. *Populus, Morus* and *Salix* are the three important genera suitable for the sports industry largely located in the north-eastern part of Pakistan. There is a need for a strong link between production and utilization of these species and the wood industries and managers of FGR to be established at national level.

Similarly, with the collaboration of the Ministry of Education, UNESCO declared Lal Suhanara National Park as a MAB Biosphere Reserve in 1977, which was done without taking into confidence of the National Council for Conservation of Wildlife (NCCW), IUCN or WWF. The result was duplication of efforts and wastage of funds. These examples demonstrate the lack of linkages among different but highly related areas in FGR conservation and management. Based upon aforementioned discussion, a list of priority species for conservation, improvement and seed procurement is given in Appendix 4.

Identification of national priorities

In a national workshop in 1993 the following species were identified as priority species for different provinces (Table 2):

Table 2. Priority species for afforestation in different provinces in Pakistan

NTFPs	Punjab	Sindh	Balochistan	AJK & NA
Pinus wallichiana	*Dalbergia sissoo*	*A. nilotica*	*Acacia victoriae* (exotic)	*P. roxburghii*
P. roxburghii	*A. nilotica*	*E. camaldulensis*	*Acacia albida* (exotic)	*Pinus wallichiana*
Cedrus deodara	*Bombax ceiba*	*Conocarpus lancifolius*	*Pinus halepensis* (exotic)	*Robinia pseudoacacia*
Eucalyptus. camaldulensis	*P. deltoides*	*Albizia procera*	*E. camaldulensis*	*Ailanthus altissima*
Acacia nilotica	*E. camaldulensis*			*Sapindus mukorossi*
Populus deltoides				

The workshop, however, did not discuss the status of conservation of other important species found mixed in the natural stands and which are utilized to meet the needs of forest communities. It was found that almost all provinces needed large quantity of seeds of several species, and in almost all afforestation programmes quality was totally ignored in order to achieve high planting targets (Shams R. Khan 1993). Species listed in Appendix 1 indicate that some of the economically important species have been left with small populations that need immediate conservation measures. For this purpose, additional suitable protected areas have to be selected and demarcated to cover endangered tree species occurring in distinct ecological zones. No stands for *in situ* and *ex situ* conservation have been declared so far and therefore these must be immediately established either in the natural forests or in plantations. The provenance/progeny trials established in the past must be revisited to survey the current status of these trials. In view of the various threats, some species are either extinct, endangered or vulnerable as explained in Appendix 3. In some cases immediate conservation measures are needed to minimize forest and soil degradation.

The PFI can hardly meet 15–20% of seed demand of the forest departments, NGOs and farmers. The available supply includes mainly lowland broad-leaved species, as there is only one Seed Centre with a capacity of 20 000 kg. However, the demand of quality seeds of coniferous as well as few broad-leaved species of high hill forests cannot be met due to non-availability of professional staff and financial constraints. Extending Appendix 1 and Appendix 3, as well as in the light of national workshop on Seed Technology, a list of priority species has been prepared for the conservation and management of FGR (Appendix 4). The criteria for selection have been mainly based upon the current status and economic importance of these species. Holding a national workshop on conservation and management of biota could provide further selection and screening of the species. It is clear from Appendix 4 that conservation and management strategies of several multipurpose tree species in arid and temperate zones are badly needed.

Institutional framework and capacity building activities

The issues of forestry research and human resource development in the PFI were highlighted in a report submitted by the author to the FAO (Shams R. Khan 2001). Several suggestions were made to develop the institutional framework and to enhance research and training capabilities, including outlines to initiate and strengthen FGR conservation strategy in Pakistan. On account of a 50% reduction in the PFI technical staff, with no induction of fresh blood during the last decade, research capabilities have suffered in almost all disciplines of forestry research. This stagnation also led to a decline in chances of training for professional staff in research and development. It is suggested that short-term training in FGR conservation be provided to each Divisional Forest Officer (DFO) (Silva) to undertake and develop conservation strategies for both flora and fauna. As the knowledge in forest genetics and silviculture plays an important role and acts as a backbone in conservation it is suggested that long-term training in related areas be provided to the young professional staff to improve their capabilities.

Both the institutes, viz. the PFI and PFRI should undertake a detailed survey to assess the status of commercially important species so far as conservation is concerned. All such activities should be part and parcel of the national forest policy with proper monitoring and evaluation. Training programmes for local communities should be initiated to conserve woody as well as non-woody FGR. The Forest Geneticist/Silviculturist should be actively involved with the DFO (Silva) from the beginning of any conservation programmes. The team of wildlife in each province should be placed at the disposal of the Forest Geneticist to conserve critically endangered biomes.

A strong coordination is needed to strengthen the international treaties, like the CBD and the MAB-programme, to which Pakistan is a signatory. The CBD has emerged as the most powerful convention in the post-Rio era. It is now almost a decade that Pakistan signed and ratified the CBD. It has approved the Biodiversity Action Plan (BAP), submitted mandatory reports to the CBD secretariat and attended almost all the international meetings arranged by the CBD secretariat.

Since the preparation of the BAP was steered by an NGO (IUCN-P), it could be observed that the level of awareness as seen in the activities of similar NGOs is quite good. This could also be attributed to the availability of donor funds mainly from the GEF window for biodiversity. However, conservation efforts appear to revolve around wildlife, natural habitats and capacity building activities. Wildlife is one of the many components of biodiversity. Simultaneously, the association of tree growers and community-based organizations, NGOs and schoolchildren need to be involved in all activities for the conservation of genetic resources. The national TV should be used to create awareness among the people. Following these guidelines it is anticipated that the endangered species in some ecosystems may be restored.

Proposal for regional and international collaboration

Most of the *ex situ* conservation programmes and tree improvement activities in Pakistan had been sponsored by donor agencies such as the USDA, FAO and GTZ in the past. However, these activities have been discontinued in the last decade, which has badly affected the progress made on genetic improvement vis-à-vis conservation activities. Currently there is no research project at the PFI or PFRI related to conservation of woody endangered species except a small project on conservation and introduction of medicinal herbs. Some economically important coniferous and broad-leaved species are spread over several countries. It is therefore, suggested that international collaboration (especially on species that cover large distribution areas) should be strengthened. Pakistan could play a leading role in genealogical studies of endangered high hill species, including conservation and management of associated non-woody species.

Following an active collaboration with the CSIRO, research on rehabilitation of saline and waterlogged areas was initiated (Marcar *et al*. 1991). There is a need to conserve a specific source of *E. camaldulensis* (No. 15441) through the CSIRO to reclaim problematic areas in the country. In view of the results achieved by neighbouring countries in conservation and management of genetic resources, seminars and workshops may be held to exchange knowledge to bring about further genetic improvement vis-à-vis developing better strategies in the region. Following these steps it is anticipated that the endangered or regionally extinct species may be recovered in the fragile ecosystems of Himalayas, especially through the exchange of germplasm of important FGR in the region.

Conclusions

Conservation and management of endangered and rare species should be taken up at national level immediately. These species include both indigenous and exotic species, such as:

- **Indigenous:** *Aelagnus hortensis, Celtis eriocarpa, Diospyrus kaki, Ficus palmata, Fraxinus xanthoxyloides, Juniperus macropoda, Morus laevigata, Populus alba, P. ciliata, P. euphratica, P. nigra, Prunus amygdalus, P. padus, Pyrus pashia, Rhododendron spp.* and *Taxus baccata*
- **Exotics:** *Acacia albida, A. ampliceps, A. victoriae, Bombacopsis quinata, Casuarina equisetifolia, C. obesa, C. montana,* an Australian source of *E. camaldulensis, E. torelliana, Paulownia tomentosa, Pinus greggii,* a few clones of *Populus deltoides, Prosopis chilensis* and *P. pallida*

Protected areas in each ecological zone should be established and properly monitored following a listing of target species that need immediate conservation measures.

Establishment of species, provenance and progeny trials and genealogical studies of both local and exotic useful species would not only help to improve productivity and biomass of timber, fodder and fuelwood species but could also be an important component of biodiversity conservation and *ex situ* conservation of prioritised species. Since species do not recognize or respect political barriers and are widely distributed across several countries, there is a need to initiate network trials of the following important but neglected projects through the establishment of *ex situ* and *in situ* conservation stands:

1. *Ex situ* and *in situ* conservation of rust resistant stands of *P. wallichiana* var. *karakorama* in the Himalayas
2. Conservation and management of multipurpose tree food species
3. Exchange of germplasm and establishment of conservation areas of endangered species through network trials

It is recommended that the forestry sector in Pakistan should identify and recognize important stakeholders for the conservation and development of the nation's forests. They should be actively involved in policy making, implementation and monitoring. Establishment of a Provincial Forest Stakeholders' Forum should be considered to ensure the institutionalization of continued stakeholder participation in different policy making initiatives including coordination between provinces and between different domains of the federal forest policy. Analogous national forest conservation and coordination council is also suggested.

The tree improvement component should be an integral component in management plan of protected areas. Production of timber and fuelwood should not be the primary objective of the natural forests. They should be managed to maximize the ecological benefits of biodiversity conservation, watershed regulation and mitigation of climatic change. Research projects are needed to assess the relative performance of tree species in order to determine most appropriate treatments to enhance their performance. The management of natural stands of coniferous species should be based on best species combinations in order to achieve the aforementioned objectives.

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Appendix 1

Value and use of target species in Pakistan, including exotics

Species name	Value code	Present, future or potential use											
		ti	po	wo	nw	pu	fo	fd	sh	ag	co	am	xx
Abies pindrow	1	+	+	+									
**Acacia albida*	2	+	+	+	+			+	+	+			
**A. ampliceps*	2							+		+	+	+	+
A. catechu	1		+	+	+		+		+	+		+	
A. nilotica var. *cupressiformis*	1	+	+	+	+	+			+	+	+	+	
A. senegal	1	+	+	+	+			+	+		+		
**A. tortilis*	2	+	+	+				+	+		+		
**A. victoriae*	2	+	+	+				+	+				
Acer caesium	1	+	+					+			+	+	
Aelagnus hortensis	2		+	+				+	+	+	+	+	
Alnus nitida	2	+	+	+				+	+	+	+		
Atropa acuminata	2				+					+			
Avicennia officinalis	1	+	+	+							+		+
Azadirachta indica	2			+	+			+	+	+		+	
**Bombacopsis quinata*	2	+	+	+		+				+	+	+	
**Casuarina equisetifolia*	2	+	+							+		+	Salinity
**C. glauca*	2	+	+							+		+	Salinity
**C. obesa*	2	+	+							+		+	Salinity
Celtis eriocarpa	1	+	+	+			+	+	+	+	+	+	
Ceratonia siliqua	1		+				+	+	+	+	+	+	
Dalbergia sissoo	1	+	+	+				+	+	+		+	
Diospyros kaki	1		+				+	+		+	+		
**Eucalyptus camaldulensis* (15441)	2	+	+	+	+	+			+	+			Salinity
E. citriodora	2	+	+	+	+	+			+				
E. microtheca	2	+	+	+	+			+	+	+			Salinity
**E. torelliana*	2	+	+	+	+				+		+	+	
Fraxinus xanthoxyloides	1	+	+	+				+					
Grewia asiatica	1							+	+	+	+		
Juglans regia	1	+	+		+	+	+		+	+	+	+	
Juniperus macropoda	1	+	+	+							+	+	
Morus alba (wild)	1	+	+	+	+		+	+	+	+	+		
**Morus alba* (Chinese)	2		+	+			+	+		+	+		Sericul.

Species name	Value	Present, future or potential use											
	code	ti	po	wo	nw	pu	fo	fd	sh	ag	co	am	xx
**Paulownia tomentosa*	2	+	+	+					+	+		+	
**Pinus greggii*	2	+	+	+									
P. gerardiana	1	+	+	+	+		+						
P. wallichiana var. karakorama	2	+	+	+	+								Blister rust
Pistacia khinjuk	1	+	+	+			+	+					
Populus alba	1	+	+	+				+			+	+	
P. ciliata	1	+	+	+				+			+		
**P. deltoides* (American)	2	+	+		+			+	+	+	+		Match
P. euphratica	1		+					+			+		
P. nigra	1	+	+		+			+		+	+	+	
**Prosopis chilensis*	2		+		+			+	+	+			
**P. pallida*	2		+		+			+	+	+			
Prunus amygdalus	1		+				+	+					
P. padus	1		+				+	+					
Pyrus communis	1		+				+	+		+			
P. pashia	1		+				+	+		+			
Quercus dilatata	1				+			+					
Q. ilex	1							+					
Q. incana	1							+					
Q. semecarpifolia	1				+			+					
Rhizophora mucronata	1	+	+		+								
Rhododendron spp.	2		+		+	+	+	+				+	
Salix babylonica	2		+					+		+	+	+	Sport
S. tetrasperma	2		+					+		+	+	+	Sport
Saussurea lappa	2					+							
Tamarindus indica	1		+		+		+						
Taxus baccata	2	+	+			+							
Tecoma undulata	1		+		+			+				+	
Ziziphus jujuba	1						+	+	+	+	+		
Z. nummularia	1		+				+	+	+	+	+		

* = Exotic species

VALUE: 1 = Species of current socioeconomic importance; 2 = Species with clear potential of future value; 3 = Species of unknown value given present knowledge and technology

UTILIZATION: ti = timber production; po = posts, poles, roundwood; wo = fuelwood, charcoal; nw = non-wood products (gums, resins, oils, tannins, medicines, dyes, etc.); pu = pulp and paper; fo = food; fd = fodder; sh = shade, shelter; ag = agroforestry systems; so = soil and water conservators; am = amenity, antithetic, ethical values; xx = other (specify)

Appendix 2

Conservation and management of economically important forest genetic resources by ecogeographic zone in Pakistan (number of individual trees in each ecological zone)

Species	Ecological zone	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment. fields, trials
Abies pindrow	DWT	>1000	–	>10000	–	–	–	–
Acacia catechu	ST	–	–	<100	–	–	–	–
A. nilotica var. *cupressiformis*	ASA	>100	–	>500	<100	>500	>1000	<1000
A. senegal	T	>1000	–	>10000	>1000	–	–	–
Acer caesium	WT	>500	–	>10000	–	–	–	–
Aelagnus hortensis	DT	<100	–	>1000	–	–	>1000	<100
Alnus nitida	ST	–	–	<100	–	–	>500	–
Atropa acuminata	DWT	<100	–	>100	–	–	–	<100
Avicennia officinalis	T	–	–	>10000	>10000	–	–	–
Azadirachta indica	ASA	–	–	–	>10000	>500	>1000	–
Celtis eriocarpa	ST	–	–	>100	–	–	<100	–
Ceratonia siliqua	A	<100	–	>500	<100	–	<100	–
Dalbergia sissoo	ASA	>10000	–	–	>10000	–	>10000	>1000
Diospyros kaki	ST, WT	–	–	>100	–	–	<100	–
Eucalyptus citriodora	ASA	–	–	–	>1000	–	–	–
E. microtheca	ASA	–	–	–	>1000	–	–	<100
Fraxinus xanthoxyloides	WT	–	–	>100	–	–	–	–
Grewia asiatica	ST	–	–	>100	–	–	<100	–
Juglans regia	DWT	<100	–	>1000	>1000	<100	<100	–
Juniperus macropoda	DT	>10000	–	>10000	–	–	–	–
Morus alba	ST	–	–	–	>10000	–	>500	–
Pinus gerardiana	DT	>10000	–	>10000	>10000	–	–	–
P. wallichiana var. *karakorama*	DT	1000	–	>10000	–	>500	–	>100
Pistacia khinjuk	DT	–	–	>1000	–	–	<100	–
Populus alba	WT	<100	–	>500	–	–	–	<100
P. ciliata	WT	<100	–	>500	–	–	–	<100

Species	Ecological zone	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment. fields*, trials
P. euphratica	T	–	–	>1000	–	–	–	<100
P. nigra	DWT	–	–	<100	>1000	–	>10000	–
Prunus amygdalus	WT	–	–	<100	–	–	<100	–
P. padus	WT	–	–	<100	–	–	<100	–
Pyrus communis	WT	–	–	<100	–	–	<100	–
P. pashia	WT	–	–	<100	–	–	<100	–
Quercus dilatata	DWT	–	–	>1000	–	–	–	–
Q. ilex	ST	–	–	>1000	–	–	–	–
Q. incana	WT	–	–	>1000	–	–	–	–
Q. semecarpifolia	WT	–	–	>1000	–	–	–	–
Rhizophora mucronata	T	–	–	>10000	–	–	–	–
Rhododendron spp.	ST	–	–	<100	–	–	–	–
Salix babylonica	WT	–	–	>1000	–	–	<100	–
S. tetrasperma	ST	–	–	<100	–	–	<100	–
Saussurea lappa	WT	–	–	>1000	–	–	–	–
Tamarindus indica	T	–	–	–	–	–	>1000	–
Taxus baccata	WT	–	–	<100	–	–	–	–
Tecoma undulata	A	–	–	–	–	–	>500	–
Ziziphus jujuba	A	–	–	>1000	–	–	>1000	<100
Z. nummularia	ST	–	–	–	–	–	<100	–

Ecological zone: A = Arid; SA = Semi-arid; ASA = Arid, semi-arid; ST = Sub-tropical; T = Tropical; DT = Dry temperate; WT = Wet temperate; DWT = Dry-wet temperate

Note: Exotics were deleted as small plots (<500 trees) are being tested on experimental basis.

Appendix 3

Level and nature of threats to the integrity of populations of important tree species in Pakistan

Species in ecogeographic (or genecological) zones	Ecological zone	Direct causes of threats (1–6)							Degree of threat i ndex (1 – 5)
		Reserves, natural areas	*In situ* conservation stands	Managed forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Exper. fields, trials	
Abies pindrow	DWT	1,2	–	1	–	–	–	–	5
Acacia albida	ASA	–	–	–	–	1	–	1	1
A. ampliceps	ASA	–	–	–	–	1	–	1	1
A. catechu	ST	–	–	–	–	–	–	1	2–4
A. nilotica var. *cupressiformis*	ASA	1,2	–	–	1,2	1	4	1,2	5
A. senegal	T	–	–	1,6	2	–	–	–	2–4
A. tortilis	ASA	–	–	–	2	–	–	–	1
A. victoriae	ASA	–	–	–	2	–	–	–	1
Acer caesium	WT	–	–	1	–	–	–	–	2–4
Aelagnus hortensis	DT	1,2	–	–	1,2	–	–	–	2–4
Alnus nitida	ST	–	–	–	–	–	1,2,4,6	–	5
Atropa acuminata	DWT	1,2,4	–	1	–	–	–	–	5
Aviecinia officinalis	T	3	–	1	–	–	–	–	2–4
Azadirachta indica	ASA	–	–	1,2	1,2	–	2,4	–	2–4
Bombacopsis quinata	T	–	–	–	–	–	–	1	1
Casuarina equisetifolia	ASA	–	–	–	–	–	–	1	1
C. glauca	ASA	–	–	–	–	–	–	1	1
C. obesa	ASA	–	–	–	–	–	–	1	1
Celtis eriocarpa	ST	1,2	–	1,2	–	–	2,4	–	5
Ceratonia siliqua	A	–	–	1,2	–	–	2,4,5	–	2–4
Dalbergia sissoo	ASA	–	–	–	1	1	3	1	2–4
Diospyrus kaki	ST	1,2	–	2	–	–	4	–	5
Eucalyptus camaldulensis (15441)	ASA	–	–	–	–	1	–	1	1
E. citriodora	ASA	1	–	–	1	1	4,5	1	5
E. microtheca	A	1	–	–	1	1	4	1	5
E. torelliana	ASA	–	–	–	1	1	–	1	1
Fraxinus xanthoxyloides	WT	1,2	–	1,2	–	–	–	–	5
Grewia asiatica	ST	2	–	1,2	–	–	2,4	–	5
Juglans regia	DWT	1	–	1	1,2	–	2,4,5	–	2–4
Juniperus macropoda	DT	2	–	1	–	–	–	–	2–4
Morus alba (wild)	ST	2	–	2	–	–	4,5	–	5
Morus alba (Chinese)	ST	–	–	–	1	–	–	–	2–4
Paulownia tomentosa	T	–	–	–	–	–	1	1	1

Species in ecogeographic (or genecological) zones	Ecological zone	Direct causes of threats (1–6)							Degree of threat i ndex (1 – 5)
		Reserves, natural areas	*In situ* conservation stands	Managed forests	Plantations	*Ex situ* conservation stands	Villages, fields, homesteads	Exper. fields, trials	
Pinus greggii	ST	1	–	–	–	2,4	4	1	1
P. gerardiana	DT	1,2,3,4	–	–	–	–	–	1	2,4
P. wallichiana var. *karakorama*	DT	1,2,3,4	–	–	1,2	1	–	1	2–4
Pistacia khinjuk	DT	1,2	–	–	–	–	–	–	2–4
Populus alba	WT	1,2	–	1	–	–	–	–	5
P. ciliata	WT	1,2	–	1	–	–	–	–	5
P. deltoides (American)	T&ST	–	–	–	3	–	–	–	2–4
P. euphratica	T	–	–	–	1,2,3,6	–	–	–	5
P. nigra	DWT	–	–	–	1,6	–	1,5	1	2–4
Prosopis chilensis	ASA	–	–	–	–	–	–	1	1
P. pallida	ASA	–	–	–	–	–	–	1	1
Prunus amygdalis	WT	1	–	1,2	–	–	–	–	5
P. padis	WT	1	–	1,2	–	–	–	–	5
Pyrus communis	WT	1,2	–	1	–	–	–	–	5
P. pashia	WT	1	–	1	–	–	–	–	5
Quercus dilatata	DWT	1,2	–	–	–	–	–	–	2–4
Q. ilex	ST	1,2	–	–	–	–	–	–	2–4
Q. incana	WT	1,2	–	–	–	–	–	–	2–4
Q. semicarpifolia	WT	1,2	–	–	–	–	–	–	2–4
Rhizophora mucronata	T	1,2,3	–	–	–	–	–	–	2–4
Rhododendron spp.	ST	1,2,6	–	–	–	–	–	–	5
Salix babylonica	WT	1,2,3	–	–	–	–	4	–	5
S. tetrasperma	ST	1,2	–	–	–	–	4	–	5
Saussuria lappa	WT	1,2,4	–	1,2	–	1	–	–	5
Taxus baccata	WT	1,2,4,6	–	1,2	–	–	–	–	5
Zizyphus jujuba/Z. nummularia	A	–	–	1	1,2	–	3,4	–	2–4

Direct causes of threats include the following categories:
1 = Unmanaged use and harvesting;
2 = Unmanaged grazing and browsing (domestic animals, wildlife);
3 = Wildfires, environmental biotic/abiotic factors (drought, pests, diseases, floods, pollution);
4 = Clearing for agriculture or pasture;
5 = Infrastructure development (dams, mining, urban expansion);
6 = Other, e.g. lack of knowledge/ignorance; fuelwood collection

Threat Index (1–5):
1 = Implementation/enforcement of regulations probable and regulations scientifically sound. Low level of threat.
5 = Implementation/enforcement of regulations unlikely; or threat severe with high probability of genetic degradation or loss. High level of threat.
2–4 = Intermediate between 1 and 5.

Appendix 4

List of priority species for conservation, improvement or seed procurement, their uses and conservation activities needed

Species	End use				Operations / activities needed								REMARKS
	W	NW	FW	O	Exploration & collection		Evaluation		Conservation		Germplasm use		
	1	2	3	4	5	6	7	8	9	10	11	12	13
Abies pindrow	+				+								(2)
Acacia albida	+		+	+		+				+	+		(2)
A. ampliceps			+	+		+				+	+		(2)
A. nilotica var. *cupressiformis*	+	+	+	+	+	+		+		+	+	+	PGT
A. senegal	+	+	+	+	+	+							(2)
A. tortilis	+		+	+		+				+	+		(2)
A. victoriae	+		+	+		+				+	+		(2)
Acer caesium	+			+	+								(1)
Aelagnus hortensis			+	+	+			+		+	+		MPTS (1)
Alnus nitida	+		+	+	+								E (1)
Atropa acuminata		+	+	+	+	+				+	+		E (1)
Avicennia officinalis	+		+		+								
Azadirachta indica		+		+	+		+	+		+	+	+	PVT/PGT (2)
Bombacopsis quinata	+		+	+						+	+		SO (2)
Casuarina equisetifolia	+		+	+		+				+	+		MPTS (2)
C. glauca	+		+	+		+				+	+		MPTS (2)
C. obesa	+		+	+		+				+	+		MPTS (2)
Celtis eriocarpa			+	+									(1)
Ceratonia siliqua				+	+						+		(2)
Dalbergia sissoo	+			+	+	+	+	+		+	+	+	SO (2)
Diospyros kaki			+	+	+								E (1)
Eucalyptus camaldulensis (15441)	+	+	+	+	+	+	+			+	+		SO (2)
E. citriodora	+	+	+	+	+					+	+		
E. microtheca	+	+	+		+					+	+		MPTS
E. torelliana	+	+	+	+		+				+	+		SO (2)
Fraxinus xanthoxyloides	+		+	+									E (1)
Grewia asiatica			+	+	+								E (1)
Juglans regia	+	+	+	+	+					+	+		SO (2)
Juniperus macropoda	+		+	+	+	+				+	+		(3)
Morus alba (wild)	+		+	+	+					+			MPTS (1)
Morus alba (Chinese)				+	+	+				+	+		MPTS (2)
Paulownia tomentosa	+			+		+				+	+		MPTS (3)
Pinus greggii	+		+	+						+			SO (2)

Species	End use				Operations / activities needed								REMARKS
	W	NW	FW	O	Exploration & collection		Evaluation		Conservation		Germplasm use		
	1	2	3	4	5	6	7	8	9	10	11	12	13
Pinus gerardiana	+			+	+						+		SO (3)
P. wallichiana var. karakorama	+	+	+		+		+	+		+	+	+	PVT (2)
Pistacia khinjuk			+	+	+								(3)
Populus alba	+		+	+	+	+	+	+		+	+	+	CLT (2)
P. ciliata	+		+	+	+	+	+	+		+		+	PGT (2)
P. deltoides (American)	+		+	+	+	+		+		+		+	PGT (3)
P. euphratica	+		+	+	+	+	+	+		+		+	PGT (1)
P. nigra	+		+	+	+								PGT (3)
Prosopis chilensis			+	+		+				+	+		MPTS (2)
P. pallida			+	+		+				+	+		MPTS (2)
Prunus amygdalus			+	+	+								MPTS, E (1)
P. padis			+	+	+								MPTS, E (1)
Pyrus communis			+	+	+								MPTS, E(1)
P. pashia			+	+	+								MPTS, E(1)
Quercus dilatata				+	+								(2)
Q. ilex				+	+								(2)
Q. incana				+	+								(2)
Q. semecarpifolia				+	+								(2)
Rhizophora mucronata	+		+		+								(3)
Rhododendron spp.				+	+								E (1)
Salix babylonica	+		+	+	+								MPTS (2)
S. tetrasperma	+		+	+	+								MPTS (2)
Saussurea lappa		+			+	+				+	+		E (2)
Taxus baccata	+	+			+								E (1)
Ziziphus jujuba				+	+	+				+	+		MPTS (2)

End uses: 1 = Industrial wood products (logs, sawtimber, construction wood, plywood, chip and particle board, wood pulp etc.); **2 =** Industrial non-wood products (gums, resin, oils, tannins); **3 =** Fuelwood, posts, poles (firewood, charcoal, roundwood used on-farm, wood for carving); **4 =** Other uses, goods and services (food, medicinal use, fodder, land stabilization/amelioration, shade, shelter, environmental values).

Exploration & collection: 5 = Biological information (natural distribution, taxonomy, genecology, phenology etc.); **6 =** Collection of germplasm for evaluation

Evaluation: 7 = *In situ* (population studies); **8 =** *Ex situ* (provenance and progeny tests)

Conservation: 9 = *In situ*; **10 =** *Ex situ*

Reproductive use/germplasm use: 11 = Semi-bulk/bulk seedlots, reproductive materials; **12 =** Selection and improvement

Remarks (13): Specific uses not obvious from columns 1-4 are mentioned. Also, work in progress is reported in this column.

PVT = provenance trials; E = endangered at species or provenance level; PGT = progeny trials; MPTS = multi-purpose tree species; CLT = clonal trials; SO = seed orchard

Rating: 1 = Highest priority, action should start, or be continued, with immediate effect; **2 =** Prompt action recommended, action should start within next two biennia; **3 =** Action required in next five to ten year.

Status of forest genetic resources conservation and management in Sri Lanka

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Introduction

Sri Lanka is a tropical island of continental origin and shares tectonic plates with Peninsular India. The island lies between 5°54′ and 9° 52′ North and 79° 41′and 81°54′ East. The island has two main climatic zones, namely the Dry Zone and the Wet Zone with an Intermediate Zone in between. Nearly two thirds of the island is constituted of the Dry Zone, which consists mainly of flat and undulating land receiving less than 2000 mm annual rainfall. The Wet Zone is located in the south and southwest of the island and consists of coastal plains and very rugged mountainous terrain (Montane Zone) rising up to an elevation of 2750 m asl. The Wet Zone receives 2500 mm to 5000 mm of rainfall annually. Sri Lanka receives rainfall from two monsoons; the northeast monsoon between October and January and the southwest monsoon from May to July and these monsoons affect the three climatic zones differently.

Soils in the Dry Zone are reddish-brown and yellowish-brown, varying from medium/ heavy to light and are generally well drained. In the Wet and Intermediate Zones, soils are prevalently red-yellow podzolic and are shallow and well drained in the highlands, but deep and poorly drained in the lowlands. The diverse climate, soil types and altitude have contributed to the high variation in natural vegetation in Sri Lanka. The flora includes 192 families of flowering plants with 1290 genera and 3268 species of which 25% are endemic to the country (Sumithraarachchi 1990).

Conservation and use of forest genetic resources

There has been a significant reduction in the natural forest cover in Sri Lanka during the recent past. The main causes of this have been clearing of forests for agricultural development, shifting cultivation and settlements. At present, a moratorium has been imposed on all harvesting activities in natural forests in the country until management plans are prepared for them. Preparation of these management plans has been started recently under the ongoing Forest Resources Management Project.

Status of forest resources and utilization of trees

Forest plantation activities started in Sri Lanka as far back as 1680 with the introduction of teak to the country. During the period of 1680–1890 several other exotic species were included in planting programmes. During the subsequent years, a substantial area was planted with of exotic species to compensate the loss of timber production from natural forests.

With the rapid development of plantation forestry and the introduction of exotic species, a need for genetic improvement was felt and activities leading to tree improvement were initiated. Early tree improvement work was carried out on four species used widely in plantation establishment, namely teak, *Pinus caribaea, Eucalyptus grandis* and *E. microcorys.* The activities included provenance trials, establishment of seed production areas, selection of plus trees and establishment of clonal seed orchards. However, due to the small-scale nature of these experiments, it was not possible to produce sufficient amount of improved planting materials for commercial planting.

Extent of natural forests and plantations

According to the latest satellite imagery and aerial photographs the total area of natural forests is 1 942 219 ha of which 1 470 636 ha are identified as dense canopy forest, while the remaining area is sparse forest. The total extent of forest plantations is estimated to be 93 000 ha. The natural forests of Sri Lanka contain more than 100 indigenous timber species. Majority of them are found in the Wet Zone while the Dry Zone and the drier parts of the Montane Zone contain fewer valuable species and the stocking is very poor (Vivekanandan 1975). With regard to the conservation of forest genetic resources (FGR) in natural forests, the Forest Department (FD) is implementing a World Bank-funded Medicinal Plant Project, in which conservation measures are taken with respect to plants with medicinal value occurring in natural forests.

The FD has been experimenting with a number of indigenous species as well as some exotic species since the inception of plantation establishment. The following species have been given priority in plantation establishment during the recent past based on the field experience gained so far:

Teak – Teak, an exotic species, has been considered the highest priority species, considering its importance as a high value furniture timber with relatively fast growth. It is therefore the most popular species planted by private tree growers. In the 1960s and 1970s planting of teak increased in the Dry Zone when degraded natural forests were planted using a modified form of the Taungya system. Many of the mature teak plantations seen today in Sri Lanka are a result of the efforts made under this programme. Presently, 28 115 ha of teak plantations have been inventoried and are managed by the FD. Majority of these plantations are located in the Dry Zone.

Eucalypts – Eucalypts, another group of exotics, have been the dominating species in the uplands since the time of the British colonization. Among the successful introductions have been *Eucalyptus grandis, E. microcorys, E. robusta, E. pilularis, E. camaldulensis, E. torelliana* and a few others. In the Dry Zone introductions have been relatively recent and among the several species tested *E. camaldulensis* and *E. tereticornis* have been the most promising ones.

Pines –The bulk of the early planting activities in the highlands consisted of *Pinus patula*. In the 1970s, with a growing interest in planting tropical pines such as *P. caribaea* and *P. oocarpa*, the FD, after a number of field evaluations, initiated large-scale planting of *P. caribaea* var. *hondurensis* in the montane and lowland Wet Zone especially in fern lands and degraded tea cultivation areas. In fact, it was the principal species used in reforesting the upland watersheds. The original objective of pine planting was to create a resource for the production of long-fibre pulp; however, local pulp industry never used this raw material for making pulp. Pines were also planted in the upcountry watershed areas with the primary objective being prevention of soil erosion, reduction in sedimentation of reservoirs and regulation of flow of water to Dry Zone reservoirs. Tapping pines for oleoresins is a fast-growing industry and currently 5300 ha of pine plantations have been leased out to the private sector for resin tapping.

Acacias – Acacias were first introduced in the highlands mainly to meet the fuelwood requirements of tea estates and the main species planted were *Acacia melanoxylon, A. decurrens* and a few others. The introductions of acacias in the Dry and lowland Wet Zones have been relatively recent. Several field trials have been conducted by the FD with assistance mainly from the Australian Tree Seed Centre, which generously provided the seeds for the trials. Based on the results of the trials, *Acacia auriculiformis* has proved to be an ideal species for the degraded sites in the Dry Zone and is now extensively planted. *A. mangium* has performed well in the intermediate and lowland Wet Zone and it is planted on a limited scale. In addition to these, *A. aulacocarpa, A. crassicarpa*, and *A. leptocarpa* have shown promising performance in field trials.

Mahogany – *Swietenia macrophylla* has been planted rather extensively in the Wet and Intermediate Zones. One of the African mahoganies, *Khaya senegalensis* has shown promising performance in the Dry and Intermediate Zones and is planted on a limited scale.

Other species – The FD has been experimenting with a number of indigenous as well as some exotic species since the inception of the silvicultural research branch in 1937. Many of the species trials have been replicated both in time and species and some species have proven to be suitable for specific sites. Of particular interest are *Azadirachta indica* (neem) and *Casuarina equisetifolia* for drier sites and coastal areas, *Melia dubia* for Dry and Intermediate Zones, *Terminalia arjuna* (kumbuk) for waterlogged lowland areas, *Berrya cordifolia* (halmilla) and *Madhuca longifolia* (mee) for relatively fertile lowland dry sites.

The Medicinal Plant Project has selected natural forests from different ecological zones in the country, with one of these forests located in the Dry Zone, two forests in the Wet Zone and two forests in the Intermediate Zone. *In situ* conservation in natural forests as well as *ex situ* conservation measures such as establishment of nurseries, home gardens and demonstration plots have been initiated under this project. The most important tree species in the Medicinal Plant Project include *Diospyros melanoxylon, Litsea glutinosa, Phyllanthus emblica, Pterocarpus marsupium, Salacia reticulata, Terminalia belerica* and *Terminalia chebula.*

Identification of threats

Most of the natural forests and some of the forest plantations in the country have faced threats from the growing human population. These forests are gradually losing their quality in terms of species diversity and stocking mainly due to illegal harvesting and clearing for agricultural activities.

Considerable attempts are being made to protect, enrich and reforest those forest areas wherever necessary in order to provide benefits to the present and future generations. The attempts made towards conservation of forest resources by the FD include enactment of forest ordinance, revision of forest policies, imposing logging bans in natural forests, establishment of biosphere reserves and other protected areas, implementing programmes of reforestation and forest management, forest protection, forestry research, social forestry and environmental management. In the Dry Zone damages caused by forest fires and cattle and elephants are also significant. Fire lines are opened in fire-prone areas as a measure of protection, but there are occasions where the fire has spread during acute dry weather in spite of fire lines.

Identification of exotic invasive forest trees

Invasive plants are a major threat to conservation of biodiversity. These plants are capable of replacing diverse ecosystems with few species, which is a direct threat to native flora and fauna.

Udawattakele is a wet semi-evergreen forest in the central hilly region of Sri Lanka, located in Kandy, the hill capital of the country. This forest is reserved as a sanctuary in Sri Lanka and the extent of the forest is about 100 ha, with high species richness. The ecological and social value of the Udawattakele is also significant to Kandy since it acts as a watershed, and creates a pleasant microenvironment. However, the introduced tree species *Myroxylon balsamum* has become invasive and is threatening the biodiversity in this forest (Pushpakumara and Hitinayake 2001).

Prosopis juliflora, a leguminous species native to Central and Northern South America has been introduced to the arid areas of the country in the 1950s to improve the salt-affected soils as well as for firewood and to provide vegetative cover. A variety of this species is found to be naturalized and it has now become invasive. The Wetland Site Report published by Central Environmental Authority in 1993 indicates that this species is a serious threat to the Bundala National Park in Hambantota district (Seneviratne and Algama 2001).

Socioeconomic conditions and issues related to the conservation, utilization and management of forest genetic resources

Links between the forestry sector and forest genetic resources

In Sri Lanka, more than 28% of the land area is reserved and administered by either the FD or the Wildlife Department. A distinct feature of these protected areas is that they are fragmented. Thirty percent of protected areas are less than 100 ha in area and 54% are less than 1000 ha in size. Most of the areas that are under the purview of the FD are smaller than 1000 ha. The largest and most important protected areas in the country are the Peak Wilderness Sanctuary and the adjacent Hortan Plains National Park (with a combined area of 25 539 ha), Knuckles Conservation Forest (16 000 ha), and Sinharaja National Heritage Wilderness area (11 187 ha). Out of these, the most important site for biodiversity conservation is Sinharaja, the country's largest remnant of rain forest, which has been declared a biosphere reserve under the UNESCO MAB programme and has been included into the World Heritage List of natural sites.

Agriculture and agroforestry

Multipurpose Tree Species (MPTS) Research Network is a local network working on research to meet the needs of small-scale farms for fuelwood and other tree products. The activities of the network are coordinated by a National MPTS Research Committee where experts from national institutions in forestry, agriculture and social sciences, universities, tree growers as well as NGOs are represented. The focal point of this network is the Faculty of Agriculture of Peradeniya University. One of the main activities is a multi-locational species trial. Other activities include studies on farmers' objectives as regard to tree breeding, regional survey of farm and village forestry practices, regional comparative studies and also establishment of a marketing network for MPTS products.

Recently, a network on *Artocarpus heterophyllus* (jackfruit), a neglected MPTS in Asia, was established. Documentation of available seed sources, collection, storage and *ex situ* conservation of jackfruit are being done under this network. In addition, exchange of seed materials and establishment of provenance trials are also being done. A tree improvement programme of jackfruit has also been initiated.

Animal husbandry

Silvopastoral systems are found in the mid to high elevations in central Sri Lanka, and also in the coconut triangle in the southwest quarter of the country. The practice is widespread in the hilly or wet grasslands. Tree components are mainly *Eucalyptus*, *Pinus* and *Cupressus* species. In the coconut areas cattle is raised in coconut fields, which are not intercropped to any large extent. In some silvopastoral areas, especially in the mid-Montane Zone, there is a danger of fires created by herders who burn the dry grass just before the rains in order to get a new flush of grass for their cattle.

Industry

The indigenous sources of energy for Sri Lanka are biomass (including fuelwood) and hydropower. The country has no fossil fuel deposits. Fuelwood is used mainly in the domestic sector for cooking, to a small extent for keeping houses warm in the montane region and in some industries for drying and heating purposes. Ninety four per cent of Sri Lankan households use fuelwood for cooking. Electricity is used mainly for lighting and in industries.

Numerous fuelwood planting programmes have been started in the country in the recent years. Fuelwood is also produced from thinnings and branches from forest plantations. The agro-based plantation fuelwood and extensive non-forest fuelwood planting programmes are mainly meant to supply fuelwood for industries. In addition to the Forest Department, agencies that have undertaken fuelwood planting programmes of their own include tea industry, Sri Lanka's State Plantation Corporation, Janatha Estate Development

Board, Ceylon Tobacco Company, Ceramic Corporation, Brick and Tile Industries and Mahaweli Development Authority. The FD, with the forestry extension division has provided technical assistance to most of these institutions in raising fuelwood plantations.

Past and present activities in conservation, utilization and management of forest genetic resources

Agroforestry, plantations and afforestation programmes

The history of cultivating trees in home gardens, social tree planting, protection and management of forests and appreciation of wildlife and the beauties of nature in Sri Lanka goes back to over 25 centuries. In chronicles there are references to social tree planting practices, well-organized village communities, and home gardens planted with flowering and fruit bearing trees. Because of the age-old agroforestry tradition, numerous examples of agroforestry practices are found in all climatic zones of the country.

Today, the traditional knowledge of agroforestry is being developed and expanded with the objective of improving living standards of rural poor. A wide range of agroforestry systems is found in Sri Lanka and their characteristic features (Nanayakkara 1991) could be summarized as below:

Shifting cultivation

Shifting cultivation is an age-old agroforestry system where forest and food crops are grown alternately in temporal sequence. The system is sustainable as long as there is a reasonably long fallow period (at least 15 years). However, with population growth and shrinking forest cover, the fallow period has shortened resulting in severe land degradation. In the Dry Zone, large tracts of forest were lost in the past due to uncontrolled shifting cultivation. Formerly, issuing of cultivation permits by the government regularized the shifting cultivation and in 1981 issuing of these permits was officially terminated. Today only few sporadic, illegal shifting cultivation activities are taking place in remote Dry Zone areas.

Cooperative reforestation

This agroforestry system was a modified form of the Burmese Taungya system. This system was practised especially to convert the degraded Dry Zone natural forests into teak plantations with participation of shifting cultivators in this scheme. Cultivators were provided an opportunity to grow agricultural crops over a three-year year period, while the farmers were also paid a monetary reward. Farmers formed cooperative societies and participated in the programme. This system has produced good results; almost all the best teak plantations established in the Dry Zone and Intermediate Zone have been raised under this scheme. Though this system was originally applied for teak, in later stages some *Eucalyptus camaldulensis* and *E. tereticornis* plantations were also raised. The shortcoming in this system has been the insecure land tenure for the cultivators; the system encouraged nomadism, which did not improve the life standard of cultivators.

Intercropping with other cash crops

Coconut is the most widely planted industrial tree crop in Sri Lanka. It covers about 25% of the total cultivated area on the island. A large number of tree crops such as teak and mahogany are grown in association with coconuts. Tea is the second largest industrial crop in the country and it is grown mainly in the central hill country and in wet southwest lowlands. A large number of leguminous and other shade trees are grown in this agroforestry system. The fuelwood needs of tea estates, including the energy for tea processing and for the domestic needs of tea estate workers, are met with firewood species grown within this system. Rubber is the third largest industrial crop in the country and fruit trees are often intercropped with rubber. As the shade cast by rubber in the later stages of its rotation is dense, intercropping is fairly restricted. Pineapple and cocoa are grown in areas where rubber canopy is not too dense. Palmyrah palm (*Borassus flabellifer*), which is a multipurpose tree yielding many products inter-cultivated with cashew nut is another agroforestry system found in coastal areas of the Dry Zone and in semi-arid areas of northern and eastern districts.

Sloping agricultural land technology

Sloping agricultural land technology is also widely adopted in central hilly areas of the country. In this system hedgerows are grown along contour lines in sloping lands of abandoned tea areas, alternating with agriculture crops. Fuelwood species, such as *Gliricidia sepium* are commonly grown in hedgerows. Continuous mulching with pruned biomass from hedgerows improves soil conditions and reduces erosion.

Kandyan home garden system

Kandyan home garden system is an age-old traditional agroforestry system practised in the central hilly areas and in some other districts in the Wet Zone. This system is an ideal form of land use combining agriculture, forestry and livestock. Trees are grown in a multi-layer arrangement and mixed cropping of trees yielding timber, small wood, fuelwood, fodder, food, fruits, medicines together with crops yielding food and medicine is practised. Maximum utilization of space, both vertical and horizontal, is ensured in this system.

Farmers' woodlots

Since the 1980s the FD has started establishing partnerships with farmers in the rural areas in raising farmers' woodlots. This system is practiced mainly in the Dry Zone and in drier sites in the central hilly areas. Relatively small blocks of degraded state lands (less than 0.1 ha) have been leased out to local farmers on a long-term lease basis. Seedlings of forest and horticulture species and technical advice are provided to the farmers free of charge by the FD. In this system, the farmer is entitled to harvest the final tree crop, leaving few mother trees in the plot. Farmers are also rewarded in the form of a food ration for successful establishment and maintenance of plantations.

Plantations and afforestation programmes

Plantation forestry is considered to be of great value in relieving pressure from natural forests and, at the same time providing more uniform products as compared to natural forests.

The forest policy of 1929 emphasized increased wood production to ensure self-sufficiency and to allow also for some exports. In 1938, a policy of planting natural grasslands (*patanas*) was commenced and planting of exotic tree species such as pines and eucalypts in up-country, reflected the prevailing emphasis of the policy. The forest policy of 1953 emphasized timber and fuelwood production to meet the increasing demand and with this development some mechanized planting of wet and dry grasslands were carried out using *Pinus caribaea.* Plantations of *Eucalyptus grandis* and *E. microcorys* as well as acacias were established at that time. Most of the *Pinus caribaea* plantations in the country were planted between 1965 and 1984. In latter part of the 1980s, with environmental concerns about monocultures, especially exotics, the planting of *Pinus* species virtually ceased.

In the Dry Zone, large scale planting of teak was carried out until the 1980s and since then the scale of planting has reduced because the successful establishment of teak depends on clearing and burning of natural forests, which is now regarded as undesirable.

During the 1970s and 1980s, *Eucalyptus camaldulensis* and *E. tereticornis* were established extensively in the Dry Zone, together with *Acacia auriculiformis.* These species were planted in a response to the concerns about a potential deficit in fuelwood supply. Some of these plantations were not successful due to damages by animals and fires.

One of the main forestry projects in the 1980s was the ADB-funded Community Forestry Project, under which the development of fuelwood plantations and agroforestry in five districts took place. During the same period, the International Development Agency (IDA) and the Finnish International Development Agency (FINNIDA) funded a Forest Resources Development Project and the FD established extensive commercial plantations under various rural development projects.

During the 1990s, under the Forestry Sector Development Project funded by the British Overseas Development Agency (ODA), UNDP/FAO and IDA, the FD established plantations of species such as acacias, mahogany as well as indigenous species. In 1993, the FD implemented an ADB-funded Participatory Forestry Project where emphasis was given to increasing wood production in home gardens, farmers' woodlots, protective woodlots and public reserve lands. This work was carried out through participation of farmers.

Presently, the FD is implementing reforestation activities under the ADB-funded Forest Resources Management Project. The main species that is being planted in the Dry Zone is teak, while eucalypts are planted in the upcountry as commercial timbers. Planting efforts implemented directly by the FD are involved mostly in regeneration cutting areas of mature forest plantations, while afforestation of degraded areas is mostly implemented through local people's participation. Relatively large blocks of land of over 25 ha are leased out to private companies to establish commercial plantations, while farmer participation is sought in establishing plantations in smaller blocks of land.

Demand and supply of seed

The seeds of indigenous tree species, such as *Terminalia arjuna, Holoptelea integrifolia, Terminalia belerica, Madhuca longifolia*, *Diospyros ebenum*, *Chloroxylon swietenia, Lagerstroemia speciosa* and *Pericopsis mooniana* are collected locally by farmers as well as by the FD. The FD also imports seeds of exotic species required for agroforestry and reforestation programmes. The FD supplies seedlings of many timber species to farmers from departmental nurseries. In addition, a large number of seedlings are produced and supplied from farmer nurseries, school nurseries and NGO nurseries that are supported with technical assistance by the FD. A Tree Seed Centre has been established in the FD, attached to the Forest Research Centre. The Seed Centre building and cold storage facilities have been constructed with assistance from the ADB.

National seed demand is calculated and seed procurement from local and foreign sources is planned accordingly. Priority is given to seed collection from seed orchards and seed production areas. Collected seeds are cleaned and dried in the sun until the seed weight remains constant. Small-scale seed collecting for special purposes is done when requested. Collected seeds are labelled and stored for future use. Seed testing is done for seed moisture, viability and germination. Certified and high-quality seed is dispatched to divisional staff as and when required. Seeds and planting materials of fruit trees and horticultural plants are supplied by the Agriculture Department through departmental and farmer nurseries.

In situ conservation

Conservation of FGR necessarily involves management of the resources in the context of human use. Long-term conservation of genetic resources requires regeneration of representative populations. Indigenous tree species and populations are most efficiently maintained *in situ* through natural regeneration or by planting trees of local origin and of wide parentage.

Many important indigenous tree species such as *Lumnitzera litoria* and *Carapa moluccencis* are facing genetic degradation due to continuous removal of phenotypically better trees under the selective management system. Thus, some of the indigenous tree species are found at present only in natural habitats. Their natural regeneration is threatened due to various factors. The activities conducted by the Forest Department in relation to *in situ* conservation could be listed as:

- Strict protection of highly valued natural forests without permitting any kind of disturbance including harvesting (Knuckles Forest and Sinharaja area have been declared as strict conservation forests under the new categorization of forests).
- Development of separate management plans for important forests to ensure their conservation while obtaining essential services.
- Maintenance of a computerized environmental database – Environmental Information Management Systems (EIMS) that contains data e.g. on plant and animal species in the country.

- Implementation of Sinharaja, Knuckles and Mangrove Conservation projects.
- Maintenance of the Man and Biosphere (MAB) reserves.
- Buffer zone management in natural forests.
- National conservation review to assess the biodiversity of natural forests, which are 200 ha or more in extent. (The work in 33 natural forests in the Wet Zone has already been completed while the work in the Dry Zone will be done in the future).
- Development of forest plantations, homegardens and other agroforestry systems to meet the social needs, which can reduce the threats to natural forests.
- Identification of medicinal plant conservation areas in selected natural forests.
- Acquiring mangrove areas from local authorities to the FD, declaring them as conservation areas and preparing management plans for them.
- Conducting research on enrichment planting and related areas in degraded natural forests. Studying natural forests in terms of biodiversity, rarity and endemism.
- Research on natural regeneration and floral biology in the natural forests.

Ex situ conservation (seed, conservation stands, *in-vitro* cultivation)

With respect to *ex situ* gene conservation, the following activities are being conducted by the Forest Department:

- Collection of germplasm of endangered species from their natural range and planting in blocks as genebanks.
- Collection of seeds of native species and establishment of plantations.
- Establishment of seed orchards to conserve superior germplasms.
- Vegetative propagation of valuable local species for genetic improvement.
- Importation of genetic materials of plantation species from other countries and planting them in the field either to broaden the genetic base of existing species or to introduce new species.
- Planting of medicinal plants in buffer zones of natural forests, home gardens, etc.

In addition to *in situ* and *ex situ* conservation measures taken by the FD under the Medicinal Plant Project, the Biodiversity Division of Ministry of Environment and Natural Resources is establishing Plant Sanctuaries, which is a form of *ex situ* conservation blocks for the conservation of indigenous tree species such as *Pterocarpus santalinus, Lumnitzera litoria, Carapa moluccensis*. This work is carried out in collaboration with the Faculty of Agriculture of the University of Ruhuna.

Tree improvement (provenance trials, progeny tests, seed orchards, etc.)

The choice of seed sources is one of the main factors affecting the establishment and productivity of tree plantations. During the pioneering years, there were hardly any scientific studies on provenance variation within species and species introductions were done in an *ad hoc* manner. The present practice of silvicultural provenance research provides a sound basis for selection of seed sources.

Tree improvement research in the Dry Zone

In the Dry Zone, the most important species for tree improvement research have been teak, eucalypts and acacias. Starting in 1941, the first teak trials examined the performance of five provenances originating from Burma as well as 'local' landraces that presumably originate from the old introductions from India (Vivekanandan 1977).

Eucalypts have been introduced into Sri Lanka since 1960s. Systematic evaluations and provenance trials have been conducted by the Research Division of the FD e.g. for *Eucalyptus tereticornis, E. alba* and *E. camaldulensis* (Vivekanandan 1979; Connelly 1990; Nikles 1992; Bandaratillake 1997); for a summary, see Appendix 1. As for acacias, *A. auriculiformis and A. crassicarpa* have shown promising performance in the Dry Zone.

Tree improvement research in the Wet, Intermediate and Montane Zones

Acacias – During the 1980s there was a widespread interest in new species of phyllode acacias that were found in Australia. *Acacia mangium* was introduced into Sri Lanka in the 1980s and was planted on a trial basis on different sites in the Wet and Intermediate Zones. The FD, in close collaboration with the Australian Tree Seed Centre embarked on the evaluation of several new species of acacias from different geographic locations in Australia (Weerawardane and Phillips 1991).

Eucalypts – Eucalypts have been the principal species planted in the hill country, the most important species being *E. grandis.* During the early stages seeds have been imported from overseas, mainly from Australia and very little attention was paid to the seed origin. Over the years the best seed sources, even though their origins are unknown, have become adapted to the local conditions and have been performing well. In the 1980s a number of species cum provenances trials were initiated in a number of locations (Weerawardane and Phillips 1991; Vivekanandan 2002).

Pines – During the 1970s, the Oxford Forestry Institute in cooperation with national forestry institutions initiated several international species cum provenance trials of tropical *Pinus* species in a number of countries in Asia, including Sri Lanka. The provenance trials of *Pinus caribaea* and *Pinus oocarpa* are of particular interest. These trials provide the basis for the large-scale establishment of plantations in degraded sites in the upland and in the low country Wet Zone.

Institutional framework

Institutions, their roles, responsibilities and capabilities

The office of the Conservator of Forests of Sri Lanka was established in 1887 but a separate Department to undertake forestry activities was not established until 1899. There have been several changes in institutions since then and currently almost all the FGR work is under the jurisdiction of the FD, in collaboration with other departments such as the Department of Agriculture, etc. There are two main research stations and the one at Kumbalpola has been developed as the Central Forest Research Station of the country, while the other centre at Badulla is functioning as a sub-station.

The FD is headed by the Conservator General of Forests with the assistance of three Additional Conservators of Forests. The research division is headed by the Additional Conservator of Forests (Research) and consist of five Research Officers, five Technical assistants and three Lab Attendants. In addition, a forestry information service unit with desktop publishing facilities has been established recently at the Head office.

National legislation, policies and strategies on forest genetic resources

The Forest Ordinance has provisions for Minister-in-charge of the Forest Department to declare areas for forest conservation. In this regard the Minister may publish gazette notifications declaring any forest area, which has unique ecosystems, genetic resources or is a habitat of rare and endemic species of flora and fauna or of threatened species, in order to achieve an ecological balance as a conservation forest. For example, most of the threatened mangrove areas that had been owned by the private sector have been taken over by the FD for conservation under this provision.

The National Forest Policy approved in 1995 gives an overriding priority to conservation of biodiversity and protection of watersheds in the forest ecosystems. One of the main objectives identified in the policy is to conserve forests for posterity, with particular emphasis to biodiversity, soils, water and historical, cultural, religious and aesthetic values. The following statements in the policy clearly stressed the need for conservation of biodiversity:

Statement 2.1: All state forest resources will be brought under sustainable management both in terms of continued existence of important ecosystems and flow of forest products and services.

Statement 2.3: The natural forests will be allocated firstly for conservation, and secondly for regulated multiple-use production forestry.

Statement 2.4: For the management and protection of the natural forests and forest plantations, the state will, where appropriate, form partnerships with local people, rural communities and other stakeholders to introduce appropriate tenurial arrangements.

Statement 4.4: Effective measures to protect the forest and prevent illegal trade in wood, non-wood forest products and endangered species of flora and fauna will be instituted.

Statement 5.3: The state will provide full support to the various resource managers for sustainable forestry development, and its institutions will be reoriented and strengthened to enable them to accomplish their role.

Statement 6.3: Nature-based tourism will be promoted to the extent that it does not damage the ecosystems and insofar as it provides benefits to the local population.

Statement 6.5: The general public and industries will be educated about the importance of forestry and of conserving biodiversity and protecting watersheds.

National forest policy and institutional issues

There are several agencies involved in forestry development activities. The major government Institutions that are directly involved in forestry activities are the Forest Department (FD), Wildlife Conservation Department (DWLC) and State Timber Corporation (STC). The FD deals with conservation, management, regulation of utilization, research and extension of forestry activities, the DWLC deals with conservation while the STC, which is a statutory body, deals with harvesting, processing and marketing of timber. The mission of the FD is to conserve and develop the forest resources in Sri Lanka to ensure the prosperity of the nation. All these three institutions are under the purview of the Ministry of Environment and Natural Resources. The Ministry is headed by the Minister who is a political appointee. The responsibility of the Secretary to the Ministry is to advise the Minister on policy formulation and implementation. In addition to the above three line agencies that are directly involved in forestry, there are several other line agencies that come under the same Ministry, such as the Central Environmental Authority and Geological Survey and Mining Bureau. There is a Planning Division operating within the Ministry to ensure that the plans produced in the Ministry are in line with the national and ministerial policies and to identify source of funds.

In addition to the FD, DWLC and STC, the other state agencies that play minor role in forestry are Mahaweli Authority, which is the body controlling activities of the largest national irrigation scheme in the country, the Plantation Ministry and Agriculture Department.

Adoption of the new National Forest Policy in 1995 required changes in the organizational structure of the forestry sector and prioritizing its various functions. As a result, the FD was subjected to restructuring in 2000, bringing about major changes in its administrative structure. Central organizational structure has been decentralized to a great extent to the regional level. Furthermore, as a measure of re-organization of the forestry sector, the FD and the DWLC were brought under one Ministry.

The long terms goals, envisaged with bringing about institutional reform under the new National Forest Policy could be summarized as follows (Sri Lanka Forestry Sector Master Plan 1995):

- Policy and legislation, as well as both state and other institutions will be made effective instruments for forestry development.

- The organizational structure of forestry and related agencies will be developed to enable them to implement the partnership approach to forestry development.
- Commercial forestry and forest industry operations of the state are separated from other operations and made financially self-sustaining and efficient, with an increasingly important role reserved for the non-state sector.
- Policy evaluation, legal and institutional reform will be institutionalized and become routine government activities.

Links with international initiatives

Sri Lanka has become a party to a number of international agreements related to the conservation of biodiversity; these include the UNESCO Man and the Biosphere Programme, Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), Convention Concerning the Protection of the World Cultural and Natural Heritage (World Heritage Convention), Convention on Wetlands of International Importance (Ramsar Convention on Wetlands), Convention on Biological Diversity and Convention on Climate Change.

Biosecurity regulations

The Forest Ordinance has provisions to regulate the import and export of timber and seeds of forest tree species and other forest products and to provide for the issue of permit for these items. The regulations have been framed under this provision to restrict export of plants, seeds and plant products of species listed under the publication "The 1999 List of Threatened Fauna and Flora of Sri Lanka" compiled by the IUCN.

Legislation regarding access to genetic resources, property rights and benefit sharing

The new Forest Policy includes provisions for:

- Enhancing the contribution of forestry to the welfare of the rural population and strengthening of the national economy, with emphasis on equity.
- Putting state forest resources under sustainable management, allocating the natural forests for regulated multiple-use forestry after the needs for conservation have been given priority.
- Forming partnerships with rural people, rural communities, and other stakeholders, and introducing appropriate tenurial arrangements.
- Rehabilitating degraded forestlands for conservation and multiple-use production.
- Promoting tree growing by rural people – individually or collectively – and by NGOs.
- Putting the responsibility for production and marketing of commercial forest products into the hands of rural people, organized groups, cooperatives, etc.

The Forest Ordinance is being revised, providing the legal basis for the above-mentioned issues. A prominent feature of the new legislation is that it classifies the forest estate into three categories, namely: Strict Conservation Forests, Conservations Forests and Multiple Use Forests. The definition of the Multiple Use Forests as a category of forest in Forest Ordinance provides much flexibility to develop partnerships and share benefits with local community. The regulations that will be framed under the new Forest Ordinance are going to enhance the accessibility to Multiple Use Forests by the local community.

Identification of national priorities

The Forest Department appointed a committee in 1992 to recommend suitable species for reforestation programmes. Concurrently, a new emphasis was given to tree improvement in the early 1990s. Teak was considered as the highest priority species considering its importance as a high value as furniture timber with relatively fast growth and the fact that it is the most popular species among private tree growers. Other major species identified were *Swietenia macrophylla, Acacia auriculiformis, Azadirachta indica, Eucalyptus grandis, E. microcorys* and *E. tereticornis.* Three indigenous species, namely *Albizia odorotissima, Melia* *dubia* and *Pterocarpus marsupium* were identified for *ex situ* conservation. Appendices 2–4 provide more information on priority species for Sri Lanka.

Exploration and conservation of *Albizia odoratissima*, *Melia dubia* and *Pterocarpus marsupium*

In addition to the species identified for conservation under the Medicinal Plant Project, other important indigenous species that have been identified for gene pool conservation are *Albizia odoratissima, Melia dubia* and *Pterocarpus marsupium.* Some of these tree species are at the present found only in home gardens while others are confined to a few remaining natural habitats and their natural regeneration is threatened due to various factors. Therefore, it has been recommended to establish *ex situ* conservation stands for these three species. Activities proposed and initiated under this programme include:

1. Explore and document natural occurrences. Select 10–20 locations throughout the natural range in Sri Lanka, where groups of trees of these species occur and collect seeds from about 200 trees per location (These trees should be sufficiently apart from each other to minimize collecting seeds from close relatives).
2. Mix equal quantities of seeds from each tree to form a bulk seed lot.
3. Plant out 10–15 ha at two to three locations. These plantations will be *ex situ* conservation stands and base populations for breeding work. These also can be used as seed production areas.

Support activities

Training and capability building

Since the early days, forestry training has been given major emphasis, for example, the first training for staff of the Forest Department was conducted in 1949 by the school of agriculture at Peradeniya. From 1958 to 1983, two-year courses were developed for Range Forest Officers and one-year courses for Beat Forest Officers at the Ceylon Forest College at China Bay, Trincomalee. In 1985, this college was closed due to security risks and later the Sri Lanka Forestry Institute was opened at Nuwara Eliya in 1990.

Until 1993, the Sri Lanka Forestry Institute offered training as a one-year course for Range Forest Officers and a 6-month course for Beat Forest Officers. A six-hectare forest plantation, within which the Institute is located, provides practical training ground in forest surveying, forest management, forest mensuration, etc. A nursery with the capacity to produce 50 000 seedlings per year is being developed to provide practical training in nursery activities. In addition to the field staff of the Forest Department, Coupe Officers of the State Timber Corporation also obtained their training from the Institute at that time.

After 1993, with the revision of the curricula of the Forestry Institute, the Range Forest Officers' course was developed into a two-year Diploma Course while Beat Forest Officer's Course was developed into a one-year Certificate course. In addition, the Sri Lanka Forestry Institute conducts in-service training programmes for the departmental officers and short–term training courses for offices of other government organizations.

Another important national institution that conducts forestry education is the University of Sri Jayawardhanapura with an MSc degree programme on Environmental Forestry. The Post Graduate Institute of Agriculture (PGI) in Peradeniya University also offers MSc degree programmes in Environmental Forestry, under which courses on FGR are included.

Research

Research and development have an important role to play in solving the problems connected with conservation, utilization and promotion of forest and tree genetic resources. Answers to many of the existing problems can be obtained only by carrying out long-term research. During the recent past, the Forest Department based the Departmental Research Programme on five priority areas: tree improvement, plantation conversion, fire prevention, site/species matching and bamboos and rattans. However, a limited amount of work could be completed in these fields due to constraints such as continuous changes in the senior staff and the lack of research officers and technical assistants. In addition to the FD, universities, various research institutes and projects are also involved in forestry research. Among Universities, Peradeniya University conducts a considerable amount of research on natural forest ecology and management, hydrology and agroforestry while the University of Sri Jayawardenapura does a lot of research in the form of projects conducted by MSc degree students. The Royal Botanical Gardens at Peradeniya undertakes research on flora, including especially medicinal forest plants, and the conservation of genetic resources. A Research and Education division in the FD implements forestry research and education programme of the Department.

Regional and international collaboration

Currently, Sri Lanka is involved in a number of international collaborative initiatives, such as the International Neem Network, Asia Pacific Agroforestry Network (APAN), Regional Wood Energy Development Programme (RWEDP), UNDP/FAO Regional Project on improved productivity of man-made forests in tree breeding and propagation (FORTIP), IUFRO, Asia Pacific Association of Forestry Research Institution (APAFRI) and Teaknet.

International Neem Network

The National Focal Institute (NFI) in Sri Lanka for the International Neem Network is the FD. The Faculty of Agriculture of the University of Peradeniya is a major collaborator with the FD in carrying out the activities planned under this network. Activities that are undertaken include identification, documentation, collecting and distribution of seeds of local provenances. Some of the seeds of different provenances collected have been documented and dispatched to other foreign network collaborators.

Asia Pacific Agroforestry Network (APAN)

The National Focal Point for APAN in Sri Lanka is the FD while the Faculty of Agriculture of the Peradeniya University participates in the activities planned under the network. The activities implemented under this network include coordination of mechanisms for agroforestry research and development, information sharing and exchange, agroforestry training and field demonstrations.

National Forestry Research Committee and MPTS research committee

The National Forestry Research Committee and MPTS research committee coordinate agroforestry research activities in Sri Lanka.

Regional Wood Energy Development Programme (RWEDP)

The FD is the national focal point for this programme and is instrumental in the establishment of the National Coordinating Mechanism of Sri Lanka whose chairman is the Conservator General of Forests. Through the networking activities of this project, Sri Lanka has obtained assistance to mobilize national efforts and strengthen inter-institutional linkages for wood energy planning. The project secretariat provided information through technical materials, publications and the Wood Energy Newsletter. The assistance provided by the project includes development of syllabi and training materials for community forestry for training institutions, training materials for rapid rural appraisal (RRA) for community forestry and publicising a report on social forestry in integrated rural development and wood energy status in Sri Lanka.

UNDP/FAO Regional Project on Improved Productivity of Man-made Forests in Tree Breeding and Propagation (FORTIP)

Under this programme seed production areas were established for *Eucalyptus grandis* and *Eucalyptus microcorys*, and clonal seed orchards were established for teak. In addition, identification of *Swietenia macrophylla* stands for seed production under a Species Improvement Network (SPIN) was conducted.

IUFRO, Asia Pacific Association of Forestry Research Institution (APAFRI) and Teaknet
The FD continues to be a member of IUFRO, APAFRI and Teaknet.

Proposals for regional and international collaboration

The following regional and international collaborations are proposed:
1. A sound germplasm exchange programme should be developed.
2. Facilities should be arranged to obtain proven provenances from international provenance trials.
3. Scientists, researchers and managers should be given opportunities to visit trials and other sites in the region and to exchange views and experiences.
4. Suitable training programmes should be developed particularly for researchers.
5. A website should be created to provide information about genetic conservation and improvement in the region.
6. Assisting in getting financial support from donor agencies for the development of appropriate FGR conservation techniques.
7. Development of a network of researchers for information exchange.
8. Organising scientific seminars and workshops to disseminate research results.

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Appendix 1

Summary of Eucalyptus provenances tested in Sri Lanka

Species	Provenance	CSIRO No.	Alt. (m)	No of plots
Eucalyptus melanoxylon	Samford, QLD	14766	300	4
E. saligna	Consuelo tableland, QLD	13263	1090	3
E. saligna	Kenilworth, QLD	13341	470	3
E. saligna	40 km W of Coffs Har our, NSW	13320		4
E. saligna	Kroombit Tops, QLD	14432	800	4
E. saligna	Blackdown Tableland, OLD	14429	780	4
E. saligna	Chaelundi State Forest, QLD	14507	640	4
E. saligna	Kenilworth State Forest, QLD	14435	600	4
E. grandis	Baldy State Forest, QLD	14423	1000	4
E. grandis	Belithorpe State Forest, QLD	14431	500	4
E. grandis	Cascade via Dorrigo, NSW	14510	640	4
E. grandis	14.5 km S of Ravens Hoe, QLD	12409	940	4
E. cloeziana	SE of Gympie, QLD	13450	150	4
E. cloeziana	26 km SW of Monto, QLD	13543	480	4
E. resinifera	14.5 km S of Ravens Hoe, QLD	12-411	940	4
E. resinifera	SW of Coffs Harbour, NSW	13977	200	4
E. resinifera	WNW of Beerburrum, QLD	13981	40	4
E. pilularis	Local (Kandapola)			4
E. pilularis	W of Coffs Harbour, NSW	13523	100	4
E. pilularis	Gallangowan State Forest, QLD	13451	610	4
E. urophylla	Mt Lewotobi, INDO	14532	398	4
E. urophylla	Mt Egon, INDO	14531	515	4
Seed lots showing poor survival or growth				
E. alba	Mt Lewotobi, INDO	14533	340	0
E. tereticomis	9 km SW of Imbil, QLD-	13541	100	0
E. tereticomis	5-12 km S of Helenvale, QLD	14212	500	2
E. torelliana	SSW of Kuranda, QLD	14130	420	0
E. torelliana	S of Helenvale, QLD	14855	200	0
E. camaldulensis	E of Petford, QLD	14338	500	0
E. staigerana	Maitland Downs, QLD	13631	550	0
E. dunii	NNW of Urbenville, NSW	14113	675	4
E. citriodora	Local			0

QLD = Queensland, Australia; NSW = New South Wales, Australia; INDO = Indonesia

Appendix 2

Value and use of target species

Species name	Value and present or potential future use										
	ti	po	Wo	nw	pu	fo	fd	sh	ag	co	am
Acacia auriculiformis		1	1								
Azadirachta indica	1										1
Eucalyptus grandis	1								1	1	
E. microcorys	1								1	1	
Swietenia macrophylla	1								1		
Tectona grandis	1								1		
Terminalia chebula				1							
Diospyros melanoxylon	1			1							
Litsea glutinosa				1							
Phyllanthus emblica				1							
Pterocarpus marsupium	1			1							
Salacia reticulata				1							
Terminalia belerica				1							
Pterocarpus santalinus				1							
Lumnitzera litoria	1			1							
Carapa moluccencis	1			1							

VALUE: 1 = Species of current socioeconomic importance; 2= Species with clear potential of future value; 3 = Species of unknown value given present knowledge and technology

UTILIZATION: ti = timber production; po = posts, poles, roundwood; wo = fuelwood, charcoal; nw = non-wood products (gums, resins, oils, tannins, medicines, dyes, etc.); pu = pulp and paper; fo = food; Fd = fodder; sh = shade, shelter; ag = agroforestry systems; so = soil and water conservators; am = amenity, antithetic, ethical values

Appendix 3

List of priority species for conservation, improvement and seed procurement plus recommended activities

Species	Use				Operations/activities needed							
	W	NW	FW	O	Exploration & Collection		Evaluation		Conservation		Germplasm use	
	1	2	3	4	5	6	7	8	9	10	11	12
Albizia odoratissima	1				1	1	1			1		1
Melia dubia	1				1	1	1			1		1
Swietenia macrophylla	1				1	1		1		1		1
Tectona grandis	1				1	1		1		1		1
Terminalia chebula				1					1	1		
Diospyros melanoxylon				1					1	1		
Litsea glutinosa				1					1	1		
Phyllanthus emblica				1					1	1		
Pterocarpus marsupium				1					1	1		
Salacia reticulata				1					1	1		
Terminalia belerica				1					1	1		
Pterocarpus santalinus				1			1		1	1		
Lumnitzera litoria				1			1		1	1		
Carapa moluccencis				1			1		1	1		

End uses: 1 = Industrial wood products (logs, sawtimber, construction wood, plywood, chip and particle board, wood pulp etc.); **2 =** Industrial non-wood products (gums, resin, oils, tannins); **3 =** Fuelwood, posts, poles (firewood, charcoal, roundwood used on-farm, wood for carving); **4 =** Other uses, goods and services (food, medicinal use, fodder, land stabilization/amelioration, shade, shelter, environmental values).

Exploration & collection: 5 = Biological information (natural distribution, taxonomy, genecology, phenology etc.); **6 =** Collection of germplasm for evaluation

Evaluation: 7 = *In situ* (population studies); **8 =** *Ex situ* (provenance and progeny tests)

Conservation: 9 = *In situ*; **10 =** *Ex situ*

Reproductive use/germplasm use: 11 = Semi-bulk/bulk seedlots, reproductive materials; **12 =** Selection and improvement

Rating for columns 5–12: 1 = Highest priority, action should start, or be continued, with immediate effect; **2 =** Prompt action recommended, action should start within next two biennia; **3 =** Action required in next five to ten years

Appendix 4

Management and location of genetic resources, by natural site and species

Species in ecogeographic zones	Nature reserves, protected areas	*In situ* conservation stands	Managed forests	Unmanaged forests	Plantations (ha)	*Ex situ* conservation stands	Villages, fields, homesteads	Experiment, fields, trials	Degree of Threat Index
Wet Zone									
Acacia auriculiformis					589				3
Swietenia macrophylla					1509				3
Tectona grandis					246				3
Montane Zone									
Eucalyptus grandis					6038				1
E. microcorys					8486				1
Dry Zone									
Acacia auriculiformis					1081				2
Azadirachta indica					673				2
Swietenia macrophylla					206				2
Tectona grandis					23 833				2
Terminalia chebula		1							
Diospyros melanoxylon		1							
Litsea glutinosa		1							
Phyllanthus emblica		1							
Pterocarpus marsupium		1							
Salacia reticulata		1							
Terminalia belerica		1							
Intermediate Zone									
Acacia auriculiformis					236				3
Azadirachta indica					115				3
Swietenia macrophylla					3498				3
Tectona grandis					4037				3
Pterocarpus santalinus						1			
Lumnitzera litoria						1			
Carapa moluccencis						1			

Status of forest genetic resources conservation and management in the People's Republic of China

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Introduction

The conservation and management of forest genetic resources (FGR) is essential for the existence and development of modern societies. Burley (2002) stressed that forest biological diversity represents a fundamental resource since it includes the world's species and their constituent genes upon which humanity depends for health, prosperity and environmental welfare. The loss of ecosystems, species and genes is a major threat to the survival of humans and other organisms.

China is one of the largest nations in area in the world with a rich biological diversity but relatively poor forest resources. With regard to the number of species per country, China is only behind Brazil and Malaysia. Over 30 000 species of vascular plants are found in China, comprising perhaps more than 10% of the world total. Many species represent archaic and distinctive evolutionary lines, for example, *Ginkgo biloba* and *Metasequoia glyptostrouboides*.

An estimated 30 560 species of plants have been documented in China, belonging to 343 families and 3150 genera. All families of Gymnospermae, apart from Araucariaceae, are naturally distributed in China. Of the total number of woody plants, over 2000 species are trees and 6000 are shrub species, belonging to more than 1200 genera and 187 families. The Chinese flora is also characterized by a great number of species that are endemic or only shared with eastern Asia. About 17 300 species are endemic accounting for more than 60% of the total in the country. On the other hand, the Chinese flora contains, in terms of origin, a great deal of floristic elements of the old world, Mediterranean and, especially, Indo-Malayan flora (Wu Zhengyi 1980; Anon 1997; Chen Linzhi and Ma Keping 2001; Liu *et al.* 2003).

There is an ecological gradient in rainfall from the east to the west of China. In general western China, being in the isocline of 400 mm rainfall, is phytogeographically characterized by arid or semi-arid desert vegetation, grassland, tundra or alpine forests, while eastern China is sub-humid or humid, covering a range of forest vegetation zones from boreal forest, cold-temperate and temperate broadleaved forest, subtropical evergreen broadleaved forest to seasonally tropical rain forests. To facilitate sustainable forest management, forest types of China are grouped into the following categories: Coniferous forests, Broadleaved forests, Bamboo forests, Bush communities and Cash tree crops (Anon 1997).

According to the forest statistics of China published by the Department of Forest Resources Management, State Forestry Administration (SFA), forest coverage reached 16.65% of the nation's area in 1998[1] (SFA 2000). The total area of forests in China is 158.94 million ha, of which 107 million ha or 69.62% can be classified as natural forests and 46.67 million ha (30.38%) are plantations, including tree crops.

Only a few native species and exotics are used in plantation programmes even though the native forest flora is very rich. For example, industrial plantations established in 2002 in the whole China covered 110 010 ha, of which 35 622 ha were of eucalypts and acacias, 24 626 ha of *Pinus elliottii, P. taeda and P. caribaea* and 26 473 ha of poplars and paulownias, the rest being mostly indigenous hardwoods and bamboos (see the web page of the Department of Afforestation, SFA at http://www.forestry.gov.cn/lytj/index.asp). The national forestry authorities have noted that more indigenous species should be used in

[1] Projected foliage coverage of canopy was changed to 0.2 from 0.3 in the 5th national forest inventory, which was carried out during 1994–1998.

planting programmes in order to maintain the biological diversity. In general, the forest resources of China can be summarised as follows:

- Forest resources are unevenly distributed in the geographic regions since 41.27% of forest area is located in only a few provinces: Heilongjiang, Jilin, Inner Mongolia, Sichuan and Yunnan.
- Age-structure of stands is far from reasonable with over 70% of immature forests, which implies that the forest resources have been cut excessively.
- The average standing volume for commercial forests is around 72.5 m^3 ha^{-1} and for plantation forests even much less; only 35 m^3 ha^{-1}. Only 8% of the total wood production is contributed by plantation forestry even though planted forests make up 20% of the total forest area.
- Most of the forest stands are dominated by *Pinus massoniana, Cunninghamia lanceolata* and species of *Larix, Picea* and hardwoods such as *Quercus, Betula* and *Populus*, etc. In total, *P. massoniana* and *C. lanceolata* contribute 23.5% of the total forest area. *Abies, Picea, Tsuga, Tilia* and some pines, for example *Pinus densata*, are not accessible for forest management activities in the remote alpine areas.

The economy of China is booming and the demand for a range of wood and wood products is on the increase. To meet the domestic demand for timber, China has to import a great deal of timber and timber products. For instance, according to the Forestry Information Institute (FII), the Chinese Academy of Forestry (CAF) the quantity of round timber imported in 2002 reached a record 24.3 million m^3 with the import value of US$ 2138 million (see http://www.lknet.forestry.ac.cn/my/ymbg.htm).

Conservation of forest genetic resources

General status

Forest biodiversity in China also suffers from the explosive increase in the intensity and extent of human activities. Poaching of timber, medicinal materials and other non-timber forest products (NTFPs) is still a serious problem for the conservation of FGR. For example, the genetic resources of *Taxus yunnanensis* have been exhaustively exploited and the species is on the verge of extinction in the forests (Chen Shaoyu *et al*. 2001). Fragmentation and degradation of natural forests are commonly seen in China. Valuable timber species are disappearing and becoming extinct.

It was highlighted in the Forestry Action Plan for China's Agenda 21, published in 1995, that great efforts must be made and scientific research must be enhanced in the conservation and sustainable utilization of FGR (MOF 1995). The Chinese government has been aware of the significance of developing socioeconomic priorities, initiatives, regulations, policies, and legislation to intensify the support for biodiversity conservation.

Since 1998, the Chinese government has launched six major forestry programmes with emphasis on the conservation of the native resources and the environment. FGR conservation activities are included as major components of these programmes. The six programmes included (a) conservation of natural forest resources, (b) land use conversion from marginal agriculture to forestry or grassland, (c) combating desertification in the vicinity of the capital Beijing, (d) networks of shelterbelts in 3N regions (Northern, Northeastern and Northwestern China) and the middle and lower reaches of Yangtze river, (e) conservation of the genetic resources of wildlife and plants and (e) the development of nature reserves and development of commercial forest plantations.

In situ conservation

FGR can be conserved with two different approaches, *in situ* and *ex situ.* The former is a dynamic and evolutionary approach. *In situ* genetic conservation is an essential component of sustainable forest management (Koski 1998; Palmberg-Lerche 1998; Sigaud *et al*. 2000; FAO, DFSC, IPGRI 2001). Unfortunately, it is often overlooked in the practice of forest management in certain circumstances.

In China, the strategy of FGR conservation has, to a certain extent, been adopted from that of agricultural crops, making much effort to establish facilities, such as *ex situ* conservation stands and genebanks with great investments. *In situ* conservation programmes are still not well designed as integrated elements in sustainable management of forest resources or seed production. Human activities are, of course, not necessarily always negative to forest ecosystems if forest management is properly carried out (Palmberg-Lerche 2002). As yet in China, *in situ* conservation has not received enough attention, even though superior populations have been identified for a number of economically important tree species. The utilization and conservation of FGR can be integrated through planning and implementing in all of the major forestry programmes mentioned above.

Nature reserves and national parks play a significant role in conservation of FGR. However, they never replace the establishment of *in situ* conservation stands in managed forests. Conservation activities in nature reserves focus dominantly on the diversity of ecosystems and endangered or threatened species, while genetic conservation programmes should give more priority to the genetic diversity among wild populations within species that are, presently or potentially in the future, important for forestry production or breeding programmes. This has been addressed during the last decade in successive sessions of the FAO Panel of Experts on FGR.

For protecting biodiversity, China has established 1757 national and local nature reserves. The total protected area is 1330 million ha, accounting for 13.2% of the country's area (see http://www.lknet.ac.cn). Out of these, 171 are national reserves, 21 have been designated as Biosphere Reserves of the UNESCO's Man and the Biosphere Programme, and seven have been designated as globally significant wetlands. China has set an ambitious goal of increasing the number of reserves to 1800 (covering 15% of the area) by 2010 and 2500 by 2050 (Liu *et al.* 2003).

Ex situ conservation

Species or provenance trials, progeny tests, seed orchards and plantations are all components of the category of *ex situ* gene conservation (Palmberg-Lerche 1998). Over 400 *ex situ* conservation areas, including about 100 botanical gardens and arboreta, have been established in the country to collect tree germplasm. Since exotic species play an increasingly important role in plantation forestry (in China about 25% of planted forests are established with introduced species), all commercial and experimental plantings of exotics can be regarded as *ex situ* conservation. However, the functioning of genetic conservation in commercial plantations is doubtful as these plantations are established with fast-growing species with short rotation, for example eucalypts, and many species do not become reproductively mature before being cut down. Indigenous and exotic species, for which some form of *ex situ* conservation stands have been established, include:

a) **Indigenous:** *Cunninghamia lanceolata, Pinus armandii, P. koraiensis, P. massoniana, P. sylvestris var. mongolica, P. tabulaeformis, P. yunnanensis, Populus simonii, P. tomentosa* and *Hippophae rhamnoides* (All of these are in the form of seed orchards, clone banks or plantations)

b) **Introduced:** *Pinus elliottii* and *P. taeda* (seed orchard), *P. caribaea var. caribaea* (progeny tests with 220 families), *P. caribaea* var. *bahamensis* (progeny test with 121 families), *Larix kaempferi* (seed orchard), *Eucalyptus globulus ssp. globulus* (progeny test with 300 families), *E. grandis, E. smithii* and *E. urophylla* (progeny test and seed orchard), *Acacia auriculiformis, A. crassicarpa* and *A. mangium* (provenance/progeny tests), *Populus euamericana* (clone bank), *Robinia pseudoacacia* (seed orchard) and other species

Research activities in tree improvement and breeding

Traditional breeding

Traditional tree breeding and improvement programmes in China have been conducted mostly in the last two decades. Much of the research in forest genetics, tree improvement and breeding has focused on creating a better understanding of patterns of genetic variation at both inter- and intraspecific levels in major commercial plantation species, which are currently used or potentially valuable in future. Understanding of the genetic structure and identifying outstanding provenances create a scientifically sound basis for *in situ* conservation programmes in sustainable forest management. Major research activities have been undertaken with the following species to understand patterns of genetic variation:

a) Conifers:
- *Cunninghamia lanceolata* (Hong and Wu 1990; Hong and Chen 1994)
- *Larix gmelinii*
- *L. olgensis*
- *L. principis-rupprechtii* (Ma 1992a)
- *Pinus armandii* (Ma 1992b)
- *P. koraiensis* (Niu 1992)
- *P. massoniana* (Wang and Chen 1992; Zhou 2001)
- *P. sylvestris* var. mongolica (Chen 1992)
- *P. tabuliformis* (Shen 1992; Xu 1992)
- *P. yunnanensis*
- *Platycladus orientalis* (Wu and Shen 1987; Liang and Chen 1989)

b) Hardwoods:
- *Betula platyphylla*
- *Paulownia* spp. (Xiong *et al*. 1991)
- *Populus cathayana*
- *P. simonii* (Lu *et al*. 2001; Lu and Fu 2002)
- *P. tomentosa* (Zhu Zhiti 1991)
- *Quercus mongolica* (Xia *et al*. 2001)
- *Salix* spp. (Tu *et al*. 1991)
- *Ulmus pumila* (Ma 1993; Anon 2002)

c) Economic trees
- *Eucommia ulmoides*
- *Camellia oleifera*
- *Aleurites fordii*
- *Rhus sylvestris*
- *Castanea mollissima*
- *Juglans regia*
- *Ziziphus jujuba*

d) Rattan and bamboo:
- Rattan (Xu *et al*. 2002)
- *Phyllostachys pubescens*

e) Shrubs: *Hippophae rhamnoides* (Zhao *et al*. 1992)

Biotechnology and GM trees

In recent years, a large proportion of research funding has been allocated to research in molecular genetics and biotechnology to detect genetic diversity and produce genetically modified (GM) trees, for instance, with *Larix* spp., *Pinus massoniana*, *Populus* section *Tacamahaca*, introduced poplars (Li *et al.* 2000), *Quercus mongolica* and *Q. mongolica* var. *liaodongenesis* as well as *Paulownia spp*.

GM trees of poplars have been released and used in commercial plantations. Eighty hectares of plantations of GM *Populus nigra*, resistant to leaf-eating insects, were established in 2002. More transgenic research is actively ongoing with species of *Populus*, *Betula* and *Larix* (Su Xiaohua, personal communication 2003).

Resource allocation

There is an imbalance in resource allocation for research in traditional breeding and research in biotechnology; only a few research projects on traditional tree breeding with seed orchards and provenance trials are surviving today as most of the governmental funding is directed to the development of new technologies.

It is noted that GM research and applied tree breeding are separated from each other; instead, they should be closely linked by project planning. Studies on GM trees should be aimed at species that are of important economic value for commercial forestry, other than at species that are biologically easier to work with by genetic engineering. Genetic materials selected by traditional breeding programmes should be made use of in genetic engineering.

Education, training, and research

Education and training on FGR conservation in Chinese universities is normally included in relevant subjects such as forest ecology, forest genetics and tree breeding, while most research projects on natural conservation, e.g. on endangered or threatened species, are assigned to ecological studies and nature reserve management. Short-term training courses and research activities are conducted or coordinated by national research organizations in close cooperation with local forestry authorities and research units. It is possible to operate activities in cooperation with international institutions; in fact, currently there are a number of international programmes going on. For example, FAO, GEF, UNDP and the World Bank, WWF and other foundations have programmes involving biodiversity and management of natural resources.

Identification of national priorities

The criteria and justification for selecting priority species have been discussed at different sessions of the FAO panel of experts on FGR and among many scientists. "Priorities in the sustainable management of forests, including the conservation of forest biological diversity at the levels of ecosystems, species and genetic resources, will depend on value judgments and the relative emphasis on the various roles and functions of forests", as Palmberg-Lerche (2002) pointed out.

It is rather difficult to set up priorities for FGR conservation in China since the Chinese forest flora is very sophisticated and diverse across the country, from the cold temperate to the tropical zone. The essential principles (FAO 1993; FAO, DFSC, IPGRI 2001; Namkoong 1998; Palmberg-Lerche 1998, 2002; Sigaud *et al*. 2000) for setting priority species include:

- Species with important economic value at present for wood production
- Species with important economic value for NTFP
- Species with important economic value in agroforestry systems, i.e. multi-purpose tree species (MPTS)
- Species with important ecological value for land reclamation and other environmental improvement
- Keystone species in forest ecosystems
- Species with obvious potential value or economical importance in the future
- Species whose economic value remains unknown under the present human knowledge

Priority species for FGR conservation programmes in China are listed in Appendix 1. Priority species that are shared with southeastern Asia in their natural range are listed in Appendix 2.

Institutional framework

The National Forestry Administration (formerly the Ministry of Forestry) has the mandate to coordinate national and international programmes on FGR conservation; in addition, the national Bureau of Environment Protection is also involved. Projects are normally approved by the Ministry of Science and Technology with governmental funds. As a research organization, the CAF is responsible for implementing conservation programmes in cooperation with the provincial forestry agencies. Currently, several conservation programmes, both national and international, are being carried out by the academy.

As for legislation on biodiversity and conservation, the Chinese government has issued the following laws or regulations:

1) The Forest Law of the People's Republic of China, issued in 1984 and revised in 1998 by the National People's Congress (NPC)
2) The Law on Seed of the People's Republic of China (NPC 2000)
3) The implementing regulation of the Forest Law (SFA 2000)
4) The Law on Combating Desertification (NPC 2002)
5) The Regulation on Preventing Forest Fires (State Council 1988)
6) Managerial Regulation on Nature Reserves (1994)
7) The Regulation on protecting wild plants (State Council 1997)
8) The Protection Regulation on New Plant Varieties (State Council 1997)
9) Managerial certificate on producing and marketing tree seed (SFA 2003)
10) Regulation on land use conversion from marginal agriculture to forestry (State Council 2002)
11) Regulation on land use conversion from forested land for other uses
12) Biosafety regulation on agricultural GMOs (State Council 2001)
13) Regulation on plant quarantine and monitoring of introduced seed, stocks and other genetic materials
14) Biosafety regulations on the application of GM trees (in progress)

All these documents reflect, to a certain extent, the essence of international instruments, for example, the CBD and other international conventions and treaties. The detailed information on each law or act can be found at the web page of the NAF, China at http://www.forestry.gov.cn/DB/zcfg/index_bmgz.asp.

Conclusions

This report can be concluded with the following points:

- Indigenous species are identified as priority species for *in situ* FGR conservation programmes that should be integrated into sustainable forest management.
- There are a few introduced species whose *ex situ* conservation should be enhanced in combination with tree breeding programmes.
- Research projects must be carried out with potentially important native species for creating an understanding of genetic variation patterns.
- Conceptual differences between gene conservation of forest trees and of agricultural crops should be better understood and distinguished; with trees more emphasis should be places on *in situ* conservation.
- Research and development of GM trees needs to be closely linked with traditional breeding programmes.
- For the time being, there are a number of both national and international forestry and environment projects that are related to FGR conservation. It is challenging to find out how to coordinate these programmes in the aspects of gene conservation.
- Table 2 lists species that are naturally distributed in not only China, but also in some other countries in Southeast Asia. Efforts for genetic conservation of these species need to be made through international cooperation between China and neighbouring countries with the coordination of FAO or IPGRI.

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Appendix 1

Priority species for FGR conservation with emphasis on species that are naturally distributed in or introduced to subtropical and tropical China

SPECIES	Presently important for wood production	Presently important for NWFP	Presently important as MPTS	Site reclamation and landscaping	Keystone species	Potential economic value	Presently unknown	Remarks and references
Abies chensiensis					+			Subtropical alpine species
A. delavayi					+			Subtropical alpine species
A. ernestii					+			Subtropical alpine species
A. fabri					+			Subtropical alpine species
A. georgei					+			Subtropical alpine species
Acacia auriculiformis	+							International PVT, exotic
A. catechu		+						Native to China and India
A. confusa				+				Native to China
A. crassicarpa	+							Exotic, PVT, SO
A. mangium	+							International PVT, SO, exotic
Acer buergerianum	+							
A. palmatum	+							
A. truncatum	+							
Albizia chinensis	+			+				
Alnus cremastogyne	+							Pioneer, fast-growing
A. japonica	+							Native to China, Japan, Korea
Alnus nepalensis	+							Pioneer, fast-growing
Amentotaxus yunnanensis				+				Rare, China
Anthocephalus chinensis				+				
Aquilaria spp.		+						Overexploited, poor regeneration, recalcitrant
Artocarpus heterophyllus		+						Tropical fruit
Azadirachta indica		+	+					International PVT initiated
Bamboos	+	+		+				(*Bambusa* spp., *Dendrocalamus* spp.)
Betula alnoides	+							PVT, SW China
B. luminifera	+							
B. pendula	+							

SPECIES	Presently important for wood production	Presently important for NWFP	Presently important as MPTS	Site reclamation and landscaping	Keystone species	Potential economic value	Presently unknown	Remarks and references
B. platyphylla	+							PVT, China
Camellia oleifera		+	+					Valuable oil, China and Japan
Canarium album								Fruit, China
C. pimela	+			+				Timber
Carya cathayensis	+	+	+					Nut and timber
Castanea henryi	+	+						Timber and nut
C. mollissima		+	+					Nut, many varieties
Castanopsis hystrix		+						Timber and nut
Casuarina equisetifolia				+				Exotic, breeding in China
Cercidiphyllum japonicum					+			(E) China, protected
Chamaecyparis formosensis	+							China
Choerospondias axillaris		+	+					MPTS
Chosenia arbutifolia	+							Monogenus*
Chukrasia tabularis								(E) some provenances
Cinnamomum camphora	+	+		+				Overexploited
C. cassia		+	+					Bark and essential oil
Cryptomeria fortunei	+							
Cupressus chengiana	+							Valuable timber, dry site
C. duclouxiana	+							Valuable timber, dry site
C. funebris	+							Valuable timber
C. gigantea				+				China
C. torulosa	+							Timber species for dry exposed sites.
Cunninghamia lanceolata	+							PVT, seed orchard, vegetative propagation
Cycas panzhihuaensis				+				China (E)
Dacrydium pierrei	+							China (E)
Dalbergia hupeana	+	+						Valuable timber
D. odorifera	+	+						China, valuable timber, becoming rare
D. obtusifolia	+	+						Valuable timber
Duabanga grandiflora	+							Yunnan, China
Elaeagnus angustifolia				+				Dry area and sandy land in temperate country

SPECIES	Presently important for wood production	Presently important for NWFP	Presently important as MPTS	Site reclamation and landscaping	Keystone species	Potential economic value	Presently unknown	Remarks and references
Erythrophleum fordii	+							Valuable timber
Eucalyptus camaldulensis	+							Exotic to China
E. globulus	+							Exotic to China
E. grandis	+							Exotic to China
E. smithii	+							Exotic to China
E. urophylla	+							Exotic to China
Eucommia ulmoides		+	+					Monogenus, endemic to China. (E). Chinese herbal medicine
Firmiana major	+							China
Fokienia hodginsii					+			Monogenus and endemic to China.
Fraxinus mandshurica	+							PVT
Ginkgo biloba		+	+	+				Seed used for human food and for medicine
Gleditsia sinensis			+					MPTS
Glyptostrobus pensilis						+		(E)
Gmelina arborea			+					International PVT
G. hainanensis			+					
Haloxylon ammodendron				+				Central Asia. Cold and dry areas
H. persicum				+				Central Asia. Cold areas
Hopea hainanensis	+							Tropical China
Hovenia dulcis	+	+						China, Japan
Illicium verum		+						China. Medicine and spice
Juglans mandshurica	+							
J. regia		+	+					Himalayas. Nuts
J. sigillata		+						Many cultivars in China
Keteleeria davidiana						+		China
K. pubescens						+		PVT. Fast-growing, good timber species
Larix griffithiana					+			Rare. Restricted to Tibet
L. gmelinii	+							PVT, SO
L. leptolepis	+							PVT, SO
L. olgensis (Larix gmelinii var. *olgensis)*	+							Important for hybridization

SPECIES	Presently important for wood production	Presently important for NWFP	Presently important as MPTS	Site reclamation and landscaping	Keystone species	Potential economic value	Presently unknown	Remarks and references
L. potaninii	+							PVT, SO
Liriodendron chinense				+				Hybridization
Liquidambar formosana	+			+				
Madhuca hainanensis.	+							China, Rare
Magnolia officinalis		+						China. Medicine
Manglietia aromatica						+		China
M. fordiana						+		
M. glauca						+		
M. insignis						+		China
Melia azedarach	+							
Mesua ferrea	+							Rare, very valuable timber, Yunnan
Metasequoia glyptostroboides				+				Living fossil, China
Michelia spp.	+							
Ormosia henryi	+							Overselected
O. macrophylla	+							
Parashorea chinensis var. *kwangsiensis*	+							China
Paulownia elongata	+		+					Work in progress. China
P. fortunei	+		+					
P. tomentosa	+		+					
Phellodendron amurense	+							Timber and medicine
Phoebe nanmu	+							
Picea asperata					+			
P. brachytyla					+			
P. brachytyla var. *complanata*					+			
P. crassifolia					+			
P. jezoensis					+			Breeding in China, Korea
P. koraiensis					+			China and Japan
P. likiangensis					+			
P. meyeri					+			
P. schrenkiana					+			Protected, NW China
P. wilsonii					+			
Pinus caribaea var. *bahamensis*	+							PVT, PGT in China
P. caribaea var. *caribaea*	+							PVT, PGT in China
P. dabeshanensis	+							Rare, China

SPECIES	Presently important for wood production	Presently important for NWFP	Presently important as MPTS	Site reclamation and landscaping	Keystone species	Potential economic value	Presently unknown	Remarks and references
P. densata	+							
P. gerardiana	+							Tibet, restricted to two dry valleys
P. fenzeliana	+							
P. kesiya	+							China, India. (E) some provenances
P. koraiensis	+							(E) in parts of the range. Protected in China.
P. massoniana	+							China, PVT, PGT, SO
P. sylvestris var. *mongolica*	+							China. PVT, PGT, SO
P. tabuliformis	+							China. PVT, PGT, SO
P. taiwanensis	+							
P. wallichiana (syn. *Pinus griffithii)*								Tibet. Vigorous regeneration
P. yunnanensis	+							PVT, PGT, SO
Pistacia chinensis			+					Adapted to calcium soil
P. vera		+						Edible nuts
Platycladus orientalis	+			+				Species for semi-arid areas
Populus deltoides	+							Introduced to China
P. euphratica					+			(E) China. Dry areas
P. simonii	+				+			PVT in China
P. tomentosa	+			+				Endemic to China
Prunus amygdalus		+		+				Nut for arid areas
Pseudolarix amabilis	+							Monogenus, protected in China
Pseudotaxus chienii							+	Overexploited
Pterocarpus indicus	+							S. China
Pteroceltis tatarinowii		+	+					Bark fibrous for Chinese painting paper and adapted to calcium soil
Quercus acutissima	+			+				
Q. mongolica	+			+				
Q. variabilis	+			+				
Salix babylonica	+			+				Ornamental
S. matsudana	+			+				

SPECIES	Presently important for wood production	Presently important for NWFP	Presently important as MPTS	Site reclamation and landscaping	Keystone species	Potential economic value	Presently unknown	Remarks and references
S. mongolica	+			+				
Sapium sebiferum		+	+					China, MPTS
Sassafras tzumu	+							
Schima superba	+							Fire protection
Sinowilsonia xylocarpa							+	Monogenus, endemic to China
Syzygium jambos		+	+	+				Fruit tree in S. China
Taiwania cryptomerioides						+		(E), Taiwan, China
T. flousiana						+		(E), China, PVT
Taxus cuspidata		+						Overexploited for medical extracts
T. yunnanensis		+						Overexploited for medical extracts
Tectona grandis	+							Exotic to China
Thuja sutchuenensis	+			+				China
Tilia amurensis	+							
Toona microcarpa	+	+	+					MPTS
T. sinensis	+	+	+					MPTS
Torreya grandis		+		+				Nut, S. China
Tsuga chinensis					+			
Ulmus parviflora				+				China, Ornamental
U. pumila	+			+				
Vatica guangxiensis								China, Tropical rain forest
V. hainanensis								China, Tropical rain forest
Xanthoceras sorbifolia	+			+				For oil in arid area
Zanthoxylum simulans	+			+				
Zelkova schneideriana								Breeding in Japan
Zenia insignis			+	+				In karst mountainous area**
Ziziphus jujuba		+	+					

PVT = Provenance trial; PGT = Progeny trial; SO = Seed orchard; E = Endemic to China; MPTS = Multi-purpose tree species

* Monogenus = a genus that includes one species only

** Karst mountainous areas are typical particularly in southern China; the topography is featured with limestone mountains or outcrops and shallow soils that make agriculture or tree growing very difficult. Only a small number of tree species are adapted to the environment.

Appendix 2

Priority species for FGR conservation, which are shared in common distribution among China and some other countries in SE Asia

SPECIES	Presently important for wood production	Presently important for NWFP	Presently important as MPTS	Site reclamation and landscaping	Keystone species	Potential economic value	Presently unknown	Remarks and references
Acacia auriculiformis	+							International PVT, exotic
A. catechu		+						China and India
A. crassicarpa	+							Exotic, PVT, SO
A. mangium	+							International PVT, SO, exotic
Albizia chinensis	+			+				
Alnus cremastogyne	+							Pioneer, fast growing
A. nepalensis	+							Pioneer, fast growing
Amentotaxus yunnanensis				+				Rare, China
Anthocephalus chinensis				+				
Aquilaria spp.		+						Overexploited, poor regeneration, recalcitrant
Artocarpus heterophyllus		+						Tropical fruit
Azadirachta indica		+	+					International PVT initiated
Bamboo	+	+		+				(*Bambusa*, *Dendrocalamus* spp.
Betula alnoides	+							PVT, SW China
Canarium album		+						Fruit, China
C. pimela	+			+				Timber
Casuarina equisetifolia				+				Exotic, breeding in China
Choerospondias axillaris		+						MPTS, China and India
Chukrasia tabularis								(E) some provenances
Dacrydium pierrei	+							China (E)
Dalbergia hupeana	+	+						Valuable timber
D. odorifera	+	+						China, valuable timber, becoming rare
Duabanga grandiflora				+				Yunnan in China and India, Malaysia

SPECIES	Presently important for wood production	Presently important for NWFP	Presently important as MPTS	Site reclamation and landscaping	Keystone species	Potential economic value	Presently unknown	Remarks and references
Erythrophleum fordii	+							Valuable timber
Eucalyptus camaldulensis	+							Exotic to China, important plantation species
E. grandis	+							Exotic to China, important plantation species
E. urophylla	+							Exotic to China, important plantation species
Gmelina arborea			+					Int. PVT
G. hainanensis			+					
Hopea hainanensis	+							Tropical China
Melia azedarach	+		+					Widely distributed in China
Mesua ferrea	+							Rare, very valuable timber, Yunnan
Ormosia henryi	+							Overselected
Ormosia macrophylla	+							
Parashorea chinensis var. *kwangsiensis*	+							China
Paulownia elongata	+		+					Work in progress. China
Pinus caribaea var. *bahamensis*	+							PVT, PGT in China
P. caribaea var. *caribaea*	+							PVT, PGT in China
P. wallichiana (syn. *Pinus griffithii*)								Tibet. Vigorous regeneration
Pinus yunnanensis	+							PVT, PGT, SO
Pterocarpus indicus	+							S China
Schima superba	+							Fire resistant
Syzygium jambos		+	+	+				Fruit tree in S. China
Tectona grandis	+							Exotic to China
Toona microcarpa	+	+	+					MPTS
Toona sinensis	+	+	+					MPTS
Vatica astrotricha								China, Tropical rain forest
Zenia insignis			+	+				In karst mountainous area

PVT = Provenance trial; PGT = Progeny trial; SO = Seed orchard; E = Endemic to China; MPTS = Multi-purpose tree species

Status of forest genetic resources conservation and management in Cambodia

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Introduction

Natural forests cover about half of the area of Cambodia and represent a wealth of forest types ranging from mangrove and tropical humid evergreen forests to dry forests and montane forests. The forests contain substantial biological resources, including valuable plants and wildlife species. The families of Dipterocarpaceae, Leguminosae, Lythraceae, Fagaceae and, in some places, Pinaceae or Podocarpaceae, dominate the forest vegetation. Bamboos are also common in some areas. The flora of lower altitudes is typical of the Indo-Chinese floristic composition, whereas that of higher altitudes is typical of the Indo-Malayan flora. The high mountain flora is poorly known (Dy Phon 1982).

In 1997, the forest area of Cambodia covered 10 638 208 ha (60.2% of the total land area), classified into evergreen, mixed, deciduous, secondary, coniferous, flooded, and mangrove forests (Table 1).

Table 1. Forest cover by forest type in hectares (DFW 2003)

Forest	Dry land forest					Edaphic	
type	Evergreen	Mixed	Deciduous	Secondary	Coniferous	Flooded	Mangrove
Area	3 986 719	1 505 326	4 281 397	374 197	82 425	335 307	72 835
Total	10 638 208						

The forests have a significant role in rehabilitation and development of Cambodia's agricultural, socioeconomic, environmental and especially tourism sectors. The forests also play a major role in subsistence livelihood of local communities, providing a major source of fuel, building materials, and non-timber forest products.

Prior to the 1970s, the estimated annual production of logs and fuelwood was 385 000 m^3 and 357 000 m^3 respectively and the average log exports amounted to 94 508 m^3. During the 1990s, log production increased substantially from 600 000 m^3 in 1991 to 4.3 million m^3 in 1997, with export earnings of US$ 114 million (DFW 2001).

Large tracts of natural forest are under heavy pressure due to logging, encroachment and shifting cultivation. Only few economically viable areas for logging remain, and a number of tree species have become vulnerable to extinction, in particular at population level and even at species level.

The ongoing forestry reforms give high priority to reforestation, the key to success being the supply and use of good quality seeds through the conservation of forest genetic resources (FGR).

Conservation of forest genetic resources

In Cambodia, the priority tree species for conservation and use are indigenous. The better wood quality and higher value of indigenous species could compensate for the slower growth rates as compared to exotics. An evaluation that includes also ecological and social considerations and future demand, could recommend planting indigenous species (Sloth 2002). However, this norm is often not followed due to other considerations.

The state of health of forests and threats to genetic diversity are not well documented in Cambodia. In general, however, valuable timber species are under threat because of forest encroachment, logging, land conversion as well as indirect human activities.

In situ and *ex situ* conservation of FGR

The preferred option for forest genetic conservation is *in situ* conservation, complemented by *ex situ* activities. *In situ* conservation is practised in two types of management regimes:

protected areas, and seed sources in natural forests. Prior to 1957, about one third of Cambodia's forested areas were inventoried and classified into 173 forest reserves (totalling 3.9 million ha) and six wildlife sanctuaries (13 million ha). The first national park in Southeast Asia, covering 10 800 ha of forested area around the temple of Angkor was designed and established in 1925. In 1993, a new system of protected areas was established by the Royal Decree on "Creation and Designation of Protected Area", signed by King Norodom Sihanouk on 1 November 1993. The Royal Decree includes 23 protected areas, covering in total 3 273 200 ha of Cambodia's land area.

The protected areas are divided into 4 categories: National Parks, Wildlife Sanctuaries, Protected Landscapes and Multi-Use Areas. The above are administered under the jurisdiction of the Ministry of Environment (MOE). In addition, the Ministry of Agriculture, Forestry and Fisheries (MAFF) manages nine protected areas which are significant for genetic resources, wildlife and watershed conservation. The total protected area under the MAFF is 1 346 225 ha.

Together with governmental *in situ* conservation activities, the Cambodia Tree Seed Project (CTSP) has established 23 seed sources in the natural forests outside protected areas (Table 2). Besides the objective of producing seed for collection, the seed sources are considered as protected sites for conserving genetic resources of priority species. *Ex situ* conservation activities include a seed production area, a seed orchard, and a provenance trial, as outlined in Section 3 below.

Specific policies for natural resource management do not exist, but activities are addressed through a number of sectoral policies. The Royal Government of Cambodia is in the early stages of preparing to develop a National Forest Programme (NFP), which will be fully consistent with international guidelines. The Department of Forestry and Wildlife (DFW), together with the CTSP, is currently developing a policy framework for the tree seed sector and forest genetic resource conservation. This framework will form an essential part of the ongoing forest reform process and contribute to the NFP. The impact of the current policy and legislation is further detailed below.

Table 2. Seed sources in the natural forests (CTSP 2002)

No. of site	Species	Area (ha)	Location		Number of mother trees
			Province	District	
1	*Dalbergia oliveri*	12.5	Preah Vihear	Tbeng Meanchey	78
2	*Sindora cochinchinensis*	117	Kampong Thom	Sandann	100
	Tarrietia javanica				39
	Shorea hypochra				22
	Shorea vulgaris				19
	Dipterocarpus costatus				396
	Anisoptera glabra				323
3	*Pterocarpus macrocarpus*	20	Siem Reap	Chikreng	83
4	*Azadirachta indica*	50	Banteay Meanchey	Mongkul Borey	90
5	*Pinus merkusii*	104	Kampong Thom	Santuk	72
	Fagraea fragrans				70
6	*Dalbergia oliveri*	21	Rattanak Kiri	O Chum	21
	Pterocarpus macrocarpus				20
	Xylia dolabriformis				22
7	*Afzelia xylocarpa*	18	Rattanak Kiri	Lumphat	27
	Dalbergia oliveri				41
	Pterocarpus macrocarpus				14
8	*Afzelia xylocarpa*	20	Rattanak Kiri	Kaun Mum	26
	Dalbergia oliveri				17
	Shorea cochinchinensis				7
9	*Hopea ferrea*	30	Rattanak Kiri	Kaun Mum	88
10	*Dalbergia cochinchinensis*	50	Siem Reap	Varinn	67
11	*Dipterocarpus alatus*	7	Siem Reap	Angkor Wat	43

Past and present research and activities in the field of conservation, utilization and management of FGR

Although the forests are considered as a main source of income for the government and local communities in Cambodia, the budget allocation for research is almost nonexistent. There is only a little coordinated forest research that has been conducted by the CTSP and basic data are not easily available. The DFW has inadequate research facilities and only few staff trained in research techniques. Official records on the management of FGR are very few.

Production and use of forest tree seed

In early 2003, the CTSP conducted a survey to estimate seed demand. The findings are presented in Table 3, but as they are based on a sample only (nurseries), the national annual seed demand is presumably higher. Among the 21 species used in planting programmes, only three are exotic (acacia, eucalypt and teak), the rest being indigenous.

In the survey, five categories of tree seed users were identified – the DFW and Provincial Forest Offices (PFO), Armed Forces, communities, pagodas and the private sector. Each year, tree seed users need seeds of both exotic and indigenous species to produce seedlings that will satisfy a range of requirements for tree planting in reforestation and forest rehabilitation programmes, community forests, within and around villages and along roadsides. Currently, indigenous species form a small percentage of total seedling production, and are used mainly in small-scale plantations, Arbour Day, research sites, and pagodas. *Acacia* spp. and *Eucalyptus* spp. account for the largest share of seedling production and play a significant role in large-scale plantations for rehabilitation of degraded forests or for the pulp and paper industry.

Table 3. Result of the CTSP seed demand survey (CTSP 2003a)

No.	Species	Amount of seeds (kg)	Seed supplier
1	*Acacia* spp.	156	Vietnam, CSIRO, local people
2	*Afzelia xylocarpa*	1072	CTSP's seed sources, local people
3	*Albizia lebbeck*	2	Local people
4	*Anisoptera costata*	5	Local people (natural forests in Kampong Thom)
5	*Aquilaria crassna*	1	Local people
6	*Azadirachta indica*	137	Local people
7	*Cassia siamea*	10	Local people
8	*Dalbergia bariensis*	2	CTSP seed sources
9	*Dalbergia cochinchinensis*	5	CTSP seed sources, local people
10	*Dipterocarpus alatus*	604	CTSP seed source, pagoda, local people
11	*Eucalyptus* spp.	16	Vietnam, CSIRO, local people
12	*Eugenia jambolana*	1	Local people
13	*Hopea odorata*	64	Pagoda, local people
14	*Leuceana leucocephala*	2	Local people
15	*Melaleuca cajuputi*	1	Local people
16	*Peltophorum dasyrhachis*	1	Local people
17	*Pterocarpus macrocarpus*	14	CTSP seed source, local people
18	*Shorea farinose*	5	Local people
19	*Shorea vulgaris*	n.a.	CTSP seed source
20	*Tarrietia javanica*	72	CTSP seed source
21	*Tectona grandis*	n.a.	Thailand, Kampong Cham province

In Cambodia, there are no enterprises or private companies dealing with tree seed supply. This is because the demand for seed is still low and it is not possible to estimate future demand, as the users do not have long-term plans for tree planting activities. This creates a major constraint to planning for the ongoing supply of good quality seeds of appropriate species, which is, by nature, a long-term process. Instead, tree seeds are obtained in a number of ways, some formal, others informal.

Sometimes nursery managers collect the seeds by selecting good mother trees. They may test the seeds by cutting them to see if they are still alive. Nursery managers also purchase seeds from local people. In this case, the nursery managers advise local people on the selection of good mother trees. This is the most common method of obtaining seeds. However, without seeing the seed source, it is difficult to evaluate the quality. Indigenous tree seeds are usually purchased from local people and, therefore, quality can be assessed only through observing the germination rate. Seeds are also obtained from colleagues in other provinces and in these cases the seed quality is difficult to assess. It is also possible to obtain seeds through the DFW. Currently, the DFW purchases seeds of *Acacia* and *Eucalyptus* from Vietnam for distribution to the planting stations and nurseries.

Several nursery managers purchase seeds from Vietnam directly, rather than going through the DFW. Seeds purchased from Vietnam are of *Acacia* and *Eucalyptus* species and they are accompanied by certificates showing the date of seed collection, amount of seeds per kg, and a guarantee of germination higher than 70%.

Seed purchases from Thailand and Australia by the Reforestation Office are regulated by the supplier as well as by the receiver. The first step is to undertake tests of the proposed planting sites to ensure compatibility with the site of origin. CSIRO (Australia) and FORGENMAP (Thailand) issue phytosanitary certificates for the seeds, consignment notes and seed certificates. From the Cambodian side, approval for the import is needed from the MAFF, which submits a letter to the Customs Department to allow clearance for the seeds.

Tree improvement activities in Cambodia

Tree improvement in Cambodia is in its infancy; only a few activities have been carried out by the CTSP since 2002. Seed production areas for four species (*Dipterocarpus turbinatus, Hopea odorata, Aquilaria crassna* and *Afzelia xylocarpa*) have been established in a 10-ha plot at Kbal Chhay, Sihanoukville. Seed orchards for two species (*Tarrietia javanica* and *Shorea vulgaris*) have been planted in a two-hectare plot at Kbal Chhay. A provenance trial is being conducted by the CTSP at Bak Sna where two species *Afzelia xylocarpa* and *Pterocarpus macrocarpus* from six provenances will be planted in a five-hectare plot in 2004.

Reforestation activities

Reforestation activities have mainly taken place on poor sites. An area of some 300–400 ha was planted each year between 1915–1972, using species such as *Hopea odorata, Dipterocarpus* spp., *Tectona grandis, Pinus merkusii* and fast-growing fuelwood species such as *Peltophorum ferrugineum* and *Combretum quadrangulare* (Sam Ang 1998). Between 1985 and 2002, a total area of 11 125 ha was planted throughout the country, the main species used being acacias and eucalypts.

The forestry sector reform process gives high priority to reforestation implemented by the DFW and the Armed Forces in the years to come. In addition, the significant contribution of local communities to national tree planting targets is recognised. In 2003, the DFW is planning to establish 1625 hectares of plantations through its planting stations, with focus on *Eucalyptus camaldulensis, Tectona grandis,* and *Dipterocarpus* spp. In addition, 1.3 million seedlings will be produced for distribution to the local population, consisting of a mix of exotics, natives and fruit tree species (DFW 2002). Activities by the Armed Forces will cover 2200 hectares each year.

Socioeconomic conditions and issues related to conservation, utilization and management of FGR

The role of indigenous species in meeting the needs of the society is very important. Over the centuries, people of Cambodia have used different tree species for many uses such as house poles, doors, frames, construction, furniture, fuelwood, etc. In addition, many non-timber forest products (NTFP), such as oils, fruits and medicines have proved essential for rural livelihoods, supplementing their subsistence agricultural activities.

Population growth is a driving force of biotic impoverishment. It is widely accepted that population pressure can lead to ecosystem degradation. However, the relationship between population pressure and the environment is complex. Cambodia's population in March 1998 was 11.43 million, with 2.188 million households (5.2 people per household). The annual growth rate is 2.5% and approximately 84% of the population lives in rural areas (Hang 2002). Households using firewood or charcoal as major forms of energy for cooking were about 90% and 5.3%, respectively. An estimated six million m^3 of wood is consumed every year as fuelwood (Soktha 2001). Thus, with no immediate alternative for fuelwood, forest species would continue to be very important to the Cambodians.

Large tracts of forest have been cut under various regimes of selective cuttings. In several places it is clear that the volume cut exceeds the limit of sustainability. Unfortunately, encroachment and shifting cultivation at former concession sites have turned out to be an even greater threat to the remaining natural forest. Areas with significant FGR that are threatened include the Cardamom and Elephant mountains in the southwest, the eastern section of the Dangrek Range, and the north-eastern border area between Lao PDR and Vietnam.

Forestry sector and FGR conservation in Cambodia

The forestry sector has the responsibility for FGR conservation in areas falling under its jurisdiction. The chosen approach is to increase the utilization of priority species through promoting them in tree planting activities within forest restoration and rehabilitation and on-farm production. Responsibility for managing tree seed sources and FGR is shifting from the traditional forestry sector approach towards community participation, which is essential for successful *in situ* conservation. The approach has been initiated in three locations: within forest concessions, within community forests and on state managed forestlands. Management agreements for each site are secured by a Ministerial Declaration.

Identification of national priorities

The first step towards FGR conservation is the identification and prioritization of species, applying three main criteria: socioeconomic importance, level of within-species variation, and the level of threat or risk (FORGENMAP 2002).

In Cambodia, detailed information on tree species is lacking. However, priority species for conservation have been identified through a process involving stakeholders from a range of sectors and institutions. Species were ranked according to their potential uses (timber, posts and poles, fuelwood and charcoal, NTFPs, pulp and paper, food, shade, agroforestry systems, soil and water conservation, amenity, aesthetic and ethical values and other) resulting in a list of 34 priority species. Each of the identified groups of species was further classified according to the IUCN Red List Categories, from critically endangered (level 5) to endangered (level 4) and threatened (levels 1–3). Where IUCN data was not available, the classification was based on local knowledge. To economise resources, priority status was initially allocated to the two most threatened categories, resulting in 21 species, as listed in Table 4. For information on priority species for APFORGEN, see Appendix 1. Species numbered as 22–34 will also receive attention, but more gradually, given their lower priority, and the limited resources for implementation.

Table 4. Priority tree species for Cambodia (CTSP 2003b)

N°	Scientific Name	Level of threat	IUCN Red List
1	*Dalbergia oliveri*	5	EN A1cd
2	*Aquilaria crassna*	5	CR A1cd
3	*Dalbergia cochinchinensis*	5	VU A1cd
4	*Gardenia ankorensis*	5	
5	*Afzelia xylocarpa*	5	EN A1cd
6	*Pterocarpus marcrocarpus*	5	VU A1d
7	*Dysoxylum loureiri*	5	
8	*Diospyros cruenta*	5	
9	*Lasianthus kamputensis*	5	
10	*Diospyros bejaudii*	4	
11	*Fagraea fragrans*	4	
12	*Dasymaschalon lamentaceum*	4	
13	*Shorea cochinchinensis*	4	
14	*Hopea helferi*	4	CR A1cd + 2cd , B1 + 2c
15	*Pinus merkusii*	4	
16	*Garcinia hanburyi*	4	
17	*Cinnamomum cambodianum*	4	
18	*Sterculia lychnophora*	4	
19	*Cananga latifolia*	4	
20	*Albizia lebbeck*	4	
21	*Hopea odorata*	4	VU A1cd + 2cd
22	*Tarrietia javanica*	3	
23	*Diospyros pilosanthera*	3	NE
24	*Hopea ferrea*	3	EN A1cd + 2cd , B1 + 2c
25	*Xylia dolabriformis*	3	
26	*Fibraurea tinctoria*	3	
27	*Shorea hypochra*	3	CR A1cd
28	*Shorea vulgaris*	3	
29	*Diospyros nitida*	3	
30	*Cassia garretiana*	2	
31	*Dipterocarpus alatus*	2	EN A1cd + 2cd , B1 + 2c
32	*Anisoptera costata*	2	EN A1cd + 2cd
33	*Melanorrhoea laccifera*	2	
34	*Artocarpus chaplasha*	1	

Level of threat: 5 = critically endangered; 4 = endangered; 1-3 = threatened

IUCN Red List categories appearing in this table: CR = critically endangered; EN = endangered; VU = vulnerable; NE = not evaluated; for further information, please refer to IUCN (2001)

Institutional framework and capacity-building activities

Responsibility for forest management in Cambodia lies with the MAFF, and MOE. Management of protected areas is under the jurisdiction of the MOE and other forest areas under the MAFF/DFW. The Department of Fisheries of the MAFF manages flooded forests and mangroves.

The forestry administration is undergoing a reform to establish a direct organizational line of command from central to local levels by returning the responsibility for forest management to the relevant authorities. Such reforms require a comprehensive review of the roles and responsibilities of all levels of the DFW, lines of communication, and interactions with other government departments to ensure effective implementation on ground level.

The Royal Government of Cambodia (RGC) acknowledges international issues, processes and commitments during and following the United Nations Conference on Environment and Development (UNCED) in 1992. Therefore, consistent with the IPF/IFF guidelines, a national forest programme will be developed as a process for forest policy implementation and strategy development. Currently in its initial stages, activities to date have consisted of capacity building meetings to familiarise the DFW staff and advisors with the elements and structures of the national forest programme.

National forest policy and sectoral plans

A statement on national forest policy was issued by the RGC in 2002. It directs the management of forest resources towards the national goals of environmental protection, biodiversity conservation, poverty reduction, economic development and good governance. Forest policy will be further developed through a consultative process within the national forest programme. Recommendations for the tree seed sector will be integrated.

In line with national development plans defined by the RGC, the forest sectoral plan aims to manage forest resources to maximize economic benefits whilst ensuring ecological sustainability, community benefits and habitat protection for native fauna and flora. The plan notes that the government has promoted nursery establishment, selection of appropriate tree species, expansion of reforestation schemes and community forestry. To continue such endeavours, the DFW will establish tree seed banks through the foundation of seed quality selection and maintenance centres, and seed source forest stands in major forested areas throughout the country in order to ensure the most effective reforestation in terms of economic benefit, genetic conservation, environmental protection and services (DFW 2001, cited in CTSP 2003b).

Forestry law and FGR

According to the forestry law approved in 2002, provision is made for FGR conservation within protection forests and within special management areas in forest concessions. Applications to designate appropriate areas of the permanent forest reserve as protected forests can be prepared by the MAFF and approved by the RGC. Management plans will be prepared, implemented and enforced for these areas by the forest administration. The Minister of MAFF has the authority to issue permits for the establishment of botanical gardens or experimental stations within the permanent forest reserve as well as for the establishment of forest nurseries to provide seedlings. The forestry law emphasises the increasing role of the DFW, the military and local people in tree planting activities. Annual planting areas and budgets have expanded accordingly.

The forest concession sub-decree, which was approved in 2000, highlights that within forest concession management, areas of natural biodiversity, important ecosystem functions and forest services must be conserved and protected through the establishment of special management areas. Strategic management plans, submitted by forest concessionaires will be evaluated against a set of criteria that includes seed source conservation.

Forest genetic resource strategy

A FGR strategy is in the process of development by the DFW and the CTSP. The process includes a number of diverse stakeholders and covers the selection of priority species, species distribution and gene-ecological zoning, conservation status of key populations, methods of conservation as well as organisation and implementation of the strategy.

Links with international initiatives

The RGC ratified the Convention on Biological Diversity (CBD) in 1995 and the forestry sector has been represented through the preparation of the mandatory National Report on Biological Diversity, and the National Biodiversity Strategy and Action Plan. The RGC views the CBD as a framework to achieve sustainable development through the sustainable use and protection of biodiversity and is now taking serious steps towards implementing conservation programmes and awareness-raising for the sound use and conservation of biodiversity resources. Links will be established with other relevant initiatives as they develop.

Biosecurity regulations
Biosecurity regulations are not yet in place in Cambodia, although an inter-ministerial team is beginning to develop the National Biosafety Framework.

Cambodia Tree Seed Project
CTSP was initiated in 1999 with financial support from the Royal Government of Denmark/ Danida. The project staff included nine counterpart staff and one technical advisor. The objective of the project is to promote the use of good quality tree seed from good seed sources. Since 1999, the CTSP has conducted many training courses for seed users and producers. The project has also published numerous posters, species leaflets and technical books for distribution during Arbour Day and to provincial foresters, nursery managers, farmers, NGOs and other seed users. A series of TV spots on the subject of using good quality seed and of conservation of priority species is being developed by the CTSP in collaboration with the DFW.

In 2002, with financial assistance from the Japan International Cooperation Agency (JICA), DFW established a forestry and wildlife training centre. A number of courses have already been conducted on different subjects related to the field of forestry, however, a course on FGR conservation is yet to be developed.

As part of a regional programme, the CTSP provides links for the DFW into the Indochina Tree Seed Project, which promotes cooperation and information exchange between the tree seed sectors in Cambodia, Vietnam and Lao PDR, and other tree seed programmes in the Southeast Asia as well as with the Danida Forest Seed Centre (DFSC).

Proposal for regional and international collaboration
Little information exists on bamboo and rattan resources utilization and management in Cambodia, even though there is a long tradition of their use. There is a need to establish a network of bamboo and rattan research and management with cooperation from the Bamboo Information Centre (China, India) or with other international institutes dealing with bamboo and rattan, such as the International Network on Bamboo and Rattan.

Research needs
The following research activities are suggested, aiming at promoting the cultivation and utilization of FGR in Cambodia:

1. An investigation is needed to determine both silvicultural and ecological requirements of the priority species and their management strategies. As information on the growing stock and distribution of these species is still meagre, a full-scale inventory coupled with phenologcal and threat studies should be conducted.
2. Pilot plantations should be established to capture the variability in growth and yield performance of the priority species in different parts of the country (covering various soil conditions). Research should be initiated for monoculture plantations as well as for agroforestry systems.
3. Initiate a genetic improvement programme of priority species through provenance trials in different ecological zones.

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Appendix 1

Information on priority species for the APFORGEN Inception Workshop

Priority species	Areas managed for conservation (ha)			Areas managed in natural forest for production of … (ha)		Areas managed in plantations for production of … (ha)		References and reports
	In situ	*Ex situ*	Seed production	Timber	Non-timber	Timber	Non-timber	
1. *Afzelia xylocarpa*	38		1			25		CTSP and reforestation reports
2. *Agathis borneensis*								
3. *Albizia lebbeck*								
4. *A. procera*								
5. *Alstonia scholaris*								
6. *Anisoptera costata*	117							CTSP's report
7. *Aquilaria crassna*							4	CTSP's report
8. *Artocarpus heterophyllus*								
9. *Avicennia alba*								
10. *Azadirachta excelsa*								
11. *A. indica*			50					CTSP's report
12. *Calamus manan* – rattan								
13. *Cassia siamea*						110		Reforestation office's report
14. *Casuarina equisetifolia*								
15. *Chukrasia tabularis*								
16. *Dalbergia bariensis*	72							CTSP's report
17. *D. cochinchinensis*	50					3		CTSP's report
18. *Dipterocarpus alatus*	20					472		Reforestation office's report
19. *D. grandiflorus*								
20. *D. tuberculatus*								
21. *Dryobalanops aromatica*								
22. *Durio* sp.								
23. *Dyera costulata*								
24. *Eusideroxylon zwageri*								
25. *Fagraea fragrans*	104							CTSP's report
26. *Gonystylus bancanus*								
27. *Hopea odorata*						190		Reforestation office's report
28. *Intsia bijuga*								

Priority species	Areas managed for conservation (ha)			Areas managed in natural forest for production of … (ha)		Areas managed in plantations for production of … (ha)		References and reports
	In situ	*Ex situ*	Seed production	Timber	Non-timber	Timber	Non-timber	
29. *I. palembanica*								
30. *Koompassia malaccensis*								
31. *Lagerstroemia ovalifolia*								
32. *Litchi sinensis*								
33. *Melaleuca cajuputi*								
34. *Metroxylon sagu*								
35. *Palaquium rostratum*								
36. *Parashorea stellata*								
37. *Parkia speciosa*								
38. *Peltophorum ferrugineum*								
39. *Pinus kesiya*								
40. *P. merkusii*			104			19		
41. *Pterocarpus indicus*								
42. *P. macrocarpus*	59							CTSP's report
43. *Rhizophora sp.*								
44. *Samanea saman*								
45. *Schima wallichii*								
46. *Shorea cochinchinensis*	20							
47. *S. hypochra*	117							
48. *S. laevis*								
49. *S. leprosula*								
50. *S. macrophylla*								
51. *S. ovalis*								
52. *S. parvifolia*								
53. *S. roxburghii*								
54. *S. stenoptera*								
55. *Sindora cochinchinensis*	117							
56. *Sterculia lychnophora*								
57. *Tarrietia javanica*	117							
58. *Tectona grandis*						336		Reforestation Office report
59. *Terminalia chebula*								
60. *Toona sinensis*								
61. *T. sureni*								

Priority species	Areas managed for conservation (ha)			Areas managed in natural forest for production of … (ha)		Areas managed in plantations for production of … (ha)		References and reports
	In situ	*Ex situ*	Seed production	Timber	Non-timber	Timber	Non-timber	
62. *Vatica odorata*								
63. *Vitex parviflora*								
64. *Xylia dolabriformis*	21							
65. *X. xylocarpa*								
List of priority bamboo & rattan species (Rao *et al.* 1998)								
Bamboo								
1. *Bambusa bambos*								
2. *B. blumeana*								
3. *B. tulda*								
4. *B. vulgaris*								
5. *Cephalostachyum pergracile*								
6. *Dendrocalamus asper*								
7. *D. giganteus*								
8. *D. latiflorus*								
9. *D. strictus*								
10. *Gigantochloa levis*								
11. *Melocanna baccifera*								
12. *Phyllostachys pubescens*								
13. *Thyrsostachys siamensis*								
14. *T. siamensis*								
Rattan								
1. *Calamus manan*								
2. *C. caesius*								
3. *C. trachycoleus*								
4. *C. merrillii*								
5. *C. nagbettai*								
6. *C. ovoideus*								
7. *C. zollingeri*								
8. *Calamus palustris* and relatives								
Additional priority species								
1. *Acacia* spp.								
2. *A. mangium*								
3. *A. nilotica*								
4. *Afzelia rhomboidea*								

Priority species	**Areas managed for conservation (ha)**			**Areas managed in natural forest for production of … (ha)**		**Areas managed in plantations for production of … (ha)**		**References and reports**
	In situ	***Ex situ***	**Seed production**	**Timber**	**Non-timber**	**Timber**	**Non-timber**	
5. *Araucaria cunninghamii*								
6. *Ailanthus excelsa*								
7. *Bambusa vulgaris* (bamboo)								
8. *B. blumeana*								
9. *Betula alnoides*								
10. *Bombax alba*								
11. *Calamus erectus* (rattan)								
12. *C. longisetus*								
13. *Calocedrus macrolepis*								
14. *Castanopsis hystrix*								
15. *C. fabri*								
16. *Cedrus deodara*								
17. *Chloroxylon swietenia*								
18. *Chukrasia velutina*								
19. *Cinnamomum cassia*								
20. *Cunninghamia lanceolata*								
21. *Dalbergia cultrata*								
22. *D. latifolia*								
23. *D. sissoo*								
24. *Dendrocalamus giganteus*								
25. *Dipterocarpus turbinatus*								
26. *Diospyros bejaudi*								
27. *D. crumenata*								
28. *D. ebenum*								
29. *D. mun*								
30. *Dysoxylom loureiri*								
31. *Endospermum malaccense*								
32. *Eucalyptus* spp.								
33. *E. camaldulensis*								
34. *E. urophylla*								
35. *E. grandis*								
36. *E. globulus*								
37. *Erythrophloeum fordii*								

Priority species	Areas managed for conservation (ha)			Areas managed in natural forest for production of … (ha)		Areas managed in plantations for production of … (ha)		References and reports
	In situ	*Ex situ*	Seed production	Timber	Non-timber	Timber	Non-timber	
38. *Fokienia hodginsii*								
39. *Gmelina arborea*								
40. *Gardenia ankorensis*								
41. *Heritiera fomes*								
42. *Khaya ivorensis*								
43. *Keteleeria fortunei*								
44. *Lagerstroemia speciosa*								
45. *Lasianthus kamputensis*								
46. *Mangifera spp.*								
47. *Melia azedarach*								
48. *M. dubia*								
49. *Morus spp.*								
50. *Persea kerrii*								
51. *Picea smithiana*								
52. *Pinus armandii*								
53. *P. caribaea*								
54. *P. massoniana*								
55. *P. roxburghii*								
56. *P. wallichiana*								
57. *P. yunnanensis*								
58. *Platanocephalus chinensis*								
59. *Populus deltoides*								
60. *Prosopis cineraria*								
61. *P. juliflora*								
62. *Pterocarpus marsupium*								
63. *Santalum album*								
64. *Sesbania sesban/grandiflora*								
65. *Shorea robusta*								
66. *S. javanica*								
67. *Swietenia macrophylla*								
68. *Syzygium grande*								
69. *S. cumini*								
70. *Taxus wallichiana*								
71. *Toona ciliata*								

Status of forest genetic resources conservation and management in Indonesia

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Introduction

Indonesia is an archipelago consisting of about 17 000 islands with a total forest area of 120.3 million 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 savannah to montane and alpine forest.

Many Indonesian people depend on forest resources for their subsistence and customary activities. Forests also generate employment as well as business opportunities. Of the total population of about 206.6 million, an estimated 36 million Indonesians rely on the forests for their livelihood either formally (e.g. industry) or informally (e.g. forest-fringe communities) (MOF 2002).

Two distinct forms of forest resource management can be detected in Indonesia. Forests in Java consist predominantly of teak plantations, while natural forests of the outer islands are more diverse and contain a mix of commercial species varying between regions. For example, dipterocarp species predominate in Kalimantan and Sumatra; *Diospyros* species predominate in Sulawesi, *Eucalyptus* in the Moluccas, and *Pometia, Agathis* and *Araucaria* species in Irian Jaya.

Teak plantation forests in Java were first established under the Dutch colonial rule. Today these forests are managed by Perum Perhutani, a state-owned enterprise that controls a forest area of about 3.2 million ha. Because of differences in area and characteristics of biodiversity, natural rain forests of the outer islands need a very different approach to forest management compared to the plantation forests in Java. A selective cutting system, known as TPI ('Tebang Pilih Indonesia') was introduced in the beginning of the implementation of a forest concession holding system called 'Hak Pengusahaan Hutan' (HPH) in order to ensure the sustainability of timber production.

Forest genetic resources (FGR) are considerably important for Indonesia, as shown by the designation of conservation forests. These forests account for approximately 17% of Indonesia's total forest area, and together with protection forests form a total protected area of 54 million hectares, 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 as well as through cooperation with international partners. The government has also recognized the value of Indonesia's protected areas that are of particular global importance. This is shown by the support that the government has given for the designation of biosphere reserves by UNESCO.

Conservation of FGR

State of forests and threats to the genetic diversity of species

Indonesia's forest area of 120.3 million ha is divided into four different categories of uses and functions (MOF 2001). These include:

- Production Forests (58.26 million ha)
- Protection Forests (33.5 million ha)
- Conservation Forests (20.5 million ha) and
- Convertible Forests (8.01 million ha)

Forest resources were adversely affected by the economic and social crises in the late 1990s. Based on data provided by the Ministry of Forestry (MOF 2001), forest degradation rate reached 1.6 million ha per year. Among the 120.3 million ha of forest areas, at least 23.9 million ha are degraded and need to be rehabilitated. Illegal logging and timber trade, forest fires, and forest encroachment are among the causes of forest degradation and consequently may threaten genetic diversity of species or even lead to extinction of some species. A number of commercial species have been reported to be under different degrees of threat of extinction (BAPPENAS 2003). For example, *Gonystylus bancanus* (ramin) has been included in the Appendix III of CITES and the distribution of *Eusideroxylon zwageri* (ulin), *Santalum album* (cendana) and a number of dipterocarp species has become narrow. Newman *et al.* (1999) stated that at least 267 dipterocarp species could be found in Kalimantan alone. However, only some of these species have been used. The same authors have suspected that many of the lesser-used species might have become extinct because of human activities.

Overview of the current FGR conservation activities

Conservation of genetic resources is an important part of the Indonesian forest policy. A number of legal measures have been put into effect as the basis for implementation of FGR conservation activities. In addition to the legal instruments, Indonesia's Biodiversity Action Plan (1993) has been used as a guide for natural resource conservation schemes such as: (1) *In situ* conservation in terrestrial parks and protected areas, (2) *In situ* conservation outside the protected area network, (3) Coastal and marine conservation and (4) *Ex situ* conservation.

Ex situ conservation activities have been carried out, for example, by establishing botanical gardens and arboreta. Seventeen botanical gardens have been established in Indonesia (BAPPENAS 2003). Among others, Bogor Botanical Garden in West Java, Purwosari Botanical Garden in East Java and the Bali Botanical Garden conserve plant germplasm from forests. The botanical gardens and arboreta play an important role in public education and in raising public awareness.

Ex situ conservation is also an integral part of tree improvement activities. This includes genebanks for seed and pollen, clonal banks, breeding populations and cryopreservation. For example, Perum Perhutani, a state-owned forestry enterprise, has established conservation stands for various teak varieties collected from all geographical areas in Indonesia since 1998. The Centre for Forest Biotechnology and Tree Improvement Research and Development (CFBTI) has an *ex situ* conservation programme as part of tree improvement activities for some tree species (*Acacia mangium*, *Eucalyptus pellita*, *Paraserianthes falcataria*, and *Melaleuca cajuputi* subsp. *cajuputi*) since the early 1990s. Later, the CFBTI also started *ex situ* conservation of some other species, such as *Santalum album*, *Tectona grandis, Eusideroxylon zwageri, Araucaria cunninghamii, Alstonia* sp., and *Artocarpus altilis.* Furthermore, *ex situ* conservation plots for a number of dipterocarps were already established in Java during the 1950s by the Centre for Forest and Nature Conservation Research and Development (CFNC).

Relevant natural resources management policies and their implementation

Management, utilization and conservation of Indonesia's forest resources are based on the Forestry Act of 1999. The Act also gives specific reference to maintaining production forests, protection forests and conservation of flora and fauna. Another related set of regulations is the Conservation of Living Resources and Their Ecosystems Act 1990. However, land use conflicts with other development sectors are often unavoidable; for example, the importance of conserving the remaining natural forests (especially protection forests and conservation forests) on one hand, and the need to utilize the other natural resources such as mineral deposits and geothermal energy on the other. These two natural resources are mostly located within protection forest or conservation forest areas.

With the commencement of the UU (Undang-Undang) Act No. 22/1999, most development sectors had to initiate a decentralization process. Under the Government Regulation (Peraturan Pemerintah/PP) No. 25/2000, district level governments have been given the authority to regulate and manage their own natural resources. Within the forestry sector, efforts for decentralizing parts of the authority in forest management to district level governments have been made since 1994 through the Minister of Forestry Decree No. 86/Kpts-II/94. The authority for five forest management activities was given to the district governments; these include afforestation and soil/water conservation, silk moth- and bee cultures, private forests, and forestry extension. Moreover, through PP No. 62/1998, the management of 'Taman Hutan Raya' (Provincial Park) and forest gazettements was decentralized to the provincial governments whereas the district governments received the authority for five additional forestry activities, including management of protection forests, non-timber forest products (NTFPs), traditional hunting of unprotected fauna, forest protection and forestry training for local communities.

The area of tropical rain forest in Indonesia has decreased considerably during the past decades. Illegal logging, forest fires and improper implementation of the Forest Land Use Change Policy are among the causes of the current problems in the forestry sector. It has been estimated that there is approximately 23.9 million ha of degraded forest land in Indonesia, distributed in the six major islands; Java, Sumatera, Sulawesi, Kalimantan, Irian Jaya and Maluku (MOF 2001).

In an effort of restoring the productivity of forests and preventing their further degradation, the Ministry of Forestry (MOF) imposed a *selective moratorium on logging* and *gradual reduction of annual allowable cut (soft landing policy)*. Furthermore, for the next 20 years the forest policy in Indonesia will be focusing on securing the tropical rain forest through rehabilitation of the degraded forest areas and conservation of the remaining forests. Rehabilitation in this context refers to all planting activities as stated in the Forestry Act (UU No. 41/1999), Article 41, which is intended to restore, protect and to improve forest functions, so that the carrying capacity, productivity and the role of forest as a life support system could be retained. For the next five years (2003–2007), approximately three million ha of degraded forest and land would be rehabilitated through a national programme called 'Gerakan National Rehabilitasi Hutan dan Lahan' (National Actions on Forest and Land Rehabilitation).

In addition, to improve the management of natural production forests, the MOF has introduced the criteria and indicators (C&I) for sustainable management of natural production forests as a compulsory measure since enacting the Ministerial Decrees No. 4795/Kpts-II/2002 and 4796/Kpts-II/2002. The Decree No. 4795 sets the criteria and indicators for sustainable production forests, while the Decree No. 4796 consists of a procedure for the evaluation of the performance of sustainable production forests at the management level. This is a major shift in the Indonesian forest policy in addressing the problems of unsustainable practices in managing natural forests. The voluntary measures, e.g. timber certification, where private companies implement C&I for sustainable forest management (SFM) for the purpose of meeting the requirements of timber importing countries, continue to be applied. In other words, the compulsory C&I for SFM is the liability of the companies to the MOF, while the voluntary C&I is a means for forest companies to improve their performance in the international market.

Past and present activities in conservation, utilisation and management of FGR

Agroforestry

Agroforestry has long been practiced in Indonesia, particularly in teak plantations in Java since the Dutch colonial era, and has developed from simple systems, such as *taungya* to complex agroforestry systems. Nowadays, an agroforestry system can be a form of collaborative management in a state land, or a form of private land management where settlers cultivate their land by applying an inter-cropping system. There is no exact data on the extent of these practices; however, some examples have shown positive impacts on the increasing participation of rural community in managing natural resources in an environmentally friendly manner.

Two examples of agroforestry practices on state land can be taken from the districts of Nusa Tenggara and Krui (Sumatera Island). In Nusa Tenggara, the local community practices agroforestry using major commercial plantation species, such as *Tectona grandis* (teak), *Swietenia* spp. (mahogany), and *Paraserianthes falcataria* (sengon), where forest tree species account for 71% of the total species composition (Roshetko and Mulawarwan 2001). People in Krui, West Lampung have carried out biodiversity conservation activities by growing *Shorea javanica* (damar mata kucing) and other tree species producing fruits and other NTFPs such as *Lansium domesticum, Durio zibethinus*, *Parkia speciosa*, *Phitelobium piringa*, *Artocarpus integer* and *Artocarpus* spp. among others.

Other forms of agroforestry practices can be found in Jambi (Sumatera Island) and Gunung Kidul (Java Island). The members of the rural community in Sungai Telang, Jambi use their lands for growing trees and cash crops, while the surrounding forests are only accessed for collecting limited amount of NTFPs. In Gunung Kidul, growing trees on private lands has been practiced since the 1930s and has contributed positively in improving the livelihoods of the rural poor.

Afforestation and reforestation

Afforestation (planting of trees and perennial plant species on non-forest lands) is a government programme that has been carried out since the 1970s. Currently available data on the total afforested area only covers three years of activities from 1999, which indicates that about 532 664 ha of degraded non-forest land was afforested during the three years through development of small-scale plantations, provision of nurseries at the village level (Kebun Bibit Desa) and land rehabilitation activities (MOF 2002).

Reforestation (planting of trees and perennial plant species on degraded forest land) is also a government programme that has been implemented since the 1970s. There is no complete data available on the total area reforested, it has been estimated that a total area of 85 910 ha has been reforested during the five years from 1997 to 2001 (MOF 2002).

Forest plantations

Establishment of forest plantations (or industrial plantation forests – Hutan Tanaman Industri, HTI) started in the early 1980s in the outer islands. At that time a target of 6.2 million ha of HTI by the year 2000 was set. However, several factors such as lack of land suitability assessments, limited availability of genetically improved seed, insufficient technical knowledge and experiences in commercial timber plantations on the outer islands contributed to the low achievement level of the HTI programme. Reliable data on the achievements of the programme is lacking. However, based on information gathered from a number of timber plantation companies (HPHTI holders), approximately one million ha of HTI using fast-growing species such as *Acacia, Eucalyptus, Paraserianthes, Gmelina* has been successfully established, mainly for producing raw material for pulp and paper. Plantations of the state-owned enterprise Perum Perhutani in Java, consisting of teak and other tree species cover about 1.8 million ha.

Demand and supply of tree seed

One of the obstacles in plantation establishment has been the limited supply of seeds and planting materials, both in quantity and quality. As each species or species group has specific characteristics in seed production and dispersal, providing planting materials at the right time and in sufficient amounts becomes very difficult.

Estimating the supply and demand of tree seed is another challenge at the current stage because of various reasons. The Directorate General of Land Rehabilitation and Social Forestry, MOF has estimated annual seed production for planting and seed production. However, as there is no information on the purpose of plantations or the use of seeds (e.g. commercial plantation, private forest, afforestation, reforestation or conservation) this information still needs to be updated in the near future.

In situ conservation

Indonesia is one of the first tropical countries in the world to create a protected area system, which includes *in situ* conservation efforts. *In situ* conservation is mainly designed to protect ecosystems or natural habitats. By the year 2001, Indonesia has established 399 terrestrial and marine conservation areas, which account for 22.5 million ha in total (see Table 1). Furthermore, 692 protection forest areas have been established, which cover approximately 34 million ha (MOF 2002).

Table 1. Status of conservation areas in 2001 (MOF 2002)

Type of conservation area	Terrestrial conservation		Marine conservation	
	Units	Area (1000 ha)	Units	Area (1000 ha)
Nature reserves	175	2354.3	8	211.3
Wildlife sanctuaries	47	3517.5	3	65.2
Nature recreation parks	81	281.2	14	668.9
Hunting parks	15	247.4	–	–
National parks	34	11 069.4	6	3681.4
Grand forest parks	16	332.5	–	–
Total	**368**	**17 802.3**	**31**	**4626.8**

In addition to the conservation activities in the allocated areas, a number of genetic resource conservation areas, called Areal Sumber Daya Genetic (ASGD) have been assigned by forest concession holders (HPHs). This is a compulsory measure imposed by the government in order to secure seed supply for plantation establishment as well as for enrichment planting purposes. Under this policy, each HPH is required to allocate 100 ha as seed stands in each five-year plan. In addition to the 100 ha of ASDG, the HPHs are also required to assign an area of 100–300 ha for germplasm conservation. The target species for these activities include: (a) tree species from endangered populations, (b) tree species with a low regeneration capacity, and (c) tree species that are scarce in their natural habitats. These two approaches to *in situ* conservation have been found ineffective because: (a) the two policy measures are not clearly understood by HPH personnel, (b) further elaboration of the policy measures to guide their implementation on the ground has not been carried out and (c) there has been a lack of monitoring and evaluation of the implementation of the two policy measures.

In an effort to sustain the genetic resources of commercial species, the Minister of Agriculture issued the Decrees No. 54/Kpts/Um/2/1972 and No. 261/Kpts-IV/1990, which set a minimum cutting diameter for a number of important species. The species are not allowed to be cut before reaching the minimum size determined in the Decree (Table 2).

Table 2. Lists of tree species protected under the Decree No. 54/Kpts/Um/2/1972 (the species are allowed to be cut only after reaching the minimum size determined)

No.	Scientific name	Local name	Minimum cutting diameter (cm)
I.	**Resin producing tree species**		
1	*Palaquium gutta*	Balam merah, Sumban	50
2	*Agathis labillardieri*	Damar, Kopal	50
3	*Dyera* sp.	Jelutung	60
4	*Palaquium leiocarpum*	Hangkang	30
5	*Dryobalanops camphora*	Kapur banis	60
6	*Styrax* sp.	Kemenyan	30
7	*Dipterocarpus* sp.	Keruing (minyak)	50
8	*Ganua motleyana*	Ketiau	30
9	*Shorea* sp.	Mata kucing (damar)	60
II.	**Fruit tree species**		
1	*Palaquium walsurlfolium*	Balam suntai	40
2	*P. burckii*	Jambu monyet	30
3	*Durio zibethinus*	Durian	60
4	*Aleurites moluccanus*	Kemiri	50
5	*Arenga pinnata*	Enau	40
III.	**Tree species with its useful bark and/or natural colour substance.**		
1	*Excoecaria agallocha*	Mata buta, garu	25
2	*Myristica argentea*	Honggi, Saya	30
3	*Cudrania* sp.	Kayu kuning	10
4	*Cinnamomum burmannii*	Kayu manis	25
5	*Caesalpinia sappan*	Kayu sepang	10
6	*Cinnamomum cullilawan*	Kulit lawang	25
7	*Cryptocarya massoy*	Massoi	25
IV.	**Tree species with one or more specific values, such as bark, wood, or essential oil**		
1	*Pterospermum* sp.	Bayur	30
2	*Eusideroxylon zwageri*	Bulian, Ulin	60
3	*Eucalyptus* sp.	Eucalyptus	40
4	*Azadirachta indica*	Imba	50
5	*Intsia amboinensis*	Ipil	60
6	*Diospyros* sp.	Kayu hitam	60
7	*Timonius sericeus*	Ketimunan	40
8	*Scorodocarpus borneensis*	Kulin, Kayu bawang	50
9	*Cordia subcordata*	Pumasamada	40
10	*Manilkara kauki*	Sawo kecik	45
11	*Dalbergia latifolia*	Sono keling	50
12	*Toona sinensis*	Suren	60
13	*Duabanga moluccana*	Taker, benuang	60
14	*Fagraea fragrans*	Tembasu	50
15	*Santalum album*	Cendana	50
16	*Protium javanicum*	Trenggulun	50

Through the Minister of Forestry Decree No. 261/Kpts-IV/1990, the following 12 species of the genus *Shorea* were added to the list in Table 2. These species were known to produce 'tengkawang fruits' which can be used for various purposes including cosmetics. These are: *Shorea stenopten* and *S. stenoptera, S. gysber, S. pinanga, S. compressa, S. seminis, S. martiniana, S. mexistropteryx, S. beccariana, S. micrantha, S. palembanica, S. lepidota* and *S. singkawang.*

Ex situ conservation

Ex situ conservation activities carried out in Indonesia have two main purposes, one as an integral part of the conservation policy and the other as an integral part of tree improvement activities. *Ex situ* conservation is normally implemented in the form of (a) botanical gardens with the main purpose being public education and raising awareness, (b) arboreta and conservation plots for research purposes and (c) seed banks for various purposes.

The development of botanical gardens in Indonesia started in 1817 through the establishment of Bogor Botanical Garden, covering an area of 87 ha. The species collections for Bogor Botanical Garden are mostly from tropical rain forests. The second botanical garden, Purwodadi Botanical garden was established in 1841 and is located in Malang, East Java, with deciduous forest species as the primary collection. In 1959, the third botanical garden was established in Bali, the Eka Karya Botanical Garden, which possesses a collection of 937 species belonging to 156 families.

Various research institutes have also established arboreta. Under the Forestry Research and Development Agency (FORDA) alone, there are ten research institutes all over Indonesia as well as two R&D Centres located in Bogor and Yogyakarta. Each of these 12 institutions has established at least one arboretum or conservation plot.

The *ex situ* conservation of teak in Java was first initiated by Perum Perhutani in 1980, and by the year 1999 Perum Perhutani successfully completed its effort in establishing *ex situ* conservation of plus trees collected from all teak origins throughout Indonesia.

As part of its long-term research programme, the CFBTI has recently established *ex situ* conservation plots in Gunung Kidul (Java) for *Santalum album* (sandalwood) and *Artocarpus* (sukun). *Ex situ* conservation of *Shorea leprosula* and *Lophopetalum multinervium* is currently in progress under an ITTO-Ministry of Forestry project. The project is implemented by the University of Gadjah Mada, in collaboration with some state-owned and private enterprises (PT. Inhutani I, II, Perhutani, PT. Musi Hutan Persada, PT ITCI, PT. Sari Bumi Kusuma and PT. Dwimajaya Utama). Conservation plots will be established in several locations, such as Carita (Perhutani), Palembang (MHP), Balikpapan (ITCI), Central Kalimantan (Alas Kusuma dan Dwimajaya Utama), Pulau Laut (Inhutani II) and East Kalimantan (Inhutani I).

Tree improvement

Tree improvement activities in Indonesia were started in 1930 by the Forest Research Institute (Lembaga Penelitian Hutan, LPH). Research on the reproductive biology of teak began in 1930–31 and then continued with provenance and variety trials (Coster in Suseno 2001). Suseno (2001) suggested that tree improvement efforts before the 1950s were not effective because of incorrect design and the fact that trial plots were not well maintained. Later on, during the 1960s, tree improvement activities for pine (*Pinus merkusii*) began. For example, the LPH, in collaboration with a seed-related project, established a provenance trial for pine (*Pinus merkusii*) during 1968–1971. Gadjah Mada University is one of the leading institutes in carrying out tree improvement activities, for example, pine and teak improvement was initiated in the 1970s. In terms of species target, Suseno (2001) divided the tree improvement activities in Indonesia into six groups as follows:

1. *Tectona grandis*
2. *Pinus merkusii*
3. *Acacia mangium* and other fast growing species for pulp and paper
4. Non-teak species in Java
5. Dipterocarps and other tropical rain forest species
6. Community forest species

Table 3 depicts some examples of existing tree improvement activities carried out by various research institutes and universities in Indonesia.

Table 3. Status of tree improvement activities carried out by various institutions in Indonesia (Suseno 2001; CFBTI 2003, unpublished)

Species	Provenance test	Progeny test	Clonal test	Seed stand	Seed orchard	Hybrid
*Acacia mangium**	X	X	X	X	X	X
*A. crassicarpa**	X	X			X	
*A auriculiformis**	X	X			X	
A. mangium X *A. auriculiformis**						X
*Artocarpus heterophyllus**		X		X	X	
Eucalyptus deglupta	X	X				
E. urophylla	X	X				
E. urophylla x E. alba						X
E. urophylla x E. pellita						X
E. urophylla x E. brassiana						X
E. urophylla x E. grandis						X
E. brassiana		X				
*E. pellita**		X			X	
Gmelina arborea	X	X			X	
*Melaleuca cajuputi**		X				
Morus spp.*			X			
*Paraserianthes falcataria**	X	X			X	X
Pinus merkusii	X	X			X	X
*Santalum album**		X				
Shorea johorensis		X				
S. macrophylla		X				
S. parvifolia		X				
S. pinanga		X				
S. stenoptera		X				
Swietenia macrophylla		X				
S. mahagoni				X	X	
*Tectona grandis***	X (+)	X (+)	X (+)	X	X	
Armelia sp.				X		
Shorea selanica				X		
Gliricidia sp.			X	X		
Aleurites moluccanus					X	
Armeia campaca					X	

Note: * = Carried out by CFBTI and no record available for other institutions
** = Carried out by Perhutani
(+) = Carried out by CFBTI

The CFBTI, as one of the research centres under the FORDA has carried out tree improvement activities for a number of species, for example: *A. mangium*, *Eucalyptus pellita*, *Melaleuca cajuputi*, *Santalum album*, *Paraserianthes falcataria*, *Tectona grandis*, *Araucaria cunninghamii*, *Morus* spp. and *Artocarpus altilis.* In addition, the CFBTI has also cooperated with private companies, such as PT. Indah Kiat, Inhutani I, II, III, MHP, Tanjung Redep Hutani and PSPI in the establishment of seed orchards (Table 4). A network on tree improvement between the CFBTI and private companies has also been established.

Table 4. Collaborative activities on tree improvement between the CFBTI and forest companies (CFBTI 2003, unpublished)

No	Name of partner	Collaborative activity	Time / period	Location
1	JKLT PT Inhutani I	Establishment of seedling seed orchard (SSO) for *Acacia mangium*: second-generation progeny test	5 years from 2000	PT Inhutani I area in Batuampar, Balikpapan PT. Tanjung Redep Hutani area, Tanjung Redep, Berau. PT. ITCI Hutani Manunggal, area, Kenangan, Balikpapan.
2	PT Inhutani II	Establishment of SSO for *Acacia mangium*	5 years from 2001	PT. Inhutani II area, Sub Unit HTI Semaras, Pulau Laut, South Kalimantan.
3	PT Inhutani III	Provenance trials, progeny tests and establishment of seed orchard Seed supply for establishing SSO for *Acacia mangium* (2nd generation)	1995 2001	PT. Inhutani III area, South Kalimantan
4	PT Indah Kiat Pulp and Paper Tbk.	Establishment of SSO for *Acacia mangium* (2nd generation), *Eucalyptus pellita* and *Acacia crassicarpa* Technical assistance in identification and plantation development of potential local species for pulp and paper	5 years from 2003	PT. Indah Kiat Pulp and Paper area, Siak, Riau.
5	PT Tanjung Redep Hutani	R&D on fast growing species Establishment of SSO for *Acacia mangium* (2nd generation)	1999 2001	PT. Tanjung Redeb Hutani area, East Kalimantan
6	PT. ITCI Hutani Manunggal	Establishment of SSO for *Eucalyptus pellita* Establishment of SSO for *Acacia mangium* (2nd generation)	1996 2001	PT. ITCI Hutani Manunggal area, Suaran, East Kalimantan
7	PT. MHP	Establishment of SSO for *Acacia crassicarpa* (1st generation) Establishment of SSO for *Acacia auriculiformis* (1st generation) Establishment of SSO for *Acacia mangium* (1st generation) Establishment of SSO for *Acacia mangium* (2nd generation)	1995 1996 1994 2000	PT MHP area, South Sumatera PT MHP area, South Sumatera PT MHP area South Sumatera Pendopo, South Sumatera
8	PT. Perawang Sukses Perkasa Industri (PSPI)	Establishment of SSO for *Eucalyptus pellita* (1st generation) Establishment of SSO for *Acacia mangium* (2nd generation) Establishment of SSO for *Eucalyptus pellita* (2nd generation)	1996 2001 2003	Riau Riau Riau

Use of biotechnology for characterisation, improvement and conservation

Biotechnology has been recognized as an important tool in both genetic conservation and tree improvement activities. Use of biotechnology has increased rapidly during the recent years, especially tissue culture techniques for the mass production of planting materials of e.g. *Tectona grandis, Eucalyptus urograndis* and *A. mangium*, are applied by business communities. The use of molecular genetics in forestry is still limited to genetic diversity analysis and marker selection. Some species being studied include *Paraserianthes falcataria, Lophopetalum multinervium, Shorea parvifolia, S. laevis, Eusideroxylon zwageri, Scaphium macropodum* and *Tectona grandis*.

Socioeconomic issues related to the conservation, utilization and management of FGR

Status of forest resources and utilization of trees

Since the beginning of the 1970s, forestry has been playing a unique role as one of the most important development sectors in the country as well as the sector on which development of other sectors depend, for example: agriculture, transmigration, industries, mining, energy/power generation, public work, public health, and tourism (see Table 5). The forestry sector has been the second greatest contributor to Indonesia's foreign exchange earnings, after oil and gas, especially during the early 1990s. Despite this obvious role of forests and forestry as a supporter of other sectors' development, however, up to now there is no formal reciprocal mechanism to guarantee the sustainability of the provision of goods and services by the forests.

Table 5. Development sectors supported by goods and services provided by forest (Wardojo and Masripatin 2003)

No.	Sectors receiving goods and services from forest	Role of forest and forestry
1	Agriculture	Allocation of forest land for agriculture purposes, providing services in the form of watershed protection, erosion control, maintenance of soil fertility and providing genetic resources
2	Transmigration	Allocation of forest land for transmigration programmes, as human settlement and agricultural land
3	Industries	Supply of water and raw materials for both timber and non-timber forest products
4	Mining	Forest areas opened for mine exploration and exploitation
5	Energy/power generation	Water power/energy, geothermal energy
6	Public work	Road construction through forest land, water supply for check dams
7	Public health	Clean water supply, pharmaceutical materials
8	Tourism and other environmental services	Natural beauty, amenity, biodiversity

The forestry sector has played a considerable role in national development for almost three decades since the early 1970s, after the introduction of the HPH. During 1993-1994 forestry sector's contribution to foreign exchange earning increased from US$ 3 billion to US$ 4.2 billion in 1994, ranking second after oil and gas. The sector has also contributed significantly to employment generation. Between the 1980s and 1990s, forestry sector provided 3–4 million labour-years of employment per year in forest management as well as in the industry (Djakaria and Nasendi 1997). Forestry sector also contributed to the national achievement in poverty reduction from 60% in 1970 to 11% in 1996 (World Bank 2000), and the average income per capita increased from US$ 80 in 1967 to US$ 1000 in 1995 (Djakaria and Nasendi 1997).

Timber industries experienced a rapid development for more than a decade, starting from the early 1980s. This development relied heavily on natural forests as the supply of raw materials. For example, the plywood industry grew from 29 mills in 1980 with the total capacity of 1.99 million m^3 per year to 117 mills in 1995 with the total capacity of 13 million m^3 per year (Paribotro 1997). Unfortunately, the rapid development in industry sector was not balanced by improvements in regeneration capacity of the forests. The MOFEC (2000a) stated that the sustainable production capacity of natural forest was only 25.36 million m^3 per year, while the realized consumption reached 58.24 million m^3, resulting in a gap of 32.88 million m^3 between the sustainable supply and realized demand.

The increase in log consumption from 3.2 million m^3 in 1967 to 70 million m^3 in 2000, most of which (± 96 % in 1998) originating from natural forests, could not be balanced by the existing forests to meet the increasing demand of the timber-based industry. In an effort to restore the productivity and prevent further degradation of natural production forests, the MOF has carried out a restructuring of timber-based industries.

Identification of threats

Forest degradation is one of the major issues that impact the environmental functions of forests. Illegal logging and illegal trade have been serious problems for forestry in Indonesia, especially during the recent years. Forest fires are another challenge that Indonesia is currently facing. Forest fires can be due to either human-induced or natural causes. Some regions are particularly sensitive to catch fire (e.g. Kalimantan's forests that are rich in coal deposits) while in other regions human activities are the main cause, usually as a result of plantation establishment. Fires in 1997/1998 affected an area of about 9.7 million ha, 4.8 million ha of which was forest. Indonesia's National Development Planning Agency (Badan Perencanaan Pembangunan Nasional, BAPPENAS) has estimated that the total economic loss as a result of forest fires reached US$ 9.3 billion. Another potential threat is the illegal trade in non-timber genetic resources, including germplasm.

Identification of invasive species

Invasive species have been suggested in various articles to be a potential problem. However, because of various reasons, including limited resources available, identification of potential invasive species has not been a priority thus far. The available information suggests that *Acacia nilotica* has become invasive in Baluran National Park, East Java.

Links between the forestry sector and FGR

Forest genetic resources are an integral part of the forestry sector. Although there are a number of government institutions dealing with FGR in Indonesia, the MOF is the authority for the management of forest land and resources. Thus, any policy concerning FGR conservation and management cannot be separated from the forestry sector policy.

Links between other sectors: agriculture, agroforestry, animal husbandry and industry

Links between FGR conservation and other sectors: agriculture, agroforestry, animal husbandry and the industrial sector may or may not be clear. Under the current governmental arrangement, agriculture and animal husbandry are under the responsibility of the Ministry of Agriculture, agroforestry is under the Ministry of Forestry and industry is under the Ministry of Trade and Industry. Therefore, the links between these five activities are not very clear unless they are brought under an integrated national programme.

Identification of national priorities

Indonesia is a centre of megadiversity and much of this biodiversity is in its forests, which are a source of famous commercial tree species such as teak and dipterocarps. As there is a large variation among regions in terms of biodiversity level, species characteristics, and social and cultural values, each region has its own priority species to be promoted. For this reason, it is understandable that there is no formal document listing priority species at the national level. A list of priority species for FGR conservation and management is provided in Appendix 1; these species have been identified by various parties in various forums and for various purposes.

Criteria or justification for selecting the priority species

There are two main reasons for genetic investigation of plant species in Indonesia, namely tree improvement and conservation. The priority species listed in Appendix 1 are primarily selected based on one or more criteria, such as their economic, social, cultural and ecological importance and their abundance in their natural habitats. The following selection criteria that were identified in two workshops organized by IPGRI in Lebanon and Syria in 1998 were also considered:

- Associated species
- Ecozones in which the species can be found
- (Potential) socioeconomic value
- Ecological value
- Distribution pattern of the species and its populations
- Distribution pattern of its genetic variation
- Threats imposed on the species
- Conservation status
- Reproductive biology
- Presence or absence of baseline information

Institutional framework for FGR management and conservation

Organizations involved in FGR management and conservation

The main government agencies responsible for genetic resources management and conservation in Indonesia are the Ministry of Environment (MOE), Ministry of Forestry (MOF), Ministry of Agriculture (MOA) and Ministry of Fishery and Marine (MOFM). In addition, a number of other government bodies, such as the Indonesia Science Institute, the State Ministry of Research and Technology and universities conduct research and development addressing major issues in environmental management and genetic resources conservation.

The MOE is the coordinating ministry responsible for the environmental policy and regulations including industrial, transportation, urban and agricultural sectors as well as forest environment. It is also the national focal point for the Convention on Biological Diversity (CBD). Hence, the MOE plays an important role in developing strategies for the conservation of biological diversity and FGR.

The MOF is responsible for the management, research and development of protected areas, while the MOA is responsible for the conservation and utilization of germplasm for agriculture and the MOFM for the conservation and utilization of beach and marine resources. Within the MOF, three agencies are involved:

1. The Directorate General for Forest Protection and Nature Conservation dealing with the management of protected forests and nature conservation
2. The Directorate of Forest Tree Seed under the Directorate General for Land Rehabilitation and Social Forestry for supervision, control and facilitation of the use of good-quality seed for plantation programs
3. The Forestry Research and Development Agency (FORDA) for conducting research and developing and supporting genetic resources management and conservation

Two research centres under FORDA are responsible for R&D activities: the Centre for Forest and Nature Conservation (CFNC) and the Centre for Forest Biotechnology and Tree Improvement (CFBTI).

The CFNC, located in Bogor, is entrusted with the responsibility for carrying out R&D activities in forestry-related topics including silviculture, forest protection (pests, diseases, forest fires, etc), plantation establishment and natural forest management.

The CFBTI, which is situated in Yogyakarta, is entrusted with the responsibility for carrying out research and development activities in biotechnology, population genetics, forest genetic conservation and genetic improvement of major and minor plantation species. The centre is active in setting up genetic resources conservation plots in forms that are suitable for breeding and genetic improvement, such as seed orchards, provenance trials and provenance resource stands, among others. Biotechnological tools, such as molecular markers are used to assist the population genetic diversity studies and understanding of the genetic structure of species of interest. Such information would be critical for the conservation work.

University of Gadjah Mada in Yogyakarta, with the support of ITTO, has been conserving two indigenous species (*Shorea leprosula* and *Lophopetalum multinervium*) since 1998. The major activities of this project include the establishment of conservation plots in Kalimantan, Sumatera and Java, establishment of genetic improvement plots and increasing public awareness on the importance of genetic conservation.

National legislation, policies and strategies on FGR

Some legislation concerning forestry and biological diversity has been enacted. Although most of the legislation does not directly deal with genetic resources, they affect the policy and strategy on utilization, conservation and management of FGR in Indonesia. The following paragraphs provide a brief description of each regulation and policy.

Legislation

Act No. 5/1990 (UU No. 5/1990) on Conservation of Living Resources and Their Ecosystems

In this act, the primary emphasis is on protection efforts, including protection of buffer zones and biodiversity preservation. There is no specific reference to the management of genetic diversity. Under the Act No. 5/1990, conservation areas are divided into (a) *Sanctuary reserves,* which consist of Strict Nature Reserves and Wildlife Sanctuaries; and (b) *Nature conservation areas,* which consist of National Parks, Grand Forest Parks and Nature Recreation Parks.

Environmental Act No. 23/1997 (UU No. 23/1997)

Under the Act No. 23/1997, policy aspects and environmental management of natural and human-made resources, including genetic resources are regulated.

Forestry Act of 1999 (UU No. 41/1999)

UU No. 41/1999 defines a *conservation forest* as a forest area with certain characteristics whose main function is the conservation of biological diversity (flora and fauna) and its ecosystem. *Conservation forests* are divided into three categories according to their main function, namely: (a) Sanctuary reserves, (b) Nature conservation areas and (c) Hunting areas. The Forestry Act of 1999 gives specific reference to the conservation of flora and fauna, although there is no specific reference to genetic resources.

Ministerial Decree (finalization process)

The MOF Decree, which regulates FGR utilization and conservation, tree improvement activities, provision and distribution of forest tree seed, is now in the process of finalization.

Policies and strategies

Designation of specific protected areas with status of international importance

- Biosphere Reserves designated by UNESCO: Gunung Leuser, Tanjung Putting, Lore Lindu, Komodo, Siberut (Taitaibatti) and Cibodas (Gede-Pangrango)
- World Heritage sites: Ujung Kulon National Park, Komodo National Park and Lorentz National Park

Indonesian Biodiversity Strategy and Action Plan (IBSAP) 2003–2020

IBSAP 2003-2020 has recently been released. The following eight points of policy direction for IBSAP implementation have been determined (BAPPENAS 2003)

- Enhance the capacity of communities in managing biodiversity.
- Enhance the assessment and development of knowledge and technology in sustainable management of biodiversity.
- Increase function sustainability and ecosystem balance at the local, regional and national levels.

- Improve the national economy through environmentally and socially sound biodiversity-based technology development.
- Improve the management systems (conservation, rehabilitation, utilization) of biodiversity on a fair and sustainable basis.
- Develop the institutional framework, local and national policies and 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 a mechanism for conflict resolution on natural resources and biodiversity at the local, regional, national and international levels.

Links with other international initiatives

The Government of Indonesia has ratified a number of conventions and other international agreements related to conservation, utilization and management of forest resources. There are three conventions, which have strong inter-linkages in Indonesia's forestry context: (1) the Convention on Biological Diversity (CBD), (2) the United Nations Framework Convention on Climate Change (UNFCCC) and (3) the United Nations Convention to Combat Desertification (UNCCD). Other conventions such as the CITES and the Ramsar Convention on Wetlands of International Importance have also been ratified.

As for other processes, the Intergovernmental Panel/Forum on Forests (IPF/IFF, now the UNFF) has produced a proposal of actions for different forest types. Considering the conditions in different countries and the national sovereignty aspect, each country is to translate these international recommendations to suit the national conditions and development priorities. In the context of Indonesia, the five-year national development programmes (PROPENAS[1]) concerning the utilization of natural resources, emphasize the need to manage or utilize the resources on a sustainable manner. The national programme on natural resource management has been further translated into the sector to suit the priorities and objectives of forestry sector development.

Basically, most of the UNFF recommendations and proposals of actions have already been implemented or followed up by the forestry sector. However, as they have been considered as a part of the sector's development priorities (not necessarily referring to conventions or other international agreements), the efforts have not received international recognition. Such efforts include, for example, the national forest and land use programme, watershed management approach for dealing with areas affected by drought, development of criteria and indicators for sustainable forest management (SFM) as well as management of protected areas.

In order to improve the management, utilization and conservation of genetic resources, Indonesia carried out a review of the 1993 Indonesian Biodiversity Action Plan. Results of the review were then formulated into the Indonesian Biodiversity Strategy and Action Plan 2003–2020, which has been published recently (BAPPENAS 2003).

Biosecurity regulations

Biosecurity is a sensitive issue for a major part of the Indonesian community, especially the question on genetically modified organisms (GMOs). However, there are probably only a limited number of scientists and people groups who really understand the issue.

Along with the development of genetic engineering technologies, the government is aware of the potential benefits and the potential dangers of this technology. In order to prevent the negative impacts of the use and production of GMOs, three related Ministries have put into effect a Joint Ministerial Decree on Biosecurity.

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[1] PROPENAS = Program Pembangunan Nasional (National Development Programme)

Legislation relating to access, property rights, and benefit sharing

In the national context, the Forestry Act No. 41/1999 deals with the access to forest resources for different groups of communities. For example, under the Forestry Act, it is possible for individuals and cooperatives to be granted license to some forest-based business, such as environmental services and NTFPs. In addition, under this Act, a large-scale enterprise can be granted license to forest-based business involving a local cooperative.

Tenure and user rights for forestland and resources are also recognized. The Forestry Act (UU No. 41/1999) recognizes these rights. Furthermore, as a follow-up to the MOF Decree no. 31/Kpts-II/2000 regarding the implementation of community forest-based management, the Government has released 26 permits for local community-based forest management, covering an area of approximately 66 214 ha in 10 provinces.

Property rights and benefit sharing from genetic resources and products derived from them are also regulated under the Act No. 29/2000 regarding the Protection of New Varieties of Plants. In relation to the international arrangements, the formulation of Act No. 29/2000 also considered relevant aspects of international agreements such as the CBD, the International Convention for the Protection of New Varieties of Plants and the WTO/Trade Related Aspects of Intellectual Property Rights (Usman 2003). Moreover, Indonesia is currently in the process of formulating an act, which will regulate the utilization, management and conservation of genetic resources.

Capacity-building activities

Capacity building can be done both through formal education and 'learning by doing' exercises. Generally, training in FGR is included in tertiary education. A number of FGR-related courses, such as genetic conservation, biodiversity conservation and tree improvement are offered at both undergraduate and postgraduate levels. Most of these courses are managed by the Faculty of Forestry or, to a lesser extent by the Faculty of Agriculture (Department of Forestry). Some prominent universities with such courses are University of Gadjah Mada in Yogyakarta, Bogor Agricultural Institute in Bogor, and University of Mulawarman in East Kalimantan.

Strengthening the human resources is crucial for the government organizations. However, as domestic funding is limited, majority of capacity building activities have been carried out through bilateral cooperation in the form of (project-based) technical assistance programmes (with e.g. JICA, GTZ, DFID) and research grants from international agencies such as FAO, ITTO, Tropenbos International, CSIRO and ACIAR. Funding provisions for training and postgraduate studies overseas have normally been a part of the projects. Opportunities for learning by doing may be obtained both in research activities during postgraduate studies or through implementation of projects.

Public awareness efforts

Enhancing public awareness about issues related to natural resource management and environmental issues is one of the priority programmes of the government and is included in almost every development sector. Creating public awareness on FGR has been carried out by the MOF, MOE, NGOs and other related organizations. However, because of a number of factors, such as different priorities or focuses of the institutions and organizations, different funding sources and a lack of communication among the parties, unnecessary duplication of activities has often been unavoidable.

Proposals for regional and international collaboration

Regional cooperation

At this stage, the establishment of a network may encourage more intensive communication among the countries in the region. Some similarities among the countries, for example in forest tree species, ecosystems and sociocultural environment, can be used as entry points for developing the network. Extending the network to reach existing regional organizations, such as ASEAN, SEAMEO-BIOTROP and APC should also be considered in order to gain support from a broader scope of stakeholders in each of the member countries.

International cooperation

There are two important aspects that need to be addressed in international cooperation: first, international policies or agreements affecting FGR conservation and management at the national level and, second, business or commercialization of FGR along with the rapid development of biotechnology.

Various FGR conservation and management issues are covered under international agreements such as the CBD and the Cartagena Protocol, the International Treaty on Plant Genetic Resources for Food and Agriculture and other agreements in the WSSD process as well as the Trade-Related Aspects of Intellectual Property Rights (TRIPS). International cooperation through APFORGEN-APAFRI-IPGRI should be directed to address some crucial issues on FGR, such as access, benefit sharing, biosecurity and intellectual property rights. The cooperation should also include joint efforts in fighting against illegal trade of FGR. Research collaboration on FGR-related fields should also be promoted.

Recommendations for regional collaboration in FGR conservation and management

Some aspects that have been proposed to be addressed at the international level are also relevant to be brought into collaboration at the regional level. These include e.g. tackling issues related to access, benefit sharing, biosecurity and intellectual property rights. Joint efforts in fighting against illegal trade of FGR and research collaboration on FGR-related fields should also be promoted at the regional level.

Information sharing on FGR conservation, utilization and management as well as exchange of genetic material for research purposes are also potential fields for collaboration among countries in the same or similar regions.

Conclusions

In the context of Indonesia, the policy direction for the next twenty years will be towards the rehabilitation of degraded lands and forests and conservation of the remaining natural forests. It is anticipated that more advanced research on species domestication, tree improvement, genetic conservation and other related fields is needed. Research to tackle the ecological aspects of plantations (monocultures) is also important for sustainable genetic resource management. International and regional collaboration is needed to tackle various issues as mentioned in the previous chapters. Identification of priority species for each participating country should be continued by involving more institutions and other stakeholders in the countries.

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Appendix 1

Priority species for FGR conservation and management identified from various sources

Species	Product type		Source of data(*)
	Timber	Non-timber	
Acacia auriculiformis	✓		CFBTI
A. crassicarpa	✓	✓	CFBTI
A. mangium	✓		CFBTI
Agathis borneensis	✓		Perhutani
A. loranthifolia	✓		
Aleurites moluccanus	✓	✓	
Alstonia palembanica	✓		
A. scholaris	✓		CFBTI
Altingia excelsa	✓	✓	
Anthocephalus chinensis	✓		
Aquilaria malaccensis		✓	FORDA
Araucaria cunninghamii	✓		CFBTI
Arenga pinnata		✓	
Artocarpus altilis		✓	CFBTI
A. heterophyllus	✓	✓	
Azadirachta excelsa	✓	✓	
Calamus manan		✓	FORDA
Calophyllum inophyllum	✓		
Canarium asperum	✓	✓	
Cassia siamea	✓		
C. vera		✓	
Casuarina equisetifolia		✓	
C. junghuhniana	✓		
Ceiba pentandra		✓	
Cinnamomum sp.	✓	✓	FORDA
Dalbergia latifolia	✓		Perhutani
Diospyros celebica	✓		
Dipterocarpus spp.	✓		
Dryobalanops aromatica	✓	✓	
Duabanga moluccana	✓		
Durio zibethinus	✓	✓	
Dyera costulata	✓	✓	
Dysoxylum mollissimum	✓		
Elmerrillia ovalis	✓		
Eucalyptus deglupta	✓		
E. pellita	✓		CFBTI
E. urophylla	✓		
Eusideroxylon zwageri	✓		CFBTI
Fagraea fragrans	✓		
Gmelina moluccana	✓		
Gnetum gnemon		✓	
Gonystylus bancanus	✓		CITES Appendix III
Hopea mengarawan	✓		
Intsia bijuga	✓		
Koompassia malaccensis	✓		
Lophopetalum multinervium	✓		UGM, FORDA
Manilkara kauki	✓	✓	

Species	Product type		Source of data[*]
	Timber	Non-timber	
Melaleuca cajuputi var. *cajuputi*	✓	✓	CFBTI
M. leucadendra	✓		FORDA
Metroxylon sagu		✓	
Mimusops elengi		✓	
Myristica fragrans		✓	
Octomeles moluccana	✓		
Palaquium amboinense	✓		
P. rostratum	✓	✓	
Paraserianthes falcataria	✓	✓	CFBTI
Parkia speciosa		✓	
Pericopsis mooniana	✓		
Peronema canescens	✓		
Pinus merkusii	✓	✓	Perhutani, UGM
Pithecellobium jiringa		✓	
Pometia pinnata	✓	✓	
Pterocarpus indicus	✓	✓	
Rhizophora spp.	✓		
Samanea saman		✓	
Santalum album	✓	✓	CFBTI
Schima wallichii	✓	✓	
Schleichera oleosa	✓	✓	
Shorea javanica	✓	✓	
S. johorensis	✓		
S. laevis	✓		
S. leprosula	✓		UGM, FORDA
S. macrophylla		✓	
S. ovalis	✓		
S. parvifolia	✓		
S. pinanga		✓	CFBTI
S. polyandra	✓		
S. selanica	✓		
S. stenoptera	✓	✓	
Styrax benzoin		✓	
Swietenia mahagoni	✓		Perhutani, FORDA
Tarrietia spp.	✓		
Tectona grandis	✓		CFBTI, Perhutani
Toona sureni	✓		
Vitex pubescens	✓		

Note: (*) The primary source of data is Ministry of Forestry (MoF 1995)
Additional sources:
CFBTI = Centre for Forest Biotechnology and Tree Improvement
FORDA = Forestry Research and Development Agency
UGM = University of Gadjah Mada
Perum Perhutani (a state-owned forestry enterprise)

Status of forest genetic resources conservation and management in Lao PDR

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Introduction

The Lao People's Democratic Republic (Lao PDR) is a landlocked country covering an area of 236 800 km^2. Lao PDR is in the watershed of the Mekong River, which forms about half of the country's border with Thailand. In 1997, the per capita GNP was only US$ 414, though the GDP grew at an annual rate of 6.5% (FAO 2001) and population reached 5.4 million in 2001 (MAF 2001). The country is predominantly mountainous, with 80% of its land area consisting of hills and mountains rising from 100 to 2820 m above the Mekong River plains. The remaining 20% comprises lowland plains of the Mekong and its main tributaries as well as the adjacent flat and undulating plains. These alluvial plains range in elevation up to approximately 200 m above sea level.

The National Forest Inventory and Planning Division (NOFIP) conducted a Nation-wide Reconnaissance Survey in 1992 (NOFIP 1992) and divided the land use and forest types into six main land-use groups as follows:

- Current Forest Areas (evergreen, dry dipterocarp, mixed deciduous, gallery, coniferous, mixed coniferous and broadleaved forest)
- Potential Forest Areas (bamboo, unstocked and ray (forest land after shifting cultivation) areas)
- Other Wooded Areas (savannah/open woodland, heath/scrub)
- Permanent Agriculture (rice paddy, agriculture plantation, other agricultural land)
- Other Land Use Areas (barren land/rock, grassland, urban areas, swamp)
- Water (river, reservoir)

A summary of land use in Lao PDR is provided in Tables 1 and 2.

Table 1. Land use and forest cover in Lao PDR in 1989

Land use	Northern region	Central region	Southern region	Country total
Current Forest	36%	52%	59%	**47%**
Potential Forest	56%	28%	21%	**38%**
Other Wooded Land	4%	8%	9%	**6%**
Other Non-forest Land	3%	8%	4%	**5%**
Permanent Agriculture	1%	4%	7%	**4%**
Total	**100%**	**100%**	**100%**	**100%**

Table 2. Land use and vegetation types in Lao PDR in 1992 (Khamphay & Mats 1992)

Land-use group/ land-use and vegetation type	Area (%)	Area (1000 ha)
1. Current Forest (CF)	**47.2%**	**11182.0**
Dry Dipterocarp (DD)	5.1%	1206.5
Dry Evergreen (DE)	4.8%	1146.5
Mixed Deciduous (MD)	35.1%	8334.9
Gallery Forest (GE)	0.4%	87.5
Coniferous (S)	0.6%	132.3
Mixed Coniferous/ Broadleaves (MS)	1.2%	280.5
2. Potential Forest (PF)	**37.8%**	**8949.0**
Bamboo (B)	6.5%	1531.9
Unstocked (T)	26.7%	6791.4
Ray (RA)	2.6%	625.6
3. Other Wooded Areas (OW)	**6.1%**	**1444.4**
Savannah / Open Woodlands (SH)	3.9%	912.5
Heath, Scrub Forest (SR)	2.2%	531.7
4. Permanent Agriculture Land (PA)	**3.6%**	**849.5**
Rice Paddy (RP)	3.3%	789.4
Agriculture Plantation (AP)	0.1%	17.8
Other Agriculture Land (OA)	0.2%	42.3
5. Other Non-Forest Land (NF)	**5.4%**	**1269.5**
Barren Lands / Rock (R)	0.5%	116.1
Grassland (G)	3.5%	822.8
Urban Areas (U)	0.4%	84.2
Swamps (SW)	0.1%	35.4
Water (W)	0.9%	210.9
TOTAL	**100%**	**23680.0**

Forest resources

Lao PDR is still quite rich in forest resources compared to many other Asian countries. However, the relatively abundant forest resources of the Lao PDR are disappearing fast. According to the national forest reconnaissance survey, in 1940 the country had about 17 million hectares of forest, accounting for 70% of the total land area. However, forest areas have diminished rapidly, accounting for only 47% of the total land area in 1992. The causes for the forest loss include encroachment into forest for permanent cultivation, slash and burn cultivation, forest fires, legal and illegal logging as well as infrastructure development.

Current economic importance of the forestry sector

The forest and forestry sector plays an important role in the national socioeconomic development process. On the other hand, forests have a role in protecting the environment, prevention of soil erosion, drought and flood hazards, maintenance of watersheds and watercourses, which are habitats for many kinds of fish and aquatic species and important for agricultural production as well as industrial development, particularly hydropower generation. However, the forests play a very significant role in economic development, income generation as well as in the livelihoods of the rural people. The forestry sub-sector contributes 8% of the national GDP (MAF 2001).

Silvicultural approaches

The National Forest Inventory and Planning Office (National Forest Inventory and Planning Division) under the Forestry Department plays an important role in the management of natural forest resources by carrying out forest management plans, pre-logging surveys and tree marking. In selective cutting, cutting limits for each species are based on the actual state and balance of forest types and species composition. The selection of suitable species and design for planting programmes is based on socioeconomic factors and environment in each planting zone.

Conservation of forest genetic resources

Lao PDR, a landlocked country, is rich in biodiversity of flora and fauna compared to the neighbouring countries and other countries in the region. Lao PDR is one of the hotspots of biodiversity in the region, yet the country is lacking in basic floristic information. According to Xu Zai Fu (1994), there are at least 8000 to 11 000 species of plants in Lao PDR. As for fauna, 100 species of bats, over 100 species of large mammals, 700 species of birds and 166 species of reptiles and amphibians have been documented in the country (Duckworth *et al.* 1999).

The Ministry for Agriculture and Forestry (MAF) provided a national list of tree species in the conservation category and only limited commercial cutting is permitted for species in this category (MAF 1997). Later, the Forestry Research Centre (FRC) identified 114 priority tree species (FRC 1999). Greijmans and Phongoudome (2003), Greijmans and Inthavong (2003), Greijmans *et al.* (2002a) and Greijmans *et al.* (2002b) prepared the national status report on the conservation of forest genetic resources (FGR) in Lao PDR. This study included information on distribution, occurrence and conservation status of selected species as well as a seed zoning system. The results of these studies were based on a database involving more than 113 indigenous tree species. The NOFIP and the National Agriculture and the Forestry Research Institute (NAFRI), with the help of national as well as international experts assessed the status of selected species in the country (for results, see Appendices 1 and 2 and Figure 1.)

Between 1998 and 2002, establishment of some National Biodiversity Conservation Areas (NBCAs), namely Nam Et-Phou Loie, PhouKhaoKuay and Phouphanang was supported by the Netherlands Committee for IUCN (NC-IUCN), Danish International Development Agency (Danida), Swedish International Development Cooperation Agency (SIDA) and other agencies. A few botanical surveys were conducted.

Bamboo and rattan diversity

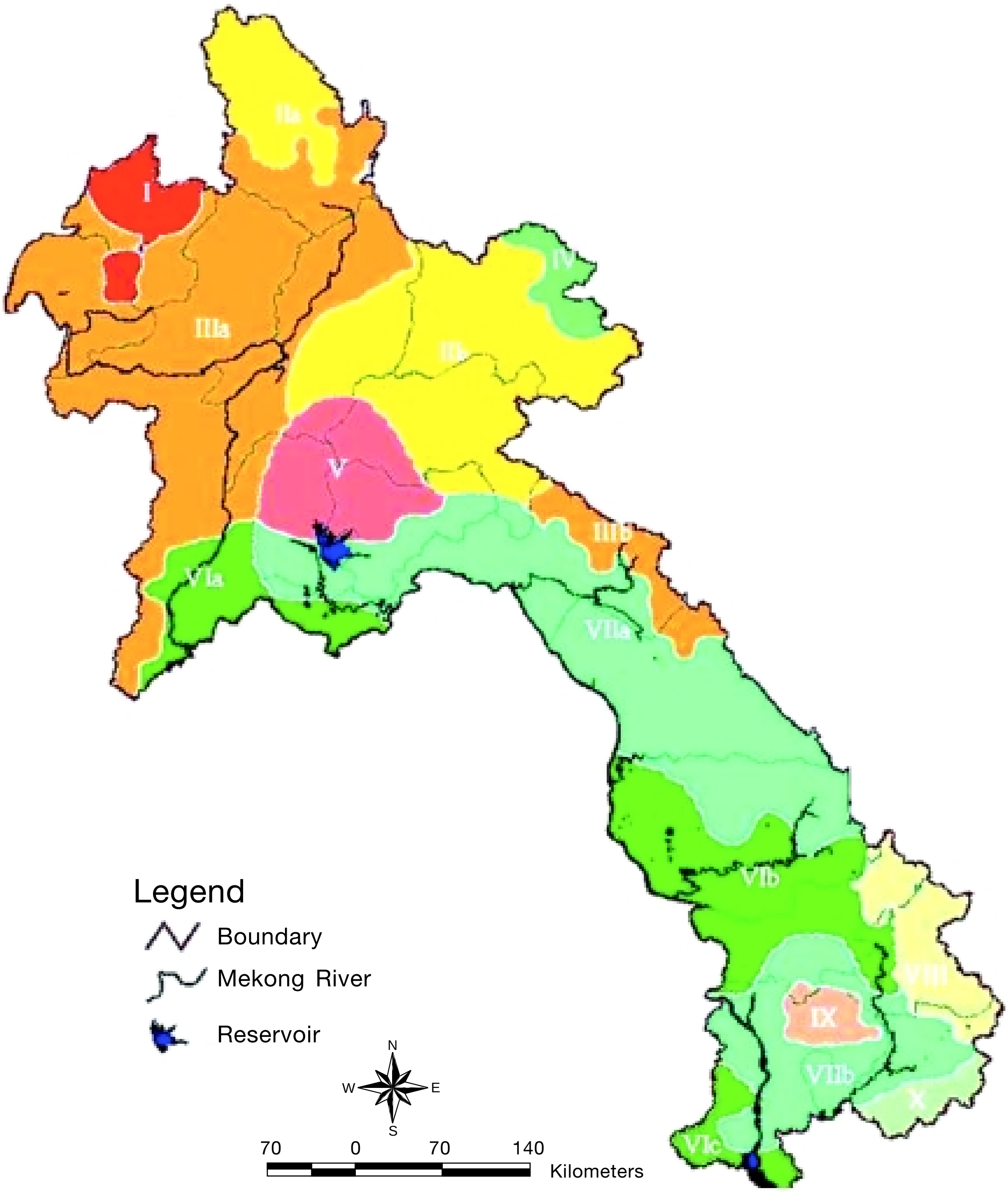
In 1994 the International Development Research Centre (IDRC) supported the FRC to conduct a survey of bamboos in Lao PDR. In total, 8 genera and 93 species were documented, of which 50 were identified and 43 are still unidentified (Sengkhamyong 1994). Vichit (2000) also provided a list of priority species based on seed demand and supply. In 2001, the Darwin Initiative supported the FRC to conduct a study on the ecology of rattan in Lao PDR. A total of 6 genera and 51 species were documented, of which 3 genera and 32 species are still unidentified (Evans *et al.* 2001).

Threats to genetic diversity of forest species

Xiong and Gilmour (2000) assessed the causes of threats to forests and species genetic diversity in Lao PDR. The five main threats identified were encroachment into forest for permanent agriculture, shifting cultivation (with short rotational cycle), forest fires, legal and illegal logging and infrastructure development.

Current FGR conservation activities

Both *in situ* and *ex situ* conservation efforts are rare in Lao PDR and there is hardly any data on the distribution of FGR. More information should be extracted from, for example, existing provenance trials and demonstration plots to develop plans for the conservation



- I. Cool-dry-short dry season
- II. Cool-dry-long dry season (a = Phongsaly, b = Xiengkhouan-Houaphane)
- III. Cool/warm-dry-long dry season (a = Northwest, b = Lak Sao-Bolikhamxai)
- IV. Cool-wet-short dry season
- VI. Warm-dry-long dry season (a = Vientiane-Xayaboury, b = Savannakhet-Salavane, c= Champasak)
- VII. Warm-wet-long dry season (a = Mekong, b = Champasak-Attapeu)
- VIII. Cool/warm-wet-long dry season
- IX. Cool/warm-wet-short dry season
- X. Warm-dry-short dry season

Figure 1. Gene-ecological zoning system for Lao PDR

of FGR. Such plans should be shared with the neighbouring countries, i.e. China, Vietnam, Cambodia, Thailand and Myanmar to learn from their experiences and to enhance regional conservation efforts (Thepphavong *et al.* 2001).

Policies and initiatives relevant to the management of natural resources (including FGR) include the 1st National Forestry Conference in 1989, National Tropical Forestry Action Plan 1990, Nation-wide Reconnaissance Survey (NRS) (NOFIP 1992) and the National Forest Inventory (NOFIP 2000), National Biodiversity Conservation Areas (NBCAs) in 1993 (see Figure 2.), Forestry Law 1996, Land Law 1997 and National Biodiversity Country Report (NBCP) 2003.

Past and present research activities in the field of conservation, utilization and management of FGR

Most research and development activities in Lao PDR emphasize adaptive research, applied research and sometimes basic research on agricultural genetics. Floristic works in Laos have been based on documentation provided by the *Flora of Indochina* (1905–1952) and *Flora of Cambodia, Laos and Vietnam* since the 1960s until today. These volumes were written mainly by French botanists. Some books were also developed specifically for Lao PDR, for example by the French botanist J. Vidal who described the taxonomy of the local tree family of Dipterocarpaceae, later revised by B. Svengsuksa and J. Vidal (Vidal 1959; Vidal 1963; Svengsuksa and Vidal 1997). Some other relevant botanical volumes include: Flora of Thailand (Smitinand 1980; Smitinand *et al.* 1970–2000), Vietnam Forest Trees (Vu Van Dung 1996; Pham Hoang Ho 1999–2001), PROSEA-volumes, etc. There is a lack of young botanists, national herbaria and laboratories for R&D in this area.

Agroforestry, plantations and afforestation programmes

Most agroforestry systems applied in Lao PDR may be classified into two categories:

- Traditional systems (shifting cultivation, economically improved fallows, living fences, plantations of orchards and taungya)
- Modern systems (biologically improved fallows, alley cropping and contour hedgerows)

The purpose of research on suitable agroforestry techniques is to explore plant species for improving local living conditions and the environment. Appendix 3 provides information on the benefits and constraints of different agroforestry systems.

Plantation and afforestation efforts in Lao PDR started during the early French colonial era for some species such as *Tectona grandis* (NOFIP 1991). There has also been testing of exotic species, e.g. *Swietenia macrophylla* and *Eucalyptus* spp. in the central and southern parts of the country since 1970. Some exotic species have been introduced into plantation and afforestation programmes since 1976. Table 3 provides a summary of domestication and plantation activities on some indigenous species. A summary of annual planting areas is presented in Table 4.

Table 3. Summary of some indigenous species used for domestication and plantation (compiled by C. Phongoudome, July 2003)

Species	Area (ha)	Province	Year	Remarks/ source of data*
Afzelia xylocarpa	135	Bolikhamxai, Vientiane	1992	
Alstonia scholaris	426	Bolikhamxai	1992, 1991	Report 1995; NOFIP 1991
Anisoptera costata	5	Bolikhamsai, Vientiane, FRC		
Anthocephalus chinensis	5		1994	FRC
Aquilaria crassna	20	Vientiane, Saravan, Champasack		
Azadirachta indica	12	FRC, Vientiane, Champasack	1998	
Cassia siamea	2	Vientiane		
Castanopsis hystrix	5	Xiengkhuang		
C. tribuloides	1	Xiengkhuang		
Chukrasia tabularis	10	Luangprabang		
Dalbergia cochinchinensis	200	Bolikhamxai, FRC	1992	
Dipterocarpus alatus	10	Champasack		
Fagraea fragrans	2	Boilikhamsai		
Gmelina arborea	3	Luangprabang, Vientaine		
Hopea odorata	5	Champasack, Savanhnakhet		
Keteleeria davidiana	3	Xiengkhuang		
Lagerstroemia calyculata	1			
Azadirachta indica	285	Champasack, Sekong, Savanhnakhet	1994	DAFI 1995
Peltophorum dasyrhachis	1	Vientaine		
Paramichelia bailonii	<10	Sekong, Champasack, Saravane	1995	
Pentace burmanica	5	Champasack		
Persia glambei	2	Champasack, Saravane, Xaiyabouli		
Pinus kesiya	5	Xiengkhuang		
P. merkusii	5	Xiengkhuang,Bolikhamsai, Huaphanh		
Pterocarpus macrocarpus	1382	Bolikamxai, Saravance, Savanhnakhet, Khammoun, Champasack	1992	NOFIP
Quercus griffithii	1	Xiengkhuang		
Q. serrata	1	Xiengkhuang		
Sandoricum koetjape	6	Champasack,		
Scaphium macropodum	4	Champasack, Attapeu, Saravan, Sekong		
Schima wallichii	1	Xiengkhuang		
Sindora cochinchinensis	1	Vientiane, Bolikhamsai		
Styrax tonkinensis	10	Luang prabang, Oudomxai		
Tectona grandis	8000	*ALL*	1932–2001	JICA Report 2001
Tetrameles nudiflora	2	Champasack,	1995	
Toona ciliata	1	Vientiane, Luangprabang		
Vatica cinerea	1	Bolikhamsai		
Wrightia arborea	2	Vientiane		
Xylia xylocarpa	3	Vientiane, Khammoun		
Other species	**84 436**	***ALL***	2002	Both indigenous and exotic

* Source of data: DAFI 1995 = Development Agriculture and Forestry Industry Database

Demand and supply of tree seed

During the past 20 years, seeds of indigenous species from unidentified seed sources and seeds of local and exotic species from mature plantations as well as imported seeds from original locations for exotic species have been used. The majority of the seeds produced have been used for forest rehabilitation and plantation establishment. A summary of seed collection and seedling production activities is provided in Table 4.

Table 4. Summary of seed collection, seedling production, plantation and rehabilitation activities in Lao PDR between 1978-2002 (compiled by C. Phongoudome, July 2003)

Year	Seed collection (kg)	Nursery (ha)	Seedling production (nos.)	Planting area (ha)		Rehabilitation (ha)	Remarks
				Target	Actual		
1978	2381	n.a.	1 134 366	n.a.	452	n.a.	
1979	5320	n.a.	2 047 649	n.a.	184	n.a.	
1980	2500	n.a.	3 000 000	n.a.	405	n.a.	
1981	7573	n.a.	n.a.	n.a.	176	n.a.	
1982	12 751	n.a.	n.a.	n.a.	202	n.a.	
1983	13 315	n.a.	n.a.	n.a.	350	n.a.	
1984	14 452	n.a.	n.a.	n.a.	310	n.a.	
1985	14 200	n.a.	574 868	n.a.	346	n.a.	
1986	18 579	n.a.	426 200	n.a.	192	n.a.	
1987	4680	n.a.	492 700	n.a.	236	n.a.	
1988	9259	n.a.	513 900	n.a.	316	n.a.	
1989	12 901	n.a.	772 000	n.a.	513	n.a.	
1990	4216	n.a.	927 180	n.a.	716	n.a.	
1991	17 585	n.a.	1 823 820	n.a.	1359	n.a.	
1992	10 400	n.a.	975 250	n.a.	901	n.a.	
1993	6651	n.a.	850 370	n.a.	2219	n.a.	
1994	46 393	n.a.	4 640 470	n.a.	3798	34 170	
1995	47 676	1787	26 382 656	10 000	8828	n.a.	Nursery all sector
1996	13 354	1796	26 707 230	20 000	11 850	6878	Nursery all sector
1997	44 849	1828	17 436 192	n.a.	12 290	4590	Nursery all sector
1998	35 167	1828	12 368 808	n.a.	9030	5780	Nursery all sector
1999	2878	2407	10 172 764	20 000	6350	5800	Nursery all sector
2000	42 843	1983	23 546 267	20 000	15 160	21 304	Nursery all sector
2001	18 783	n.a.	9 430 133	23 000	20 500	n.a.	
2002	2871	n.a.	22 600 000	25 000	15 000	4000	2871 Kg by FRC provinces
Total	**411 577**	——	**201 822 823**	**118 000**	**111 683**	**82 522**	

n.a. = figures not available

Data compiled from databases of the Forestry Department, Forestry Extension Division, NAFRI Forestry Research Centre, MAF Basic Statistics, Department of Finance and Planning and the LTSP.

In situ conservation

Presently the emphasis of most *in situ* conservation activities is on protected areas and NBCAs (Figure 2). Table 5 provides a summary of different types of conservation areas in Lao PDR.

Table 5. Conservation areas in Lao PDR in 1993

Category	Units	Area (ha)	%	Remarks
National Biodiversity Conservation Areas (NBCA)	20	3 315 200	14.0	See Figure 2.
District Conservation Forests	144	503 000	2.1	Excluded from Fig. 2.
Provincial Conservation Forests	57	932 000	3.9	Excluded from Fig. 2.
District Protection Forests	52	55 713	0.2	Excluded from Fig. 2.
Provincial Protection Forests	23	461 410	2.0	Excluded from Fig. 2.
Total	**296**	**5 267 323**	**22.24**	

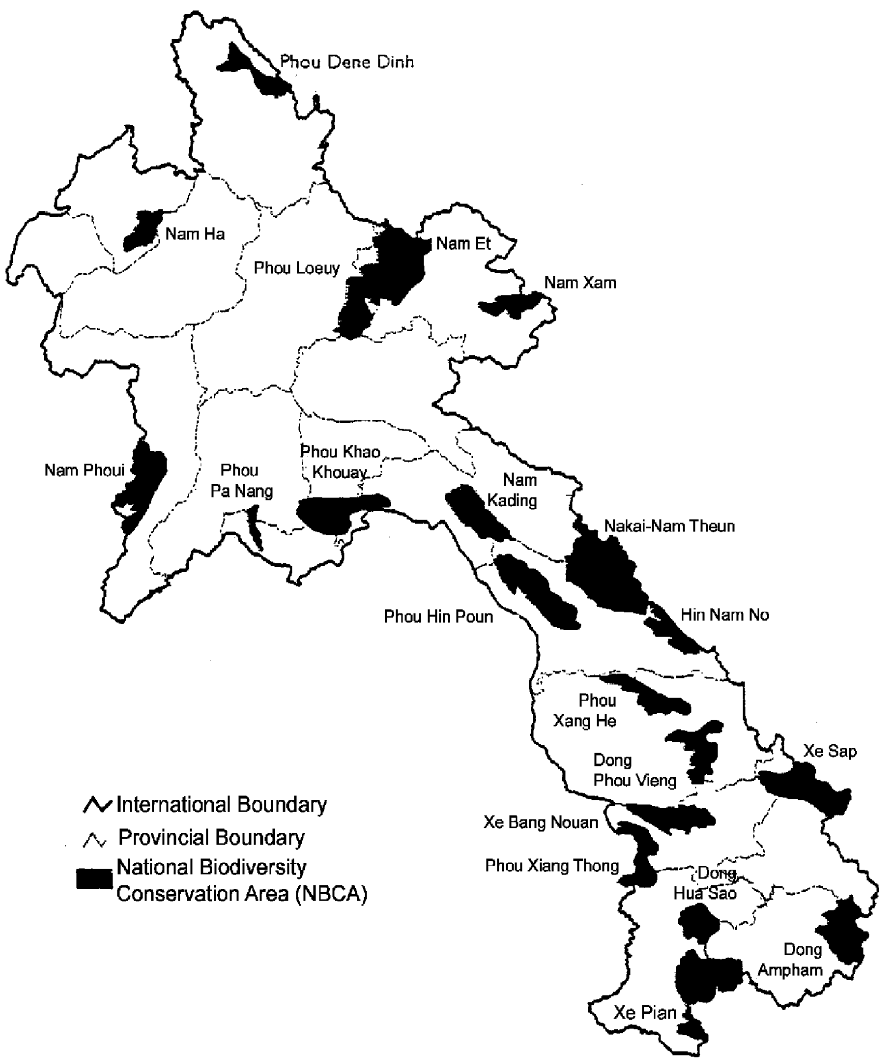


Figure 2. National Biodiversity Conservation Areas (NBCA) in Lao PDR

Ex situ conservation

Demonstration plots for some indigenous species have been established by the FRC/Lao Tree Seed Project (LTSP). The purpose of these demonstration plots is to conserve the high economic value indigenous tree species. A summary of tree domestication activities is provided in Appendix 4.

Tree improvement activities

The identification of 50 seed sources in natural forests was initiated by LTSP in 2002/2003. Some provenance trials of indigenous species have been established for species such as *Chukrasia tabularis* and *Azadirachta indica*. Seedling seed orchards for certain exotic species, such as *Eucalyptus camaldulensis* have been established in 2000. Appendix 5 provides a summary of registered seed sources in Lao PDR.

Use of biotechnology for characterisation, improvement and conservation

The National Agriculture Research Centre under the MAF, located in the southern part of Lao PDR, and the Science, Technology and Environment Agency (STEA) at the Institute of Biotechnology have established three tissue culture laboratories. These laboratories provide services to some research activities and for students in practical training.

Socioeconomic conditions and issues related to conservation, utilization and management of FGR

Status of forest resources and utilization of trees

In 1940, the total forest area of Lao PDR was estimated to be 17 million ha, or 70% of the total territory of the country (NOFIP 1992). By 2000, this area had declined to 12.5 million ha, or 54% of the total territory (FAO 2001). Utilization of trees has been based on regulations by the MAF that created a forest management plan for each concession area based on species composition, selective cutting and cutting limits that were applied for each zone.

Based on the 1st National Forestry Conference held in 1989 and Tropical Forestry Action Plan (TFAP) in 1990, the forest areas allocated for management and development within the categories described are shown in the Table 6.

Table 6. Forest area in Lao PDR divided into management categories (TFAP 1990)

Forest type	Area
Protection forest	9.5 million ha
Conservation forest	2.5 million ha
Production forest	5.0 million ha
Total	**17 million ha**

Identification of national priorities

List of priority species for FGR conservation and management

The list of national priority species is provided in Table 7. The criteria used for selecting the priority species include: a) the species is indigenous to Lao PDR, b) economically important now or in the near future and c) threatened as a result of over-use or destruction of natural habitats. The list is based on the preliminary list provided by APFORGEN.

Table 7. Priority species for Lao PDR (compiled by C. Phongoudome)

No.	Priority species	References and reports
1	*Afzelia xylocarpa*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
2	*Albizia lebbeck*	FRC 1999
3	*A. procera*	FRC 1999
4	*Alstonia scholaris*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
5	*Anisoptera costata*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
6	*Aquilaria crassna*	MAF 1997; FRC 1997; Greijmans *et al.* 2002b
7	*Azadirachta indica*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
8	*Cassia siamea*	FRC 1999
9	*Chukrasia tabularis*	Greijmans *et al.* 2002b
10	*Dalbergia cochinchinensis*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
11	*Dipterocarpus alatus*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
12	*D. grandifolius*	MAF 1997
13	*D. tuberculatus*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
14	*Fagraea fragrans*	MAF 1997; Greijmans *et al.* 2002b
15	*Hopea odorata*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
16	*Parashorea stellata*	Greijmans *et al.* 2002b
17	*Parkia speciosa*	MAF 1997; Greijmans *et al.* 2002b
18	*Pinus kesiya*	MAF 1997; Greijmans *et al.* 2002b
19	*P. merkusii*	MAF 1997; Greijmans *et al.* 2002b
20	*Pterocarpus indicus*	MAF 1997; Greijmans *et al.* 2002b
21	*P. macrocarpus*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
22	*Schima wallichii*	Greijmans *et al.* 2002b
23	*Shorea cochinchinensis*	MAF 1997; Greijmans *et al.* 2002b
24	*S. roxburghii*	Greijmans *et al.* 2002b
25	*Sindora cochinchinensis*	MAF 1997
26	*Sterculia lychnophora*	MAF 1997; Greijmans *et al.* 2002b
27	*Tarrietia javanica*	MAF 1997
28	*Tectona grandis*	MAF 1997; FRC 1999; Greijmans *et al.* 2002b
29	*Toona sureni*	Greijmans *et al.* 2002b
30	*Vatica odorata*	MAF 1997; Greijmans *et al.* 2002b
31	*Xylia xylocarpa*	MAF 1997; Greijmans *et al.* 2002b
Bamboo & rattan species (Rao *et al*. 1998)		
Bamboo		
1	*Bambusa* spp.	Sengkhamyong 1994
2	*B. tulda*	Sengkhamyong 1994
3	*B. vulgaris*	Sengkhamyong 1994
4	*B. blumeana*	Sengkhamyong 1994
5	*Cephalostachyum* spp.	Sengkhamyong 1994
6	*Dendrocalamus asper*	Sengkhamyong 1994
7	*D. latifolius*	Sengkhamyong 1994
Rattan		
1	*Calamus palustris*	Evans *et al.* 2001
ADDITIONAL PRIORITY SPECIES		
1	*Acacia mangium*	Greijmans and Phongoudome 2003
2	*Ailanthus excelsa*	MAF 1997; Greijmans and Phongoudome 2003
3	*Betula alnoides*	Greijmans and Phongoudome 2003
4	*Calamus erectus* (rattan)	Evans *et al.* 2001
5	*C. longisetus* (rattan)	Evans *et al.* 2001
6	*Cunninghamia lanceolata*	MAF 1997; Greijmans *et al.* 2002b
7	*Dalbergia cultrata*	MAF 1997, FRC 1999; Greijmans *et al.* 2002b
8	*Diospyros mun*	MAF 1997; Greijmans *et al.* 2002b
9	*Dipterocarpus turbinatus*	MAF 1997; Greijmans *et al.* 2002b
10	*Dysoxylum loureirii*	MAF 1997; Greijmans *et al.* 2002b
11	*Erythrophleum fordii*	MAF 1997; Greijmans *et al.* 2002b
12	*Eucalyptus camaldulensis*	Greijmans and Phongoudome 2003
13	*Fokienia hodginsii*	MAF 1997; Greijmans *et al.* 2002b
14	*Gmelina arborea*	MAF 1997, FRC 1999; Greijmans *et al.* 2002b
15	*Toona ciliata*	MAF 1997; Greijmans *et al.* 2002b

Institutional framework and capacity-building activities

Institutions and organizations involved in FGR conservation & management: their roles, responsibilities and capabilities

The following national and international organizations are involved in FGR conservation and management activities in Lao PDR:

- Ministry of Agriculture and Forestry (MAF):
  - Department of Forestry (DOF)
  - Centre of Watershed and Conservation
  - National Agriculture and Forestry Research Institute (NAFRI)
  - Forestry Research Centre (FRC)
  - Tree Seed and Tree Improvement Research Unit
  - National Agriculture and Forestry Service (NAFES)
  - Division of Forest Extension and Rehabilitation
- Science, Technology and Environment Agency (STEA):
  - Department of Environment (Strategy and Action Plan on Biodiversity)
  - National University of Laos (NuoL), Faculty of Science, Department of Biology and Faculty of Forestry, Department of Forest Management (important role in education)
- IUCN, Lao PDR office: (Advises the Government)
- Danida: (Supports Lao Tree Seed Project (LTSP) as one component of the Indochina Tree Seed Programme (ITSP))
- SIDA: (Supports research activities on upland agriculture and forestry)
- JICA: (Supports activities such as training on field forestry and afforestation programme)
- Korea International Cooperation Agency (KOICA): (Provides volunteers to work in fields of forestry and entomology at the Provincial Agriculture and Forestry Office (PAFO) level)
- APAFRI: (Lao PDR is a member of APAFRI)

National legislation, policies and strategies on FGR

The National Strategy of the Forestry Sector Vision 2020 aims to increase the forest cover up to 60–70% through the establishment of 0.5 million ha of forest plantations, using both indigenous and exotic species as well as the rehabilitation of 2 million ha of natural forest. At present, the following laws and decrees concerning FGR are in force:

- Decree No. 164/PM on Established National Biodiversity Conservation Areas (1993)
- Forestry Law (1996)
- Land Law 1997
- Decree No. 196/MAF on Promotion of Forest Plantation (2000)
- Decree No. 0524/MAF on Conservation and Administration of NBCAs and Wildlife

Biosecurity regulations

In early 2003, several concerned ministries, such as MAF and STEA played an important role in the newly established technical working group that prepared a draft of the National Biodiversity Strategy and Action Plan as well as other related regulations.

Links with other international initiatives

Lao PDR has ratified the Convention on Biological Diversity (CBD) in 1996 and the United Nations Framework Convention on Climate Change (UNFCCC) in 2003. Lao PDR is a new party to the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). There have been discussions at the national level on future activities in international cooperation.

Training and capacity building activities

There is a need for capacity building on FGR conservation and management in Lao PDR, for example in plant genetic resources conservation technologies. There is no specific training on forest genetics and flora supported by international organisations but only on natural resources management and the environment in general.

Public awareness efforts

Some authors have provided articles on FGR and conservation to The Lao National Television, Vientiane News (in Lao and English), Lao newspapers as well as the National Radio Station. Some extension materials, such as posters, video programmes and songs have been produced by the MAF, DOF and LTSP.

Proposal for regional and international collaboration

The areas proposed for regional co-operation and networking to improve FGR conservation and management and information flow in the region could include determining the status of forest resources and FGR, creating lists and databases for priority species, ecological zoning, species distribution and genetic variation as well as regional strategies and action plans on FGR. Human resources development and capacity building are the main prerequisites for these activities and funding is needed.

Conclusions

FGR activities in Lao PDR are still new compared to other countries in the Asia-Pacific region. This is because of a lack of human resources and funding to carry out this kind of work. Research and national capability building need more support in the fields of genetics, taxonomy, ecology, botany and forest tree improvement. International collaboration and networking are recommended.

Acknowledgements

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Appendix 1

Selected tree species assessed for their conservation status in Lao PDR

1. *Afzelia xylocarpa* (Tekha)
2. *Aglaia giganthea* (Nok kok)
3. *A. grandis* (Mak kong)
4. *Allospondias lakonensis* (Som ho)
5. *Alstonia rostata* (Teen Pet, T. Khai)
6. *A. scholaris* (Teen pet)
7. *A. spathulata* (Teen pet)
8. *Anisoptera costata* (Bak, B. deng, B. khao)
9. *A. scaphula* (Bak luang)
10. *Aquilaria crassna* (Ked sana, Dam, Po huang)
11. *Azadirachta indica* (Ka dao, Khom ka dao)
12. *Bischofia javanica* (Khom fad, Fung fad)
13. *Broussonetia papyrifera* (Poh sa)
14. *Caesalpinia sappan* (Fang deng)
15. *Castanopsis acuminatissima* (Ko duay)
16. *C. hystrix* (Ko deng, Ko fan)
17. *Cephalotaxus mannii* (Kham pom deng, Pek khon nok)
18. *Chukrasia tabularis* (Nhom, N. hen, N. hao)
19. *Cinnamomum iners* (Sa chouang, Si khai ton, Chouang hom)
20. *C. obtusifolium* (Khae)
21. *Cunninghamia lanceolata* (Hing hoame)
22. *Dacrycarpus imbricatus* (Pek deng, Hing)
23. *Dalbergia cochinchinensis* (Kha nhoung)
24. *D. cultrata* (Ka bo, Kamphee, Nang noune, Kha nhoung)
25. *D. hupeana* (Kha nhoung)
26. *D. lanceolaria* (Khamphee, Nang noune, Pa dong deng)
27. *D. oliveri* (Kampee)
28. *Dialium cochinchinense* (Kheng)
29. *D. indium* (Kham phaep, Kam thep)
30. *Diospyros ferrea* (Makhua)
31. *D. malabarica* (Makhua, Lang dam, Kua nam)
32. *D. mollis* (Makhua)
33. *D. mun* (Makhua, Moun)
34. *Dipterocarpus alatus* (Nhang khao, N. na, N. khiauw, N. mwak)
35. *D. costatus* (Nhang deng)
36. *D. hasseltii* (Nhang kiang)
37. *D. intricatus* (Ta baeng, Sa baeng)
38. *D. kerrii* (Nhang khayeng)
39. *D. obtusifolius* (Sad)
40. *D. retusus* (Nhang dong)
41. *D. tuberculatus* (Koung)
42. *D. turbinatus* (Nhang deng)
43. *Dysoxylum binectariferum* (Khouang deng, Chan luang, Kon ta sewa)
44. *D. loureirii* (Khon ta sang)
45. *Elaeocarpus stipularis* (Moune)
46. *Eriobotrya serrata* (Khon dok)
47. *Erythrophleum fordii* (Kha cha, Than, Lem)
48. *Fagraea fragrans* (Man pa)
49. *Fokienia hodginsii* (Long leng, Len le, Lang Len)
50. *Garcinia fagraeoides* (See)
51. *Gmelina arborea* (So)
52. *Haldina cordifolia* (Khao)
53. *Hopea chinensis* (Khaen see)
54. *H. ferrea* (Khen hen)
55. *H. odorata* (Khen hua)
56. *H. pierrei* (Khaen hen, K. hak yong, La en)
57. *H. recopei* (See dok deng, Khen fai)
58. *H. thorelii* (Khaen see)
59. *Irvingia malayana* (Bok)
60. *Keteleeria evelyniana* (Hing)
61. *Lagerstroemia calyculata* (Puay khao, P. dok khao)
62. *L. floribunda* (Puay phuak bang, P. dok deng)
63. *Litsea glutinosa* (Bong mee)
64. *Mangifera pentandra* (Mouang pa)
65. *Manglietia garrettii* (Mak thek)
66. *Mansonia gagei* (Chan hom)
67. *Melia azedarach* (Hien, Khadao sang)
68. *Melientha suavis* (Pak wan pa)
69. *Mesua ferrea* (Lek)
70. *Michelia champaca* (Cham pa pa)
71. *M. masticata* (Ham)
72. *M. mediocris* (Cham pa pa)
73. *Millettia leucantha* (Sa thon)
74. *Mitragyna diversifolia* (Thom dong)
75. *Paramichelia baillonii* (Cham pipa, Som suai, Sai)
76. *Parashorea stellata* (Hao)
77. *Parkia speciosa* (Houa lone)
78. *Peltophorum dasyrhachis* (Sa phang, Sa kham)
79. *Pentace burmanica* (Si siat)
80. *Persea gamblei* (Bong deng)
81. *Pinus dalatensis* (Pek 5 bai)
82. *P. kesiya* (Pek 3 bai)
83. *P. merkusii* (Pek 2 bai, Pek yang, Khoua)
84. *Pometia pinnata* (Koh ka, Deng nam)
85. *Pterocarpus indicus* (Dou khang, D. khon)
86. *P. macrocarpus* (Dou, D. luad, Padou pa)
87. *Sandoricum koetjape* (Mak thong)
88. *Scaphium macropodum* (Chong ban)
89. *Schima wallichii* (Mee)
90. *Shorea henryana* (See)

91. *S. obtusa* (Chik)
92. *S. roxburghii* (Khen kha nhom)
93. *S. siamensis* (Hang, Phao)
94. *S. thorelii* (Khen ning)
95. *Sindora siamensis* (Te nam)
96. *Stereospermum fimbriatum* (Khe Foy)
97. *Strychnos nux-vomica* (Toum)
98. *Styrax benzoides* (Chan pa, C. dong, Nyan deng, N. hom)
99. *S. tonkinensis* (Nyan, N. khao)
100. *Syzygium chloranthus* (Wa deng)
101. *S. grata* (Sameth, Samek)
102. *S. tinctorium* (Ha, Wa dong)
103. *Toxicodendron succedanea* (Klet ling, Ket lin)
104. *Tectona grandis* (Sak)
105. *Terminalia alata* (Seuak)
106. *Tetrameles nudiflora* (Phoung, Sa phoung)
107. *Toona ciliata* (Nhom hom)
108. *T. sureni* (Yom hom, Nhom hom)
109. *Vatica harmandii* (See dong, Chik dong)
110. *V. odorata* (Khen se See khen)
111. *Wrightia arborea* (Mouk)
112. *Xylia xylocarpa* (Deng)
113. *Zanthoxylum rhetsa* (Khaen, Khouang)

Backup list of tree species not assessed for conservation status

This list have been obtained from WCMC (UNEP World Conservation Monitoring Centre, Tree Conservation Database, 2001), IUCN (The World Conservation Union, 2001) and LTSP (Lao Tree Seed Project, 2000). The expert group rejected these 24 tree species for the selected list, for various reasons as these did not fulfil the criteria used. Some incorrect names may be listed here and the list needs to be further verified.

1. *Aglaia lawii* (WCMC)
2. *A. odorata* (WCMC, IUCN)
3. *A. simplicifolia* (WCMC, IUCN)
4. *A. spectabilis* (WCMC)
5. *A. tomentosa* (WCMC)
6. *Albizia lebbeck* (LTSP)
7. *A. procera* (LTSP)
8. *Amesiodendron chinense* (WCMC)
9. *Cyclobalanopsis rex* (WCMC, IUCN)
10. *Knema globularia* (WCMC)
11. *K. tenuinervia ssp. setosa* (WCMC)
12. *K. tonkinensis* (WCMC, IUCN)
13. *Lophopetalum wightianum* (WCMC)
14. *Magnolia henryi* (WCMC, IUCN)
15. *Markhamia stipulata* (WCMC)
16. *Millingtonia hortensis* (WCMC)
17. *Paradina hirsuta* (WCMC)
18. *Pauldopia ghorta* (WCMC)
19. *Platanus kerrii* (WCMC, IUCN)
20. *Rhamnoneuron balansae* (WCMC)
21. *Schoutenia hypoleuca* (WCMC)
22. *Tabernaemontana corymbosa* (WCMC)
23. *Taraktogenos annamensis* (WCMC, IUCN)
24. *Wrightia laevis* (WCMC)

Appendix 2

Conservation status scores and ranking of tree species in Lao PDR

No.	Species	Vernacular (Lao) name	Geographical range & rarity	Habitat specificity	Habitat status	Human impact on habitat	Human impact on species	Total	Category (consultancy)
1	*Aquilaria crassna*	Ked sana, Dam, Po huang	4	3	5	5	5	22	A
2	*Cunninghamia lanceolata*	Hing hoame, Mai long len	5	3	5	4	5	22	A
3	*Michelia champaca*	Cham pa pa	5	3	5	4	5	22	A
4	*Anisoptera scaphula*	May Bak Luang	5	3	5	4	4	21	A
5	*Caesalpinia sappan*	Fang deng	4	3	5	4	5	21	A
6	*Cinnamomum obtusifolium*	Khae	4	3	5	4	5	21	A
7	*Erythrophleum fordii*	Lem, Kacha	4	3	5	4	5	21	A
8	*Fokienia hodginsii*	Long leng, Len le, Lang Len	4	3	5	4	5	21	A
9	*Pentace burmanica*	Si siat	4	3	5	4	5	21	A
10	*Persea gamblei*	Bong deng	4	3	5	4	5	21	A
11	*Dalbergia cochinchinensis*	Kha nhoung	4	3	4	4	5	20	B
12	*Dialium indicum*	Kham phep, Kam thep	4	3	5	4	4	20	B
13	*Melientha suavis*	Pak van	4	3	5	4	4	20	B
14	*Paramichelia baillonii*	Cham pa pa, Some suay	4	3	5	4	4	20	B
15	*Dalbergia cultrata*	Ka bo, Kamphee, Nang noune	4	3	5	4	3	19	B
16	*Dipterocarpus costatus*	Nhang deng	4	3	4	4	4	19	B
17	*Fagraea fragrans*	Man pa	4	3	4	4	4	19	B
18	*Hopea chinensis*	Khaen see	5	3	5	3	3	19	B
19	*Pinus dalatensis*	Pek 5 bai	5	5	5	2	2	19	B
20	*Shorea henryana*	Si	5	3	5	3	3	19	B
21	*Sindora siamensis*	Te nam	4	3	4	4	4	19	B
22	*Tectona grandis*	Sak	5	3	5	3	3	19	B
23	*Zanthoxylum rhetsa*	Khaen	2	3	5	4	5	19	B
24	*Dipterocarpus alatus*	Nhang khao, N. na, N. khiauw, N. mwak	2	3	4	4	5	18	B
25	*D. kerrii*	Nhang kha nheng	4	3	5	3	3	18	B
26	*Hopea pierrei*	Khaen hin, La en, Khaen hak yong	4	3	5	3	3	18	B
27	*H. recopei*	See dok deng, Khen fai	4	3	5	3	3	18	B
28	*H. thorelii*	Khaen see	4	3	5	3	3	18	B
29	*Keteleeria evelyniana*	May Hing	4	3	4	3	4	18	B
30	*Mangifera pentandra*	Muang pa	4	3	5	3	3	18	B
31	*Manglietia garrettii*	Luang khom (Mak Tek)	4	3	5	3	3	18	B
32	*Mesua ferrea*	Lek	5	3	4	3	3	18	B
33	*Parashorea stellata*	Hao, Phao	4	3	5	3	3	18	B

No.	Species	Vernacular (Lao) name	Geographical range & rarity	Habitat specificity	Habitat status	Human impact on habitat	Human impact on species	Total	Category (consultancy)
34	*Pinus kesiya*	Pek 3 bai	4	3	5	3	3	18	B
35	*Pinus merkusii*	Pek 2 bai, Khoua	2	3	5	4	4	18	B
36	*Pterocarpus indicus*	Dou khang, Dou khon	4	3	5	3	3	18	B
37	*Scaphium macropodum*	Chong ban	4	5	5	2	2	18	B
38	*Shorea thorelii*	Khing ning	4	3	5	3	3	18	B
39	*Styrax benzoides*	Nhan deng	4	3	5	3	3	18	B
40	*S. tonkinensis*	Nyan khao, Nhan, Sanjaan deng	4	3	5	3	3	18	B
41	*Syzygium chloranthum*	Va deng	4	3	5	3	3	18	B
42	*Afzelia xylocarpa*	May tekha	4	1	4	3	5	17	B
43	*Castanopsis acuminatissima*	Ko deua	4	3	4	3	3	17	B
44	*Dacrycarpus imbricatus*	Mai Hing Khieo	4	3	4	3	3	17	B
45	*Dalbergia lanceolaria*	Khamphee, Nang noune, Pa dong deng	4	3	4	3	3	17	B
46	*D. oliveri*	Kampee	4	3	4	3	3	17	B
47	*Dipterocarpus hasseltii*	Nhang kiang	4	3	4	3	3	17	B
48	*Dysoxylum binectariferum*	Quang deng, Chan luang, Khon ta seau	4	3	4	3	3	17	B
49	*Garcinia fagraeoides*	Lee	4	3	4	3	3	17	B
50	*Millettia leucantha*	Sa thon	4	3	4	3	3	17	B
51	*Mitragyna diversifolia*	Thom dong	4	3	4	3	3	17	B
52	*Pometia pinnata*	Deng nam	4	3	4	3	3	17	B
53	*Strychnos nux-vomica*	Seng bua, Toum	5	3	5	2	2	17	B
54	*Aglaia gigantea*	Nok kok	4	3	5	2	2	16	B
55	*Bischofia javanica*	Khom fad, Fung fad	2	3	4	4	3	16	B
56	*Dipterocarpus intricatus*	Ta baeng, Sa baeng	2	3	3	3	5	16	B
57	*D. obtusifolius*	Sad	2	3	3	3	5	16	B
58	*D. tuberculatus*	Kung	2	3	3	3	5	16	B
59	*Hopea ferrea*	Khen hin	2	3	3	4	4	16	B
60	*Pterocarpus macrocarpus*	Dou	2	1	4	4	5	16	B
61	*Toxicodendron succedaneum*	Ket lin	4	3	5	2	2	16	B
62	*Allospondias lakonensis*	Som ho	4	3	5	2	2	16	B
63	*Castanopsis hystrix*	Ko fan	2	1	4	4	4	15	C
64	*Gmelina arborea*	So	2	3	4	3	3	15	C
65	*Hopea odorata*	Khen hua	2	3	3	3	4	15	C
66	*Lagerstroemia calyculata*	Puay (Dok khao)	2	3	3	3	4	15	C
67	*L. floribunda*	Puay (Dok Si Boua)	2	3	3	3	4	15	C
68	*Litsea glutinosa*	Bong Mi	4	3	4	2	2	15	C
69	*Alstonia rostata*	Teen pet	4	3	5	1	1	14	C
70	*Anisoptera costata*	May bak	2	1	3	3	5	14	C

No.	Species	Vernacular (Lao) name	Geographical range & rarity	Habitat specificity	Habitat status	Human impact on habitat	Human impact on species	Total	Category (consultancy)
71	*Chukrasia tabularis*	Nhom, Nhom hin, Nhom khao	2	1	4	4	3	14	C
72	*Parkia speciosa*	Huoa lone	2	3	3	3	3	14	C
73	*Sandoricum koetjape*	Mak thong	2	3	3	3	3	14	C
74	*Shorea obtusa*	Chik	2	3	3	3	3	14	C
75	*S. roxburghii*	Khen kha nhom	2	3	3	3	3	14	C
76	*S. siamensis*	Hang, Phao	2	3	3	3	3	14	C
77	*Terminalia alata*	Seuak	2	3	3	3	3	14	C
78	*Xylia xylocarpa*	Deng	2	3	2	3	4	14	C
79	*Azadirachta indica*	Ka dau, Khom ka dao	2	1	5	3	2	13	C
80	*Broussonetia papyrifera*	Po sa	2	1	2	4	4	13	C
81	*Dialium cochinchinense*	Kheng	2	3	4	2	2	13	C
82	*Elaeocarpus stipularis*	Moune	2	3	4	2	2	13	C
83	*Irvingia malayana*	Bok	2	1	2	4	4	13	C
84	*Stereospermum fimbriatum*	Khe foy	2	3	4	2	2	13	C
85	*Vatica odorata*	Xi khen, Khen xi, Chik dong, Si peuk bang	4	3	4	1	1	13	C
86	*Haldina cordifolia*	Khao, Thom na	2	3	3	2	2	12	C
87	*Schima wallichii*	Mee	2	1	3	3	3	12	C
88	*Syzygium tinctorium*	Ha, Va dong	2	3	3	2	2	12	C
89	*Diospyros malabarica*	Lang dam	2	1	4	2	2	11	C
90	*Wrightia arborea*	Mouk nhai	2	1	2	3	3	11	C
91	*Cinnamomum iners*	Sa chuang, Si khai ton, Chuong hom	2	1	2	2	3	10	D
92	*Peltophorum dasyrhachis*	Sa phang, Sa kham	1	1	2	3	3	10	D
93	*Alstonia scholaris*	Teen pet	1	1	2	4	1	9	D
94	*Syzygium grata*	Samek	2	1	2	2	2	9	D
95	*Tetrameles nudiflora*	Phuong, Saphuong	2	1	2	2	2	9	D
96	*Aglaia grandis*	Mak Kong	2	1	3	1	1	8	D
97	*Melia azedarach*	Hien, Kadauxang	1	1	1	2	2	7	D
98	*Alstonia spathulata*	Teen pet	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
99	*Cephalotaxus mannii*	Kam pom deng	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
100	*Dalbergia hupeana*	Ka nhung	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
101	*Diospyros ferrea*	Makluay	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
102	*D. mollis*	Makluay	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
103	*D. mun*	Makluay	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
104	*Dipterocarpus retusus*	Nhang dong	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
105	*D. turbinatus*	Nhang deng	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
106	*Dysoxylum loureirii*	Khon ta sang	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
107	*Eriobotrya serrata*	Khon dok	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E

No.	Species	Vernacular (Lao) name	Geographical range & rarity	Habitat specificity	Habitat status	Human impact on habitat	Human impact on species	Total	Category (consultancy)
108	*Mansonia gagei*	Chan home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
109	*Michelia masticata*	Ham, Hum	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
110	*M. mediocris*	Cham pa pa	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
111	*Toona ciliata*	Nhom home	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
112	*T. febrifuga*	Yom Hom	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
113	*Vatica cinerea*	Xi dong	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.	E
	TOTAL		9	2	39	1	18		

n.a. = data not available

NOTES:

Criteria/Score	5	4	3	2	1
Geographical range and rarity	Very rare, found in 1 zone	Rare, found in more than 1 zone	Common, found in 1 zone	Common, found in more than 1 zone	Very common
Habitat specificity	Highly specific		Restricted		Broad
Habitat status (% under protection)	<5 11–15	6–10 16–20	>20		
Human impact on the habitat	Conversion	Heavy	Regular	Periodical	Little or no impact
Human impact on the species	Always	Almost always	Regular	Periodical	Little or no impact

Category	Description	Score	No. of species	Recommendations
A	Endangered	21–25	10	*Ex-situ* conservation, survey, update the DOF list = no cutting, participatory conservation
B	Vulnerable	16–20	52	Update the DOF list, survey, *ex situ* and participatory conservation
C	Lower risk, conservation dependent/ nearly threatened	11–15	28	Monitor, survey
D	Lower risk, least concern	5–10	7	Monitor
E	Lacking information	16	7	

Appendix 3

Benefits and constraints of agroforestry systems in shifting cultivation areas of Lao PDR (Humchitsavath and Hansen 1996)

Agroforestry system	Description	Benefits	Constraints	Example from Lao PDR
Traditional systems				
Shifting cultivation	Alternating periods of tree growth and agricultural crops.	Restoration of soil fertility. Suppression of weeds and crop pests.	Requires long fallow periods. Low productivity with short fallows. Government condemnation.	Most widespread cropping system in Lao PDR
Economically improved fallows	The economic benefit of the fallow is improved through manipulation of the fallow vegetation.	Increased income or output from the fallow.	Increased labour needs. May require long fallow periods.	Production of paper mulberry bark, cardamom, and benzoin.
Living fences	Hedges of woody species planted around agriculture fields.	Mainly to fence off agriculture fields, but also for leaf fodder, mulch, firewood and wind reduction.	Efficient only after several years. May complete with crops.	Widely used around permanent fields and gardens.
Plantations of orchards	Various other combinations of tree and crops, such as multi-storey gardens, home gardens, and estate plantations.	High productivity per area unit. Good use of the available resources.	Herbaceous component suppressed in older plantations. Rational management may be difficult.	Homegardens and multi-storey gardens common in older villages all over Lao PDR
Taungya	Cultivation of agricultural crops during the early stages of tree establishment.	Economic return from the plantation during the early years. Ensures weeding during the cropping periods. Cheap establishment.	Agriculture land is lost. Land-use rights may be transferred to investors Farmers may become labourers.	Common along river banks in the North. In recent years also in upland areas. Traditional planting method of forest authorities.
Modern systems				
Biologically improved fallows	The biophysical effects of natural fallows are improved through enrichment planting or other manipulation.	Increased restoration of soil fertility. Increased suppression of weeds and pests.	The improved fallow may become a serious weed during the cultivation periods.	Experimental stage at the moment. No extension recommendations.
Alley cropping	Belts of woody species alternate with belts of agriculture crops.	Nutrient recycling and nitrogen fixing. May also produce leaf fodder, firewood and mulching material.	Occupies agriculture land. Woody component may compete with agriculture crops. Requires additional labour.	Introduced by various projects, but little or no adoption by farmers.
Contour hedgerows	Woody species planted in hedges along the contours alternating with belts of crops.	Mainly for erosion control; may have benefits similar to alley cropping.	Occupies agriculture land. Woody component may compete with agriculture crops.	Requires additional labour. Introduced by various projects, but little or no adoption by farmers.

Appendix 4

Summary of domestication activities of forest tree species in Lao PDR (compiled by C. Phongoudome, July 2003)

No.	Species	Vernacular name	Family	Purpose of domestication
1	*Adenanthera microsperma*	Mak lam noy	Papionoideae	Reh, Dem
2	*Afzelia xylocarpa*	Te kha	Caesalpinioideae	Exc, Dem, Pt
3	*Ailanthus malabarica*	Nhom pha	Simarubaceae	Dem
4	*Albizia lebbeck*	Thon	Mimosoideae	Dem, Exc
5	*A. procera*	Sa thon	Mimosoideae	Dem, Exc
6	*Alstonia rostata*	Teen pet noy	Apocynaceae	Exc, Dem
7	*A. scholaris*	Teen pet	Apocynaceae	Reh, Lans, Dem, Pt
8	*Anacardium occidentale*	Mouang him ma phan	Anacardiaceae	Ex, Hg, Ftf
9	*Anisoptera costata*	Bak	Dipterocarpaceae	Dem, Exc
10	*Anthocephalus chinensis*	Kan luang	Rubiaceae	Dem, Agr
11	*Aquilaria crassna*	Ket sa na	Thymelaeaceae	Exc, Agr, NTFP
12	*Artocarpus* spp.	Mi ban	Moraceae	Hg, Agr
13	*Asoka longifolia*	A sok	Anonaceae	Lans, Ex
14	*Averrhoa carambola*	Fuang	Rosaceae	Hg, Lans
15	*Azadirachta indica*	Khom ka dao	Meliaceae	Exc, Dem, Prot
16	*Bauhinia variegata*	Dok ban	Caesalpinioideae	Reh, Dem
17	*Bischofia javanica*	Fung fad	Euphorbiaceae	Exc, Reh, Dem
18	*Bombax ceiba*	Ngiou	Malvaceae	Hg, Pt
19	*Bouea burmanica*	Fang	Anacardiaceae	Hg, Ftf
20	*Broussonetia papyrifera*	Po sa	Moraceae	Agr, Hg
21	*Caesalpinia sappan*	Fang deng	Caesalpiniaceae	Exc, Hg
22	*Carpinus poilanei*	Kiou	Betulaceae	Reh
23	*Cassia fistula*	Khoun	Caesalpinioideae	Lans
24	*C. javanica*	Ka la pheuk	Leguminoseae	Lans, Agr
25	*C. siamea*	Khi lek	Caesalpiniaceae	Hg, Pt, Agr, Reh
26	*Castanopsis hystrix*	Ko deng	Fagaceae	Reh
27	*C.* spp.	Ko	Fagaceae	Reh
28	*C. tribuloides*	Ko keut	Fagaceae	Reh
29	*Casuarina equisetifolia*	Son tha le	Casuarinaceae	Lans, Ex
30	*Chrysophyllum cainito*	Nam nom	Spotaceae	Hg, Lans
31	*Chukrasia tabularis*	Nhom hin	Meliaceae	Prot
32	*Cinnamomum cassia*	Khe hom	Lauraceae	Exc, Hg
33	*Citrus aurantium*	Kieng	Rutaceae	Hg, Ftf
34	*C. bergamia*	Veu	Rutaceae	Hg, Ftf
35	*C. digitata*	Mu	Rutaceae	Hg, Agr
36	*C. grandis*	Som o	Rutaceae	Hg, Ftf, Agr
37	*C. hystrix*	Khi hoot	Rutaceae	Hg, Ftf, Agr
38	*C. medica*	Nao	Rutaceae	Hg, Agr
39	*C. nobilis*	Liou	Rutaceae	Hg, Agr
40	*Coffea* spp.	Ka fe	Rubiaceae	Hg, Agr, Ftf
41	*Dalbergia cochinchinensis*	Kha nhoung	Papilinoideae	Exc, Dem
42	*Dipterocarpus alatus*	Nhang khao	Dipterocarpaceae	Ex, Dem
43	*Dorenix regia/ Poinciana regia*	Hang nhoung	Caesalpinioideae	Lans
44	*Eucalyptus* spp.	Vic	Myrtaceae	Ex
45	*Eugenia* spp.	Chieng	Myrtaceae	Hg
46	*Euphoria longana*	Lam yai	Sapindaceae	Hg, Ftf
47	*Fagraea fragrans*	Man pa	Loganiaceae	Exc, Dem
48	*Gliricidia sepium*	Khe frang	Leguminoseae	Lans, Agr
49	*Gmelina arborea*	So	Verbenaceae	Exc, Dem
50	*Hopea odorata*	Khen heua	Dipterocarpaceae	Exc, Dem, Reh, Pt
51	*Keteleeria davidiana*	Hing	Pinaceae	Reh
52	*Lagerstroemia calyculata*	Peuay khao	Myrtaceae	Dem

No.	Species	Vernacular name	Family	Purpose of domestication
53	*Leucaena leucocephala*	Ka thin phan	Mimosoideae	Agr, Hg, Reh, Ex ?
54	*Litchi* spp.	Lin chi	Sapindaceae	Hg
55	*Mangifera indica*	Mouang	Anacardiaceae	Hg, Ftf
56	*Melia azedarach*	Ka dao sang	Meliaceae	Agr, Hg, Pt
57	*Moringa pterygosperma*	Phak I houm	Moringaceae	Hg
58	*Nyssa javanica*	Mak theun	Cornaceae	Heh, Dem
59	*Ormosia semicatrata*	Mak lam nhai	Papionoideae	Reh
60	*Oroxylum indicum*	Lin mai	Bignoniaceae	Hg
61	*Paramichelia bailonii*	Som souay, Cham pa pa, Ham, Xay	Magnoniaceae	Heh, Dem, Ex
62	*Peltophorum dasyrhachis*	Sa fang, Sa kham	Caesalpinioideae	Reh, Dem, Pt
63	*Pentace burmanica*	Si siet	Tiliaceae	Ex, Hg, Pt
64	*Persea gamblei*	Bong	Lauraceae	NTFP, Hg, Pt, Dem
65	*Pinus kesiya*	Pek sam bai	Pinacaee	Exc, Dem, Reh
66	*P. merkusii*	Pek song bai	Pinaceae	Exc, Dem, Reh
67	*Pyrus laosensis*	Leung	Rosaceae	Hg, Lans, Ftf
68	*P. pashia*	Chong	Rosaceae	Hg, Ftf
69	*Prunus armeniaca*	Foung khai	Rosaceae	Hg, Ftf
70	*P.puddum*	Man theun	Rosaceae	Hg
71	*P. persica*	Khai	Rosaceae	Hg, Ftf
72	*P. salicina*	Man	Rosaceae	Hg, Ftf
73	*Psidium guajava*	Si da	Myrtaceae	Hg, Agr
74	*Pterocarpus indicus*	Cham pa pa, Dou King on	Papilinoides	Dem, Pt
75	*P. macrocarpus*	Dou	Papilinoideae	Exc, Dem, Pt, Reh
76	*Punica granatum*	Phi la	Punicaceae	Hg, Agr
77	*Quercus griffithii*	Ko sa	Fagaceae	Reh
78	*Q. serrata*	Ko sa	Fagaceae	Reh
79	*Q. serrata*	Ko khe	Fagaceae	Reh
80	*Samanea saman*	Sam sa	Caesalpinioideaea	Lans
81	*Sandoricum koetjape*	Tong	Meliaceae	Hg, Ftf
82	*Scaphium macropodum*	Mak chong ban	Sterculiaceae	Dem, Hg
83	*Schima wallichii*	Mi	Theaceae	Reh, Dem
84	*Sesbania grandiflora*	Khe khao	Fabaceae	Hg
85	*Sindora cochinchinensis*	Te ho	Caesalpinioideae	Exc, Dem
86	*Spondias axillaris*	Mak meu	Anacardiaceae	Dem
87	*Strychnos nux-vomica*	Toum ka	Loganiaceae	Hg
88	*Styrax tonkinensis*	Nhan	Styracaceae	Exc, Dem, Pt, Reh
89	*Swietenia macrophylla*	Ham ngoua yai	Meliaceae	Ex, Lans
90	*Syzygium grata*	Chieng	Myrtaceae	Hg
91	*Ziziphus jujuba*	Ka than	Ramnaceae	Hg, Lans
92	*Tamarindus indica*	Kham	Caesalpinioideae	Hg, Ftf
93	*Tarrietia javanica*	Hao	Sterculiaceae	Dem
94	*Tectona grandis*	Sak	Verbenaceae	Exc, Dem, Pt, Hg Agr, Tip
95	*Terminalia catappa*	Hou kuang	Combretaceae	Lans, Ex ?
96	*Tetrameles nudiflora*	Phoung	Datiscaceae	Exc, Dem, Pt
97	*Toona ciliata*	Nhom hom	Meliaceae	Exc, Dem, Prot
98	*Toxicodendron succedaneum*	Ket lin	Anacardiaceae	Exc, Dem
99	*Vatica cinerea*	Si	Dipterocarpaceae	Dem, Pt
100	*Wrightia arborea*	Mouk	Apocynaceae	Dem, Pt
101	*Xylia xylocarpa*	Deng	Mimosaceae	Exc, Dem
102	*Zanthoxylum rhetsa*	Khen	Rutaceae	Hg, Reh, Inc
103	*Z. alatum*	Mat	Rutaceae	Hg

Agr = Agroforestry, Dem = Demonstration, Ex = Exotic, Exc = *Ex situ* conservation, Ftf = Fruit tree farm, Hg = Home garden, Inc = *In situ* conservation, Lans = Landscape, NTFP = Non-timber forest product, Prot = Provenance trial, Pt = Plantation, Reh = Rehabilitation, Tip = Tree improvement

Appendix 5

Summary of registered seed sources in Lao PDR as in July 2003

No	Province	District	Village	Species	Area (ha)	Number of trees	Estimate of seed	Period of seed collection	Remark
1	Xayabouly	Paklai	Nasak	*Tectona grandis*	2750	90	900	Dec–March	Natural forest (conservation)
2	Xayabouly	Paklai	Nakha yang	*Afzelia xylocarpa*	222	37	2.22	Dec–March	Natural forest (conservation)
3	Xayabouly	Paklai	Nakhayang	*Vatica cinerea*		21	210	April–May	Natural forest (conservation)
4	Xayabouly	Phieng	Phonsak	*Dipterocarpus alatus*	25	17	234	April–May	Natural forest (conservation)
5	Vientiane Pro.	Thulakhom	Vangheua	*Pinus merkusii*	135	134		Nov–Dec	PKK National Park
6	Vientiane Pro.	Keooudome	Mai Nangeng	*Dipterocarpus alatus*	500	22			PKK National Park
7	Vientiane Pro.	Keooudome	Mai Nangeng	*Hopea ferrea*		39			PKK National Park
8	Vientiane Pro.	Keooudome	Mai Nangeng	*Pterocarpus macrocarpus*	50	15			Village Protected Forest
9	Vientiane Mun.	Naxay thong	Syvilai	*Pterocarpus macrocarpus*		35	399	Dec–March	Livestock Research Centre & Farm Land
10	Vientiane Mun.	Xaithany	Nonsaat	*Afzelia xylocarpa*		28			Huay yang Conservation Area
11	Vientiane Mun.	Xaithany	Dongsanghin	*Dipterocarpus alatus*	300	39			Conservation & Rice field
12	Bolikhamsai	Khamkeut	Poung	*Aquilaria crassna* (Big)		107		April–August	Natural forest (conservation)
13	Bolikhamsai	Khamkeut	Poung	*Aquilaria crassna* (Small)		11			
14	Bolikhamsai	Khamkeut	Thongchaleun	*Dalbergia cochinchinensis*		46		Sep–Nov	Natural forest (conservation)
15	Bolikhamsai	Khamkeut	Namphao	*Dalbergia cochinchinensis*		52		Sep–Nov	Natural forest (conservation)
16	Khammuan	Yommalat	Huatat	*Hopea odorata*		30	105	March–April	Natural forest (conservation)
17	Khammuan	Mahasay	Phonsavan	*Dipterocarpus alatus*	322	41	564	April–May	Natural forest (conservation)
18	Savanna khet	Khantha bouly	That, Phon sim	*Anisoptera costata*	50	34	510	March–April	Natural forest (conservation)
19	Savanna khet	Khantha bouly	That, Phon sim	*Hopea odorata*		19	429	March–April	Natural forest (conservation)
20	Savanna khet	Khantha bouly	That, Phon sim	*Dalbergia cochinchinensis*		10	60	Sep–Nov	Natural forest (conservation)
21	Savanna khet	Khantha bouly	That, Phon sim	*Dipterocarpus alatus*		31	426	April–May	Natural forest (conservation)
22	Savanna khet	Phin	Alao dong	*Dipterocarpus alatus*	1111	50	688	April–May	Natural forest (conservation)
23	Savanna khet	Phin	Alao dong	*Xylia xylocarpa*		28	42	Feb–April	Natural forest (conservation)
24	Savanna khet	Khantha bouly	Nachilith	*Eucalyptus camaldulensis*	5	501		May–Aug	Plantation 1996
25	Champasak	Sanasomboun	Nadan	*Azadirachta indica*	50	52	910	March–May	Farmer land
26	Champasak	Khong	Hua moung	*Dalbergia cultata*	60	24	336	Sep–Nov	Natural forest (conservation)
27	Champasak	Khong	Don khong	*Pterocarpus macrocarpus*	60	27	308	Dec–March	Natural forest (conservation)
28	Champasak	Khong	Veun kham	*Pterocarpus macrocarpus*	250	50	570	Dec–March	Natural forest (conservation)
29	Champasak	Pathum phon	Kiet Ngong	*Dipterocarpus alatus*	60	38	523	April–May	Natural forest (conservation)
30	Champasak	Pathum phon	Kiet Ngong	*Hopea odorata*		15			
TOTAL					**5950**	**1643**	**7216**		

Status of forest genetic resources conservation and management in Malaysia

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Introduction

Malaysia is located between latitudes 1°N to 7°N and longitudes 100°E to 119°E and comprises of two distinct regions separated by about 650 km of the South China Sea. The regions are Peninsular Malaysia and East Malaysia consisting of Sarawak and Sabah. Peninsular Malaysia comprises 11 states and two Federal Territories (Kuala Lumpur and Putrajaya), occupying 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, Sarawak and Federal Territory of Labuan occupy the northern third of the island of Borneo. The country occupies about 329 750 km^2 of land area, of which 40% is the Peninsula and 60% Sabah and Sarawak.

Malaysia has a hot and humid tropical climate marked by seasonal variations in rainfall. The annual rainfall in Peninsular Malaysia is approximately 2540 mm, with most precipitation occurring during the southwest monsoon (September to December) as opposed to East Malaysia, which receives most of its rainfall during the northeast monsoon (October to February). Sabah's average annual rainfall is 2630 mm and Sarawak's is approximately 3850 mm. Mean annual temperature is 27°C with a diurnal range of 9°C. Relative humidity is high (85 – 95%), particularly in the coastal areas (Anon 1997).

Having evolved over millions of years, Malaysia's rich and diverse tropical rainforests have been recognised internationally as a depository of megadiversity of both flora and fauna and act as a large storehouse of untapped genetic resources. At present, it is estimated that the forests of Malaysia contain some 14 500 species of flowering plants, 1000 species of vertebrates, more than 6000 species of butterflies and moths, an estimated 20 to 80 thousand of invertebrates and an unaccounted number of species of insects and other life forms (Anon 2001). 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 strongly suggest that many species of Malaysian flora first appeared as long ago as 60-70 million years (Soepadmo 1998a). The incredible biodiversity found in the tropical forest of Malaysia is due to 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.

This paper examines the current status of forest genetic resources (FGR) conservation and management in Malaysia, providing an update to the country report prepared in 2001 (Lee *et al*. 2002a), which was presented during the Southeast Asian Moving Workshop on Conservation, Management and Utilisation of FGR in Thailand.

Forest cover

Data on the forest cover in Malaysia differ according to different sources. However, according to the Ministry of Primary Industries, the total forested area in Malaysia in 2001 amounted 20.2 million hectares or 62% of the country's land area (Anon 2002a). The detail of the distribution and extent of natural forest by major forest types in 2001 is given in Table 1 and Appendixes 3-5. However, if one considers also the 4.8 million 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 million hectares (Anon 2002a), amounting to about 76% of the total land area. Of the total forested area in 2001, 14.45 million ha or about 44% of the total land area has been designed as Permanent Forest Estate (PFE) to be managed sustainably for the benefit of present and future generations. Of the total PFE, approximately 3.81 million ha are classified as Protection Forest with the remaining 10.64 million ha being classified as Production Forest.

The function of the Protection Forest is to ensure climatic stability, the 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 (Anon 2001).

Table 1. Distribution and extent of natural forest by major forest types in Malaysia, 2001 in million hectares (Anon 2001; Anon 2002a)

Region	Total land area	Inland (Dipterocarp) forests	Swamp forests	Mangrove forests	Plantation forests	Total forested land	% of total forested land
Peninsular Malaysia	13.15	5.46	0.30	0.11	0.07	5.94	45.2%
Sabah	7.37	3.81	0.12	0.34	0.15	4.42	60.0%
Sarawak Malaysia	12.30	8.64	1.04	0.13	0.03	9.84	80.0%
TOTAL	**32.82**	**17.91**	**1.46**	**0.58**	**0.25**	**20.20**	**62.0 %**

Forest types

Much of the Malaysian FGR 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 FGR 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 have been 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 categorised into 16 habitat and vegetation types (Table 2). Lowland, hill and upper hill dipterocarp forests occur from sea level to about 1200 m and 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 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, in the case of limestone and quartzite vegetation, to periodic drought and, for ultramafic conditions, to tolerance of heavy metal toxicity. Because of their high species endemism, the floras of limestone, quartzite and ultramafic soils are of great conservation importance.

Freshwater and peat swamp forests that 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 the hydrological and carbon cycles.

Sandwiched between land and 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 that means 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 habitats 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 the forested land in Malaysia (Anon 1998a)

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	Peat swamp forest
Subalpine vegetation	Mangrove forest
Alpine vegetation	Heath/kerangas forest
	Sandy beach vegetation
	Rocky shore vegetation

Utilization of forest resources

Forests in Malaysia have multiple functions. The forests are generally associated with timber harvesting, non-wood resources (rattans, bamboo, fruits, vegetables, spices medicinal plants and ornamentals), habitats for wildlife, water production, as well as services, such as recreation and aesthetics. As a national renewable resource, forests have contributed significantly towards the socioeconomic development of the country. In 2001, the total forest revenue collected by the various State Forestry Departments in Peninsular Malaysia amounted to RM265 million (about US$ 69.73 million), while the total roundlog production was 4.15 million m^3 (Anon 2002b). The export value of major timber products, i.e. logs, sawntimber, plywood, veneer, and moulding for that year totalled RM8.36 billion (US$ 2.28 billion) (Anon 2002a).

During the same year, the forestry sector provided employment for 196 612 people in the forestry services and agencies (public sector), which are responsible for forestry administration and for management and development of the forest resources, while another 185 891 people were employed in the private forest industries (Anon 2002a). Employment opportunities in the sector are expected to increase substantially in view of the priority accorded to the expansion of the forest resources base through intensive forest management and development and the establishment of fast-growing tree plantations, as well as the modernization of forest industries to produce higher value-added products. Forestry sector is anticipated to continue to generate substantial revenues to support the development and administration for both Federal and State Governments. Forests will also continue to play an important role in the maintenance of climatic and environmental stability, conservation of invaluable biodiversity and supply of clean water resources.

Constitution, policies and legal provisions related to forestry

Malaysia has a federal system of government. Under 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 Permanent Forest Estate (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), chaired by the Deputy Prime Minister was accepted in 1971 and endorsed on 19 April 1978 by the National Land Council to serve as a forum for federal and state governments to discuss forestry issues, such as planning, management and development of forest resources, and plays a major role in encouraging the adoption of federal acts at state level. Members of the NFC include Chief Ministers from all the states, 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 provide the basis for systematic management, development and conservation of the forest resources as the latter stipulates the preparation of forest management plans and the classification of forest for various functional classes.

The revised National Forestry Policy in 1992 and the amended National Forestry Act in 1993 manifest a vital change in the philosophy of forest management, away 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 (provides guidelines for the maintenance of riparian strips of river reserves), Land Conservation Act 1960, National Land Code 1965, Protection of Wildlife Act 1972 (provides the legal framework for the protection of threatened and endangered species), Environmental Quality Act 1974 (amended 1985; prescribes Environmental Impact Assessment for activities involving forest land), and National Parks Act 1980 (provides the legal framework for the conservation of national/state parks).

Apart from the National Forestry Policy, however, various state governments have their own forest policies. In the case of Sarawak, a forest policy adopted in 1954 provides the framework for forest management. In addition, Sarawak has also amended its forest laws and enacted new laws to strengthen its role and responsibilities in facing the challenges in implementing 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 Biodiversity Centre Ordinance 1997; Forests (Planted Forests) Rules 1997; National Parks and Nature Reserves Ordinance 1998; Wildlife Protection Ordinance 1998 and Wildlife Protection Rules 1998 (Anon 2001).

Similarly, Sabah has formulated it own Forest Policy in 1948 and implemented 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 Park Enactment 1984; Culture Heritage (Conservation) Enactment 1997; Wildlife Conservation Enactment 1997; State Water Resources Enactment 1998; Environment and Conservation Enactment 1999; and Sabah Biodiversity Enactment 2000 (Anon 2001).

In 1998, the National Biodiversity Policy was formulated with the aim of enhancing the conservation of the country's plant and animal life and creating a safe, healthy and productive environment (Anon 1998b). It is the first policy that has documented multi-sectoral involvement, including the Ministry of Primary Industries, the Ministry of Agriculture, 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 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.

Characterization of forest genetic resources

The characterization 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 gives 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.

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 (Anon 1997). 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 which 746 are endemic and 511 endangered because they are rare, hyper-endemic or their habitats are threatened (Ng 1991).

The Tree Flora of Sabah and Sarawak (Soepadmo and Wong 1995; Soepadmo *et al*. 1996, 2002; Soepadmo and Saw 2000) documented the tree species of Sabah and Sarawak. Other plant species in Peninsular Malaysia that have been documented 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). In addition, over 1300 plant species and 76 species of ferns have been documented to have potential pharmaceutical properties and traditionally, some of these are being used as herbal medicine (Burkill 1966).

Endemic plants are those that are confined in their occurrence to a specific area or habitat. Various estimates of endemism have been made for flowering plants and 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, in Peninsular Malaysia, it is 97% for begonia species (Bignoniaceae) and 100% for *Didissandra* species (Gesneriaceae) (Kiew 1998a).

Genetically sound conservation requires a robust understanding of the processes by which species organize genetic variation in local populations and the patterns of this variation among populations. Genetic information on most Malaysian plant species is lacking and currently, this information is available for the following species: *Hopea odorata* (Wickneswari *et al*. 1994), *Dyera costulata* (Norwati 1994), *Shorea leprosula* (Lee *et al*. 2000a, 2000b; Nagamitsu *et al*. 2001), *Dryobalanops aromatica* (Lee 2000; Lee *et al*. 2000c; Lim *et al*. 2002), *Aquilaria malaccensis* (Norwati 2000), *Neobalanocarpus heimii* (Konuma *et al*. 2000), *Intsia palembanica* (Lee *et al*. 2002b), *Shorea macrophylla* (Ng *et al*. 2002), *S. curtisii* (Obayashi *et al*. 2002); *S. parvifolia* (Salwana *et al*. unpublished data), *S. lumutensis* (Lee *et al*. unpublished data), *S. ovalis* (Ng *et al*. unpublished data) and *Koompassia malaccensis* (Lee *et al*. unpublished data).

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) PFE (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.

Under the National Forestry Policy 1978 (revised 1992), the PFE needs 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 PFE is 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: Malayan Uniform System (MUS) based on 55-year cutting cycle) and the Selective Management System (SMS) based on 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), while the SMS entails the selection of optimum management (felling) regimes based on pre-felling forest inventory data (Thang 1987, 1988).

Under MUS, all the large timber trees are harvested in one operation in an area being logged. Following this, all remaining large trees left behind due to defects of 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 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 discriminating use of the poison-girdling technique and a more conservative approach in silvicultural treatments and thus conserving forest genetic resources (Hashim 1997).

After the modification, this system has been applied successfully to the lowland dipterocarp forests. However, it has been found to be unsuitable in the hill dipterocarp forests, due to 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, based on selective removal of the mature crop in a single operation. This approach allows more flexible timber harvesting regimes; emphasis is on the advanced growth of trees having diameter of 15-45 cm as the next crop. It discourages poison girdling of the presently non-commercial timber species, thus conserving the forest genetic resources available in the forest. Selective felling is carried out; the cutting limit for dipterocarp species should not be less than 50 cm dbh, and for non-dipterocarp species it should not be less than 45 cm dbh. However, the cutting limit prescribed for *Neobelanocarpus heimii* (Dipterocarpaceae) should be above 60 cm dbh. The difference in the cutting limits prescribed between the dipterocarp species and non-dipterocarp species should be at least 5 cm in order to conserve a higher percentage of dipterocarp species in the next crop (Thang 1988).

Opposing views are held on the suitability of SMS for managing dipterocarp forests. While Cheah (1978), Thang (1987) and FAO (1989) viewed 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 unfit 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 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 being 60 cm dbh, and 45 cm dbh and above, 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 between 20 to 30 years. In Peninsular Malaysia, mature trees are clear-felled with the retention of seven mother trees per hectare and a three meter wide rive bank and coastal strip for enduring adequate natural regeneration and in the protection of the environment (Thang 1997b).

Several regulations and guidelines with special emphasis on environmental measures include 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.

The Continuous Forest Resources Monitoring System has also been developed for Peninsular Malaysia and has been operational since 1993 for the continuous monitoring of the forest resources using 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 in managing the state's forest resources more effectively (for details, connect to the Sarawak Forest Department web site at http://www. forestry.sarawak.gov.my).

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 (for details, connect to the Sabah Forest Department web site at http://www.sabah.gov.my/htan). 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 International Tropical Timber Organization (ITTO) development programmes. Experiences in felling blocks with Path Logging from 1997 indicate considerable reduction in damages as compared with conventional working practices (for details, connect to the Sarawak Forest Department web site at http://www.forestry.sarawak.gov.my). As for the harvesting of hill forests in the remote and difficult terrain regions of Sarawak, the Forest Department is encouraging the timber operators to adopt helicopter harvesting.

Management and conservation of forest genetic resources

In situ conservation

Malaysia has adopted several measures to protect and conserve biological diversity of forests. These include the creation of a network of totally protected areas including national parks and state parks, wildlife and bird sanctuaries and the PFEs. Currently, Malaysia has 2.15 million ha of protected areas, which have been gazetted or proposed as national parks and wildlife and bird sanctuaries (Table 3). Of this, 0.32 million ha are located within the PFE (Anon 2001). With the 3.81 million ha of protected forests of the PFE, which also serve similar functions, the total area designated for protection amounts to 5.96 million ha or 29.5% of the country's total forested land (Anon 2001).

Table 3. Area (million ha) of national parks, wildlife and bird sanctuaries in Malaysia (Anon 2001)

Region	National parks	Wildlife and bird sanctuaries	TOTAL
Peninsular Malaysia[a]	0.43	0.31	0.74
Sabah	0.25	0.16	0.41
Sarawak	0.70[b]	0.30[c]	1.00
Malaysia TOTAL	**1.38**	**0.77[d]**	**2.15**

[a] Estimate;

[b] Includes 0.57 million ha of proposed national parks;

[c] Includes 0.14 million ha of proposed wildlife sanctuaries;

[d] A total of 0.19 million ha and 0.13 million ha is located in the PFEs of Peninsular Malaysia and Sabah, respectively.

Peninsular Malaysia has a total of 40 TPAs in all eleven states with a total area of 751 413 ha (for details, connect to the Department of Wildlife and National Parks web site at http://www.wildlife.gov.my/protected.htm). Taman Negara National Park is the largest of all TPAs in Peninsular Malaysia with 434 351 ha, located in three states Pahang, Kelantan and Terengganu (Table 4). It was gazetted separately by each state under the states' enactment between 1938–1939. It represents the flora of central Peninsular Malaysia together with the Krau, Sungkai and Sungai Dusun Wildlife Reserves. Endau-Rompin (Johor) National Park and Endau-Rompin (Pahang) Wildlife Reserves represent the southern flora while the Perlis and 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 (for details, see http://www.forestry.sarawak.gov.my). In Sabah, the protected area network consists of six natural parks, two wildlife reserves and two conservation areas.

In its efforts to conserve various forest and ecological types in their original conditions, Malaysia has set aside pockets of virgin forest throughout the country. These pockets, known as Virgin Jungle Reserves (VJRs), were established to serve as permanent nature reserves and natural arboreta, as control plots for comparing with harvested and silviculturally treated forests and as undisturbed natural forests for ecological and botanical studies. Currently, a total of 120 VJRs covering an area of 111 800 ha have been established (Anon 2001). These VJRs represent samples of the many types of virgin forest found in the country, which are located in the PFE. Represented forest types include mangrove forest, heath forest, peat swamp forest, lowland dipterocarp forest, hill dipterocarp forest, upper hill dipterocarp forest and subalpine vegetation.

Malaysia has also established two Genetic Resources Areas (GRAs), one in the Ulu Sedili Forest Reserve in Johor, covering 4806 ha and the other one in 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.

Table 4. Some of the totally protected areas in Malaysia

Totally protected area	Size (ha)	Year established	State
Taman Negara National Park	434 351	1939	Kelantan, Pahang, Terengganu
Endau-Rompin (Johor) National Park	48 905	–	Johor
Perlis State Park	5075	1996	Perlis
Pantai Acheh National Park	2562	2003	Penang
Belum State Park (Proposed)	–	–	Perak
Endau-Rompin (Pahang) Wildlife Reserve	40 197	–	Pahang
Krau Wildlife Reserve	62 395	–	Pahang
Sungai Dusun Wildlife Reserve	4330	1964	Selangor
Sungkai Wildlife Reserve	2468	1928	Perak
Tioman Island Wildlife Reserve	9455	1984	Pahang
Bako National Park	2727	1957	Sarawak
Gunung Mulu National Park	52 865	1974	Sarawak
Niah National Park	3138	1975	Sarawak
Lambir National Park	6949	1975	Sarawak
Similajau National Park	7064	1978	Sarawak
Gunung Gading National Park	4104	1983	Sarawak
Kubah National Park	2230	1989	Sarawak
Batang Ai National Park	24 040	1991	Sarawak
Loagan Bunut National Park	10 736	1991	Sarawak
Tanjung Datu National Park	1379	1994	Sarawak
Talang-Satang National Park	19 414	1999	Sarawak
Bukit Tiban National Park	8000	2000	Sarawak
Maludam National Park	43 147	2000	Sarawak
Rajang Mangroves National Park	9374	2000	Sarawak
Gunung Buda National Park	6235	2001	Sarawak
Semengoh Wildlife Rehabilitation Centre	–	1975	Sarawak
Matang Wildlife Centre	179	–	Sarawak
Lanjak-Entimau Wildlife Sanctuaries	168 758	1983	Sarawak
Pulau Tukong Ara-Banun Wildlife Sanctuaries	1.4	1985	Sarawak
Samunsam Wildlife Sanctuaries	6090	1979	Sarawak
Wind Cave Nature Reserve	–	–	Sarawak
Sama Jaya Nature Reserve	18	–	Sarawak
Semenggoh Nature Reserve	653	2000	Sarawak
Bukit Sembiling Nature Reserve	–	–	Sarawak
Bukit Hitam Nature Reserve	–	–	Sarawak
Crocker Range Park	139 919	1984	Sabah
Kinabalu Park	73 370	1964	Sabah
Pulau Tiga Park	607	1978	Sabah
Tawau Hills Park	27 972	1979	Sabah
Tunku Abdul Rahman Park	1289	1974	Sabah
Turtle Island Park	15	1977	Sabah
Kulamba Wildlife Reserve	20 682	–	Sabah
Tabin Wildlife Reserve	120 521	–	Sabah
Maliau Basin Conservation Area	58 840	1984	Sabah
Danum Valley Conservation Area	43 800	1980	Sabah

Ex situ conservation

Ex situ conservation means maintaining 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 some examples in various states are given in Table 5. Collections are conserved mainly in arboreta of research institutions, universities and government agencies. The universities include Universiti Malaya, Universiti Putra Malaysia and Universiti Kebangsaan Malaysia, 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, the Malaysia Rubber Board and the Malaysian Agricultural Research and Development Institute 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 (Table 6).

Table 5. Examples of *ex situ* conservation areas in various states in Malaysia (Anon 1998a)

State	Ex situ conservation area
Johor	Research Station, Palm Oil Research Institute Malaysia, Kluang
Melacca	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
	Ethnobotany 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, Universiti Malaya, Kuala Lumpur
	Fern Garden, Universiti Kebangsaan Malaysia, Bangi
	Taman Pantun, Universiti Kebangsaan Malaysia, Bangi

Table 6. The *ex situ* conservation areas at Forest Research Institute Malaysia

Arboretum	Year established	Area (ha)	No. of species
Dipterocarp	1929	6.5	150
Non-dipterocarp	1929	14.0	275
Gymnosperm	1949	2.5	17
Fruit tree	1979	0.6	34
Monocotyledon	1981	1.5	35

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 the documenting Malayan flora. The Penang Botanical Garden, established during British rule, is currently the oldest *ex situ* conservation area in Malaysia. However, the garden has carried out little research during the recent years. Its major functions are education, recreation and as tourism. For these reasons, FRIM has begun to develop a national botanical garden (Kepong Botanical Garden), with support from the federal government and private institutions. This 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 that cannot be stored for long. Various institutes in the country are carrying out 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, Thyrsostachys siamensis, Bambusa arundinacea, Dendrocalamus membranaceus* and *D. brandisii*. Tissue culture through *in vitro* techniques has been widely studied in *Swietenia macrophylla, Shorea leprosula, Shorea ovalis, S. parvifolia, S. macrophylla, Hopea odorata,* and *Calamus manan*.

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; 70 000 ha were in Peninsular Malaysia, 140 000 ha in Sabah and 23 000 ha in Sarawak (Anon 2001). 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*, *Gmelina arborea* and *Paraserianthes falcataria*. Other species planted include *Tectona grandis*, *Shorea macrophylla* and *Durio zibethinus*.

Forest plantation establishment will be accelerated, particularly in Sarawak and Sabah, while those already established by the Forest Department in Peninsular Malaysia will be privatised. The State Government of Sarawak has planned for one million hectares of forestland 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 "The Forest (Planted Forest) Rules 1997", which set out the procedures and condition for the orderly establishment of forest plantations in Sarawak (for details, see http://www.forestry.sarawak.gov.my/forweb/homepage.htm). Incentives in the form of low land premium and long leases have been provided to encourage investments. In Sabah, a total of 745 080 ha have been identified as suitable for forest plantations.

Forest plantations are capable of yielding higher volume of timber per unit area, which will relieve pressure from overharvesting the natural forests for supplementing the future wood supply of the country. Consequently, to encourage investments by private sector in forest plantation development, the government of Malaysia has reviewed the existing fiscal incentives and has granted full tax exemption under the pioneer status for ten years and 100% tax exemption under the Investment Tax Allowance (ITA) for five years.

Non-timber forest products (NTFPs)

Besides the production of timber products, policies are now geared towards the development of 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 year, 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 increasingly scarce availability of land and raw materials. This will allow for a wider range of agricultural crops to be planted with forest tree species, optimising land use and returns to the sector. In addition, 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 have been promoted through various initiatives, including the establishment of Malaysian Biovalley in 2003. 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.

Malaysian criteria and indicators for SFM

Malaysia is a member of the ITTO and has adopted ITTO's guidelines for the SFM of natural tropical forests and its criteria for the measurement of sustainable tropical forest management. 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 seven criteria, 64 indicators, 201 activities and 170 standards of performance. At the FMU level, the MC&I consist of seven 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 being undertaken to monitor the implementation of all these activities that are to be carried out at the state and 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 (for details, see web site at http://www.sabah.gov.my/htan). 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 100 years. Under this concept, the SFMLA holders need to manage the forest areas sustainably, prepare long-term forest management plans, employ eco-friendly harvesting plans and undertake enrichment planting, forest rehabilitation and silviculture.

Timber certification

To strengthen the measures towards SFM, the Federal Government established the Malaysian Timber Certification Council (MTCC) in 1998. The MTCC operates as a non-profit organization and as an 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 FMUs is the MC&I developed by the Forestry Department of Peninsular Malaysia. As of 1 March 2003, the MTCC had certified three FMUs (Pahang, Selangor and Terengganu) and issued certificates for Chain-of-Custody to 29 companies in Malaysia (for details, connect to the Malaysian Timber Certification Council web site at http://www.mtcc.com.my/documents/index.html).

The MTCC is currently in the process of developing a set of standards, which is 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 FSC's P&C. A National Working Group (NWG) has been established to formulate a standard for submission to the FSC for endorsement (Chew 2002).

As a recent development, the MTCC has been admitted as a member in the Pan-European Forest Certification (PEFCC) Council. MTCC intends to submit its scheme for PEFCC endorsement soon. 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.

Institutional framework

The FRIM, the Forestry Department of Peninsular Malaysia, the Forestry Department of Sabah and Sarawak, the Malaysia Timber Industry Board (MTIB) and the Malaysia Timber Council (MTC) are directly involved in administration, management, research and development in the forestry sector. All of these agencies are under the Ministry of Primary Industries. In addition, a number of other centres of excellence conduct complementary research and development. These include the Forest Research Centre at Sandakan in Sabah, the Timber Research and Technical Centre and the Forestry Research Division of the Sarawak Forestry Department, the Sarawak Timber Industry Development Corporation and the Faculty of Forestry at the Universiti Putra Malaysia. The Malaysian Timber Certification Council MTCC is an independent non-profit organisation established to plan and operate a voluntary national timber certification scheme to provide assurance to buyers of Malaysian timber products that the products have been sourced from sustainably managed forests. It has a Board of Trustees comprising of representatives from academic as well as research and development institutions, timber industry, non-governmental organisations (NGOs) and government agencies.

There are a number of NGOs in the country that are active, in some way or another, with issues related to the conservation of biological diversity and sustainable utilisation of its components. Some of these are the Malaysian Nature Society, World Wide Fund for Nature (WWF), Sahabat Alam Malaysia (SAM) and Environment Protection Society of Malaysia (EPSM). While some of the work is to influence policy and legislative decisions, others have full-time staff and work on projects that include awareness programmes.

Identification of national priorities

The priority species for Malaysia are listed in Appendix 1. 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*). Besides, Appendix 1 also includes other indigenous timber species which are not popular at the moment for forest plantation (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* (Anon 1999).

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 (except for *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., *Shorea macrophylla*, *S. pauciflora*, *S. splendida* and *S. stenoptera*). Majority of the indigenous species can be found in natural forest and managed for production.

Appendix 2 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 and nowhere else. 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 should receive special attention.

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Appendix 1

Information on priority species and other important species in Malaysia

Species (family)	Managed for conservation		Managed for production		Field trial
	In situ	*Ex situ*	Natural forest	Plantation	
Priority species					
1. *Agathis borneensis* (Araucariaceae)	+	+ [b]	+	K	+
2. *Azadirachta excelsa* (Meliaceae)	K [a]	+ [b]	−	+	+
3. *Calamus manan* (Palmae)	+	+ [b]	+	+	+
4. *Chukrasia tabularis* (Meliaceae)	K	K	+	+	+
5. *Dryobalanops aromatica* (Dipterocarpaceae)	+	+	+	+	+
6. *Dyera costulata* (Apocynaceae)	K	+	+	+	+
7. *Eurycoma longifolia* (Simaroubaceae)[d]	K	+ [b]	+	+	+
8. *Eusideroxylon zwageri* (Lauraceae)	K	+	+	−	+
9. *Fagraea fragrans* (Loganiaceae)	K	+ [b]	+	K	+
10. *Gonystylus bancanus* (Thymelaeaceae)	K	+ [b]	+	K	−
11. *Hopea odorata* (Diptreocarpaceae)	K	+	−	+	+
12. *Intsia palembanica* (Leguminosae)	K	+	+	K	+
13. *Khaya ivorensis* (Meliaceae)[e]	−	−	−	+	+
14. *Koompassia malaccensis* (Leguminosae)[d]	K	+ [b]	+	K	+
15. *Labisia pumila* (Myrsinaceae)	K	K	+	+	+
16. *Melaleuca cajuputi* (Myrtaceae)[e]	−	−	−	+	+
17. *Neobalanocarpus heimii* (Dipterocarpaceae)	+	+	+	K	+
18. *Palaquium rostratum* (Sapotaceae)	K	+ [b]	+	K	+
19. *Pterocarpus indicus* ((Leguminosae)	K	+ [b]	−	K	+
20. *Shorea leprosula* (Dipterocarpaceae)	K	+ [b]	+	K	+
21. *S. macrophylla* (Dipterocarpaceae)[d]	+	+	+	+	+
22. *S. ovalis* (Dipterocarpaceae)	K	+ [b]	+	K	+
23. *S. parvifolia* (Dipterocarpaceae)	K	+ [b]	+	K	+
24. *S. roxburghii* (Dipterocarpaceae)	K	+ [b]	+	K	−
25. *Tectona grandis* (Verbenaceae)[e]	−	−	−	+	+
Other important species					
26. *Acalypha hispida* (Euphorbiaceae)	K	+ [b]	+	−	−
27. *Acorus calamus* (Araceae)	K	+ [b]	+	−	−
28. *Alangium serraca* (Alangiaceae)	K	+ [b]	+	−	−
29. *Alstonia scholaris* (Apocynaceae)	K	−	+	−	−
30. *Andrographis paniculata* (Acanthaceae)	K	+ [b]	+	−	−
31. *Anisoptera costata* (Dipterocarpaceae)	K	+	+	−	−
32. *A. curtisii* (Dipterocarpaceae)	K	−	+	−	−
33. *Antiaris toxicaria* (Moraceae)[d]	K	+ [b]	+	−	−
34. *Aquilaria malaccensis* (Thymelaeaceae)[d]	+	+ [b]	+	−	+
35. *Artocarpus elasticus* (Moraceae)	K	+ [b]	+	−	+
36. *A. lanceifolius* (Moraceae)	K	+ [b]	+	−	−
37. *Avicennia alba* (Verbenaceae)[d]	K	−	+	−	−
38. *Brucea javanica* (Simaroubaceae)	K	−	+	−	−
39. *Calamus subinermis* (Palmae)	K	−	+	−	−
40. *Calophyllum lanigerum* var. *austrocoriaceum* (Guttiferae)	K	−	+	−	−
41. *Cantella assiatica* (Umbelliferae)	K	−	+	−	+
42. *Casuarina equisetifolia* (Casuarinaceae)[d]	K	+	+	−	+
43. *Cotylelobium lanceolatum* (Dipterocarpaceae)	K	+ [b]	+	−	−
44. *Cycas* sp. (Cycadaceae)	K	+ [b]	+	−	−
45. *Dillenia grandifolia* (Dilleniaceae)	K	+ [b]	+	−	−
46. *Dipterocarpus baudii* (Dipterocarpaceae)	K	+ [b]	+	−	+
47. *D. cornutus* (Dipterocarpaceae)	K	+ [b]	+	−	+
48. *D. costulatus* (Dipterocarpaceae)	K	+ [b]	+	−	+
49. *D. crinitus* (Dipterocarpaceae)	K	+ [b]	+	−	+
50. *D. grandiflorus* (Dipterocarpaceae)	K	+ [b]	+	−	+
51. *D. oblongifolius* (Dipterocarpaceae)[d]	K	+ [b]	+	−	+
52. *D. oblongifolia* (Dipterocarpaceae)	K	+	+	−	+
53. *Durio* sp. (Bombacaceae)	K	+	+	−	+

Species (family)	Managed for conservation		Managed for production		Field trial
	In situ	*Ex situ*	Natural forest	Plantation	
54. *Endospermum diadenum* (Euphorbiaceae)	K	+ [b]	+	K	+
55. *Ficus deltoidea* (Moraceae)	K	–	+	–	–
56. *Garcinia* sp. (Guttiferae)	K	+	+	–	–
57. *Gigantochloa scortechinii* (Gramineae)	K	–	+	–	–
58. *Gmelina arborea* (Verbenaceae)[e]	–	–	–	–	+
59. *Goniothalamus velutinus* (Anonaceae)[d]	K	–	+	–	–
60. *Heritiera javanica* (Sterculiaceae)	K	+ [b]	+	–	–
61. *Hopea nervosa* (Dipterocarpaceae)	K	+ [b]	+	–	+
62. *H. nutans* (Dipterocarpaceae)	K	+ [b]	+	–	+
63. *Johannesteijsmannia* sp. (Palmae)	K	–	+	–	–
64. *Metroxylon rumphii* (Palmae)	K	+	+	–	–
65. *M. sagu* (Palmae)	K	+ [b]	+	–	–
66. *Nepenthes* sp. (Nepenthaceae)[d]	+ [c]	+	+	–	–
67. *Nephelium* sp. (Sapindaceae)	K	+	+	–	–
68. *Oncosperma tigillaria* (Palmae)	K	+ [b]	+	–	–
69. *Orthosiphon grandiflorus* (Labiatae)	K	+ [b]	+	–	–
70. *Palaquium maingayi* (Sapotaceae)	K	+ [b]	+	–	+
71. *Paphiopedilum* sp. (Orchidaceae)[d]	K	+ [b]	+	–	–
72. *Parashorea lucida* (Dipterocarpaceae)	K	–	+	–	–
73. *P. stellata* (Dipterocarpaceae)	K	–	+	–	–
74. *Parkia javanica* (Leguminosae)	K	+ [b]	+	–	–
75. *Parkia speciosa* (Leguminosae)	K	+ [b]	+	–	+
76. *Phalaenopsis* sp. (Orchidaceae)	K	+ [b]	+	–	–
77. *Rafflesia* sp. (Rafflesiaceae)[d]	+	+	+	–	–
78. *Santiria laevigata* (Burseraceae)	K	+ [b]	+	–	–
79. *Schima wallichii* (Theaceae)	K	–	+	–	–
80. *Senna alata* (Leguminosae)	K	–	+	–	–
81. *Shorea acuminata* (Dipterocarpaceae)	K	+ [b]	+	–	+
82. *S. bracteolata* (Dipterocarpaceae)	K	+ [b]	+	–	–
83. *S. curtisii* (Dipterocarpaceae)	+	+ [b]	+	–	+
84. *S. glauca* (Dipterocarpaceae)	+	+ [b]	+	–	+
85. *S. hemsleyana* (Dipterocarpaceae)[d]	+	+ [b]	+	–	+
86. *S. kunstleri* (Dipterocarpaceae)	K	+ [b]	+	–	+
87. *S. laevis* (Dipterocarpaceae)	K	+ [b]	+	–	+
88. *S. lepidota* (Dipterocarpaceae)	K	+ [b]	+	–	+
89. *S. longisperma* (Dipterocarpaceae)	K	+ [b]	+	–	–
90. *S. macroptera* (Dipterocarpaceae)	K	+ [b]	+	–	+
91. *S. maxwelliana* (Dipterocarpaceae)	K	+ [b]	+	–	+
92. *S. multiflora* (Dipterocarpaceae)	K	+ [b]	+	–	+
93. *S. pauciflora* (Dipterocarpaceae)	K	+	+	–	+
94. *S. platyclados* (Dipterocarpaceae)	K	+ [b]	+	–	+
95. *S. resinosa* (Dipterocarpaceae)	K	+ [b]	+	–	+
96. *S. splendida* (Dipterocarpaceae)[d]	+	+	+	–	–
97. *S. stenoptera* (Dipterocarpaceae)[d]	+	+	+	–	–
98. *Sindora coriacea* (Leguminosae)	K	+ [b]	+	–	–
99. *Sonneratia alba* (Sonneratiaceae)[d]	K	–	+	–	–
100. *Swietenia macrophylla* (Meliaceae)[e]	–	–	–	+	+
101. *Tinospora crispa* (Menispermaceae)	K	–	+	–	–
102. *Toona sinensis* (Meliaceae)	K	–	+	–	–
103. *T. sureni* (Meliaceae)	K	–	+	–	–
104. *Vatica maingayi* (Dipterocarpaceae)	K	-	+	–	–
105. *V. pauciflora* (Dipterocarpaceae)	K	+ [b]	+	–	–

[a] K = insufficiently known
[b] Less than 10 accessions
[c] *Nepenthes hamulatum*
[d] Protected species by law in Sarawak
[e] Exotic species

Sources of data: Ng and Tang 1974; Patrick and Muhammad 1980; Anon 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; de Padua *et al*. 1999

Appendix 2

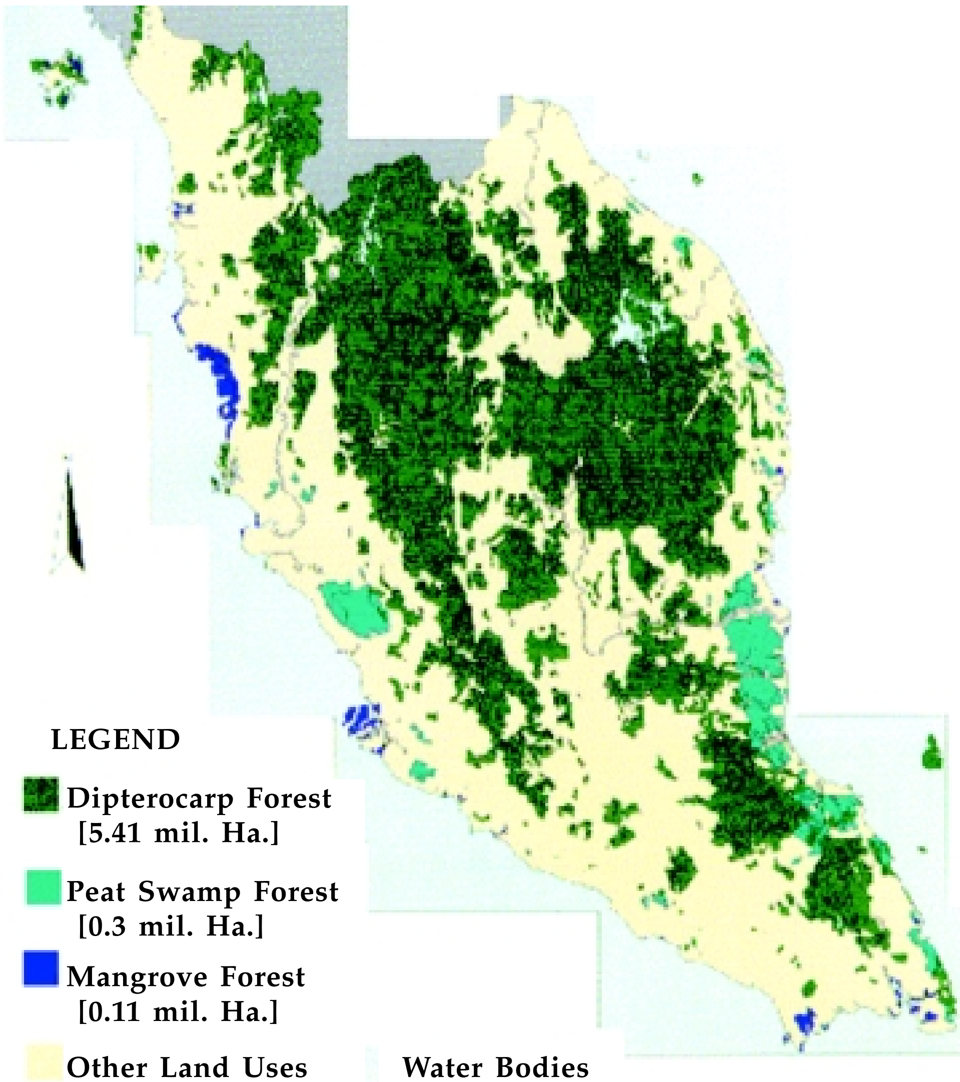
List of endemic and rare species in Malaysia

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)

1. *Acrymia ajugiflora* (Labiatae)
2. *Actinodaphne cuspidata* (Lauraceae)
3. *Aglaia densitricha* (Meliaceae)
4. *Alphonsea kingii* (Annonaceae)
5. *Ardisia langkawiensis* (Myrsinaceae)
6. *Begonia eiromischa* (Begoniaceae)
7. *B. rajah* (Begoniaceae)
8. *Beilschmiedia* penangiana (Lauraceae)
9. *Brownlowia velutina* (Tiliaceae)
10. *Calamus balingensis* (Palmae)
11. *C. viminalis* (Palmae)
12. *Castanopsis catappaefolia* (Fagaceae)
13. *Cleistanthus major* (Euphorbiaceae)
14. *Croton macrocarpus* (Euphorbiaceae)
15. *Cryptocoryne elliptica* (Araceae)
16. *Cycas pectinata* (Cycadaceae)
17. *Dendrobium langkawiense* (Orchidaceae)
18. *Didymocarpus pumilus* (Gesneriaceae)
19. *Diplodiscus hookerianus* (Tiliaceae)
20. *Dipterocarpus lamellatus* (Dipterocarpaceae)
21. *D. perakensis* (Dipterocarpaceae)
22. *D. rotundifolius* (Dipterocarpaceae)
23. *Eugenia camptophylla* (Myrtaceae)
24. *E. gageana* (Myrtaceae)
25. *E. johorensis* (Myrtaceae)
26. *E. klossii* (Myrtaceae)
27. *E. scalarinervis* (Myrtaceae)
28. *E. taipingensis* (Myrtaceae)
29. *Glycosmis crassifolia* (Rutaceae)
30. *G. monticola* (Rutaceae)
31. *G. tomentella* (Rutaceae)
32. *Goniothalamus subevenius* (Annonaceae)
33. *Hexapora curtisii* (Lauraceae)
34. *Homalium spathulatum* (Flacourtiaceae)
35. *Hopea auriculata* (Dipterocarpaceae)
36. *H. depressinerva* (Dipterocarpaceae)
37. *H. johorensis* (Dipterocarpaceae)
38. *H. polyalthioides* (Dipterocarpaceae)
39. *H. subalata* (Dipterocarpaceae)
40. *Horsfieldia sessilifolia* (Myristicacceae)
41. *Hydnocarpus scortechinii* (Flacourtiaceae)
42. *Ilex pauciflora* (Aquifoliaceae)
43. *Johannesteijsmannia lanceolata* (Palmae)
44. *Johannesteijsmannia magnifica* (Palmae)
45. *Justicia subalternans* (Acanthaceae)
46. *Kibatalia borneensis* (Apocynaceae)
47. *Koilodepas ferrugineum* (Euphorbiaceae)
48. *Kostermanthus malayus* (Chrysobalanaceae)
49. *Lagerstroemia langkawiensis* (Lythraceae)
50. *Litsea scortechinii* (Lauraceae)
51. *Maclurochloa montana* (Gramineae)
52. *Madhuca calcicola* (Sapodaceae)
53. *Mallotus smilaciformis* (Euphorbiaceae)
54. *Mangifera superba* (Anacardiaceae)
55. *Mezzettia herveyana* (Annonaceae)
56. *Nepenthes gracillima* (Napenthaceae)
57. *N. northiana* (Napenthaceae)
58. *Oberonia calcicola* (Orchidaceae)
59. *Paphiopedilum niveum* (Orchidaceae)
60. *P. philippinense* (Orchidaceae)
61. *Peperomia maxwelliana* (Piperaceae)
62. *Phyllagathis stonei* (Melastomataceae)
63. *Polyalthia glabra* (Annonaceae)
64. *P. hirtifolia* (Annonaceae)
65. *Popowia pauciflora* (Annonaceae)
66. *P. velutina* (Annonaceae)
67. *Pseudeugenia tenuifolia* (Myrtaceae)
68. *Rafflesia kerrii* (Rafflesiaceae)
69. *Sauropus elegantissimus* (Euphorbiaceae)
70. *Schefflera cephalotes* (Araliaceae)
71. *S. kuchingensis* (Araliaceae)
72. *Schoutenia cornerii* (Tiliaceae)
73. *Shorea bentongensis* (Dipterocarpaceae)
74. *S. kuantanensis* (Dipterocarpaceae)
75. *S. kudatensis* (Dipterocarpaceae)
76. *S. lumutensis* (Dipterocarpaceae)
77. *S. maxima* (Dipterocarpaceae)
78. *S. palembanica* (Dipterocarpaceae)
79. *S. singkawang* ssp. *scabrosa* (Dipterocarpaceae)
80. *Strobilanthes pachyphyllus* (Acanthaceae)
81. *Symplocos nivea* (Symplocaceae)
82. *Tristania pontianensis* (Myrtaceae)
83. *Vaccinium whitmorei* (Ericaceae)
84. *Vatica flavida* (Dipterocarpaceae)
85. *Zollingeria borneensis* (Sapindaceae)

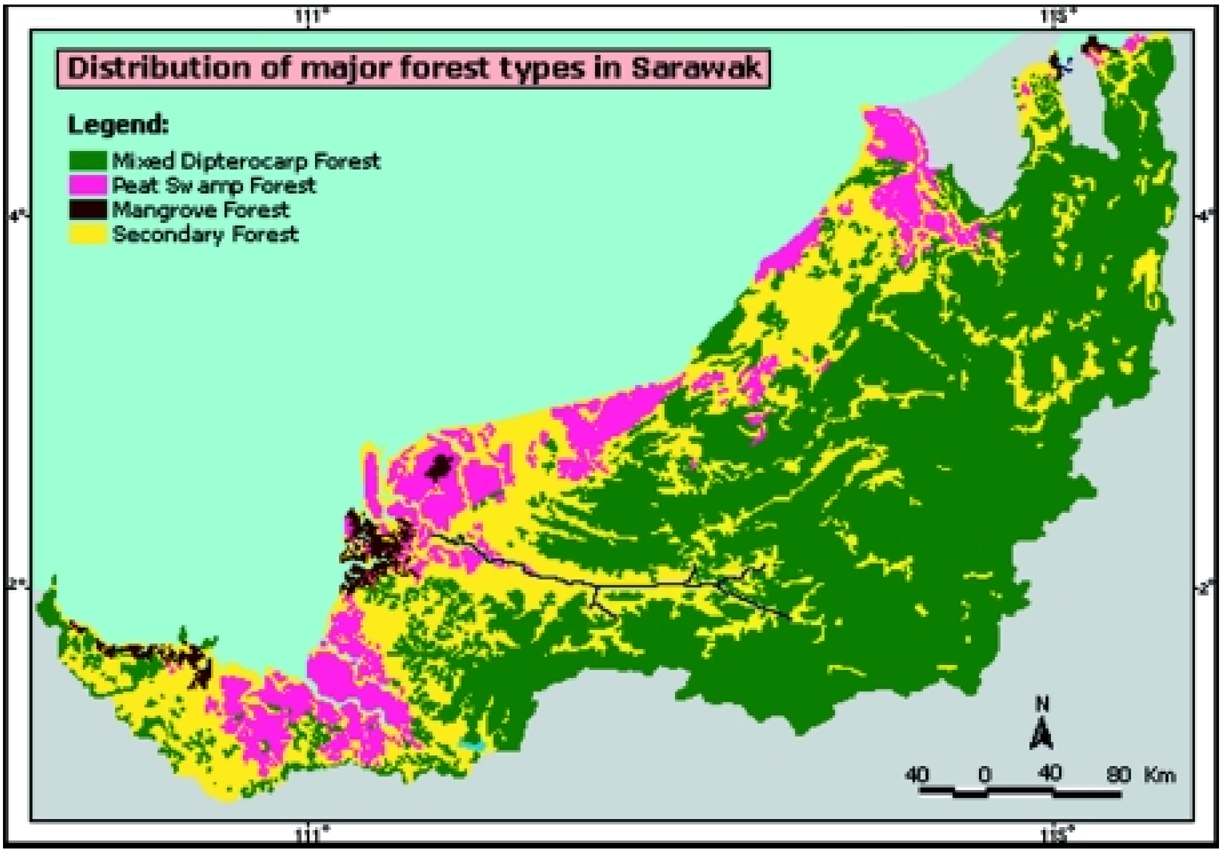
Appendix 3

Forest cover map of Peninsular Malaysia
(adapted from the Forest Department Peninsular Malaysia web site at http://www.forestry.gov.my)



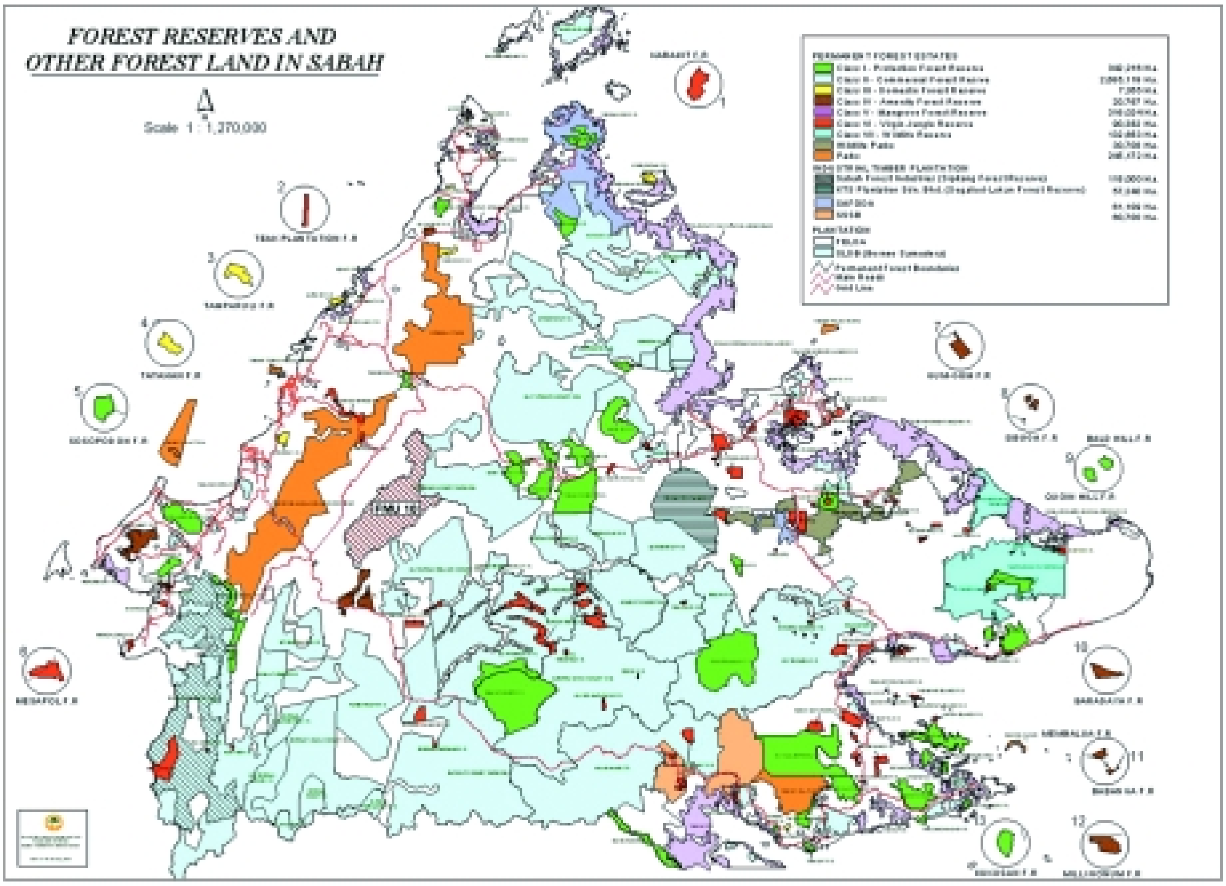
Appendix 4

Distribution of major forest types in Sarawak
(adapted from the Sarawak Forest Department web site at http://www.forestry.sarawak.gov.my)



Appendix 5

Forest reserves and other forest land in Sabah
(adapted from the Sabah Forest Department web site at http://www.sabah.gov.my/htan)



Status of forest genetic resources conservation and management in the Philippines

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Introduction

It has been estimated that in the early 1500s, the Philippines possessed 27 million ha of forest, representing 90% of the country's total land area. The forest cover amounted to 21 million ha at the beginning of the 1900s and by 1996 had decreased to 6.1 million ha, representing a loss of 15 million ha in less than one century (Lasco *et al.* 2001). Land use distribution in the Philippines as of 1997 is shown in Table 1. Forest area totals about 5.4 million ha or 18% of the total area. The old growth dipterocarp forests (mature forests) cover only 2.7% (804 900 ha), while the residual dipterocarp forests cover about 9% (2 731 117 ha) of the total land area. The combined area of closed and open pine forests (227 900 ha) is about 0.7% of the total land area. Currently, non-forest uses account for almost three-fourths of the total land use in the country (DENR 2001). The historical change in land use from 1990 to 2000 is shown in Table 2. For the last decade of the previous century, a -1.4% change occurred in the forest cover of the country.[1]

Table 1. Forest lands in the Philippines in 1997 (DENR 2001)

Land-use types	Area (ha)	%
Forest	**5 391 717**	**18.0**
Old Growth Dipterocarp	804 900	2.7
Residual Dipterocarp	2 731 117	9.1
Closed Pine	123 900	0.4
Open Pine	104 000	0.3
Submarginal	475 100	1.6
Mossy	1 040 300	3.5
Mangrove	112 400	0.4
Brushland	**2 232 300**	**7.4**
Other land use	**22 375 983**	**74.6**
GRAND TOTAL	**30 000 000**	**100**

Table 2. Land use change in the Philippines from 1990 to 2000

Forest cover	Forest cover change 1990–2000	
ha	ha yr^{-1}	% yr^{-1}
5 788 828	–88 764	–1.4

Source: FAO website (see http://www.fao.org/forestry/index.jsp)

Forest types in the Philippines

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

Broad-leaved forests

These are found at altitudes up to 800 m above sea level and on well-drained soils along the lower slopes of mountains in areas where the dry season is not pronounced. Members

[1] The actual figure for forest area is a controversial issue in Philippines. In a recent seminar (April 8, 2003), Dr Dave Kummer presented information showing conflicting estimates of forest cover by the National Mapping and Resource Information Authority (NAMRIA) and Forest Management Bureau (FMB).

of the family Dipterocarpaceae dominate this forest type, namely: *Dipterocarpus grandiflorus*, *D. warburghii*, *Parashorea plicata*, *Pentacme contorta*, *Shorea polysperma*, *S. almon*, *S. negrosensis*, *S. squamata*, *S. astylosa*, and *S. guiso*. The group known as lauan or Philippine mahogany in the trade is composed mainly of the first six *Shorea* listed above plus *Parashorea* and *Pentacme* species.

Mixed dipterocarp forests

Five subtypes are recognized in the mixed dipterocarp forests:

Lauan forest – Dominant species are *Shorea negrosensis*, *S. squamata*, *S. polysperma*, *S. almon, S. contorta*, *Parashorea plicata* and *Dipterocarpus grandiflorus*. This forest type occurs in lowland areas and foothills up to an elevation of about 400 m asl. where there is no pronounced dry season. Generally trees can reach 50 m or more in height, however, in some areas like Mindanao, some grow to no more than 25 m with poor lopsided crowns. In the eastern part of the country, where strong winds and typhoons normally cross, the upper canopy is uncharacteristically flat.

Lauan-apitong forest – Many species are deciduous and the forest type occurs in areas of low elevation where there is a pronounced dry season. Unlike the lauan subtype, the profile of this forest is not so tall, more open and has denser shrub and ground flora layers.

Yakal-lauan – Species are often deciduous to semi-deciduous and occurs in areas with a pronounced but short dry season. This type is found mainly in narrow belts on low coastal hills of volcanic origin. The area covered by this forest type is small.

Lauan-hagakhak – Common in river bottoms and along streambeds; restricted to areas without a dry season and a high water table. *Dipterocarpus warburghii* is common.

Montane forests – Montane forests are located at elevations between 400-500 m and 800-900 m asl, with evenly distributed rainfall and high relative humidity. It is essentially a non-dipterocarp formation, *Shorea polysperma* and *Lithocarpus* spp. as main species with occasional *Hopea, Vatica, Agathis, Cinnamomum, Tristania* and *Eugenia* species.

Mossy forests

Mossy forests consist of stunted trees with trunks and branches commonly covered with mosses and liverworts and occur in areas with relatively low temperature, high and uniform humidity, short sunshine duration and strong winds. This forest type is found in high mountainous regions above montane forest. On the slopes and dry ridges of northern Luzon it is replaced by forests dominated by the indigenous pine species, *Pinus kesiya*. Philippine oak (*Lithocarpus* spp.) is common but not commercially harvested. The forest serves more for protection rather than production purposes.

Molave forests

Molave forests are dominated by *Pterocarpus* spp., *Afzelia rhomboidea*, *Vitex parviflora* and *Dracontomelon dao*, and are commonly found in areas with very distinct wet and dry seasons and in the coastal areas on shallow and excessively drained limestone soils. Molave forests can be found in isolated patches or blend with the other forest types. The wood of the species listed is valued for its natural beauty and durability.

Mangrove forests

Mangrove forests are normally dominated by *Rhizophora apiculata, R. mucronata, Ceriops tagal, C. roxburghiana, Bruguiera gymnorhiza, B. parviflora, B. cylindrica* and *B. sexangula*. Mangrove forests occur on tidal flat bordering coastal areas and along the mouths of rivers where water is brackish. The forest is valued for its tan bark by the tannin industry and for fuelwood and charcoal making. In the upstream areas, where water is less brackish, nipa palm (*Nypa fruticans*) can be found as extensive and dense stands that are major sources of roofing materials in coastal areas.

Coniferous forests

Coniferous forests are found in the upper elevations of the Caraballo-Cordillera mountain ranges in northern Luzon, the Tarlac-Zambales mountain ranges in western Luzon, and the high mountains of Mindoro Island. Two pine species are found in the Philippines: *Pinus kesiya* (Benguet pine) and *P. merkusii* (Mindoro pine). The former is found at elevations ranging from 700 to 1800 m asl in northern Luzon, while *P. merkusii* is limited to 100 and 500 m asl in the northern Zambales and northern Mindoro. *P. kesiya* is valued as mining timber and tapped for resins.

Biological diversity of the forest types

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 megadiversity countries with an impressive record of species diversity and endemism (Mittermeier *et al.* 1999). The complex geological history, archipelagic character and mountainous terrain of the more than 7000 islands have been the major causes for diverse habitats and broader ecological opportunities that have enhanced adaptive radiation and speciation (Fernando *et al.* 2001). However, 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. The Department of Environment and Natural Resources (DENR) has classified the country into 15 biogeographic regions (Figure 1), primarily based on the floristic, faunistic and geological composition.

Silvicultural systems

The Bureau of Forest Development Administrative Order No. 74 Series of 1974 specifies the use of the Philippine Selective Logging System for the dipterocarp forests. The system is a modified selection system where mature, overmature and defective trees are removed leaving behind an adequate stand of healthy and sound trees to grow for the next cutting cycle. It has three phases, namely: tree marking, residual inventory and timber stand improvement. For the pine forest, the prescribed silvicultural system is seed tree method where 16–20 healthy and vigorous mother trees per hectare should be left and properly distributed throughout the logging set-up. For the mangrove forest the prescribed system is seed tree method combined with planting where 20 or more healthy and thrifty seed trees with diameters 10 cm or more are left for every hectare. For industrial plantations and tree farms specifically those for chipwood, railroad ties and sawtimber, the prescribed silvicultural system is clear-cutting with planting. For plantations for poles, piles, matchwood and furniture/novelties, it should be clear-cutting with planting system, or selection and shelterwood system.

Conservation of forest genetic resources

Threats to genetic diversity of the species

Environmental degradation in the Philippines, particularly in the uplands, is threatening the forest genetic resources (FGR), due to both natural and human-made causes (Bugna and Blastique 2001). The former include volcanic eruptions, earthquakes, natural fires, typhoons, and pests and diseases. Human-made causes include land conversion, introduction of exotic species, unsustainable logging, pollution, human-induced fires, siltation, destructive fishing methods in mangrove forests and encroachment and occupancy in protected areas. Garcia (1999) listed other important threats such as chemical and environmental pollution, biological pollution (introduction of exotic species), deficiencies in knowledge and its applications and weak and slow implementation of environmental laws and other legal instruments.

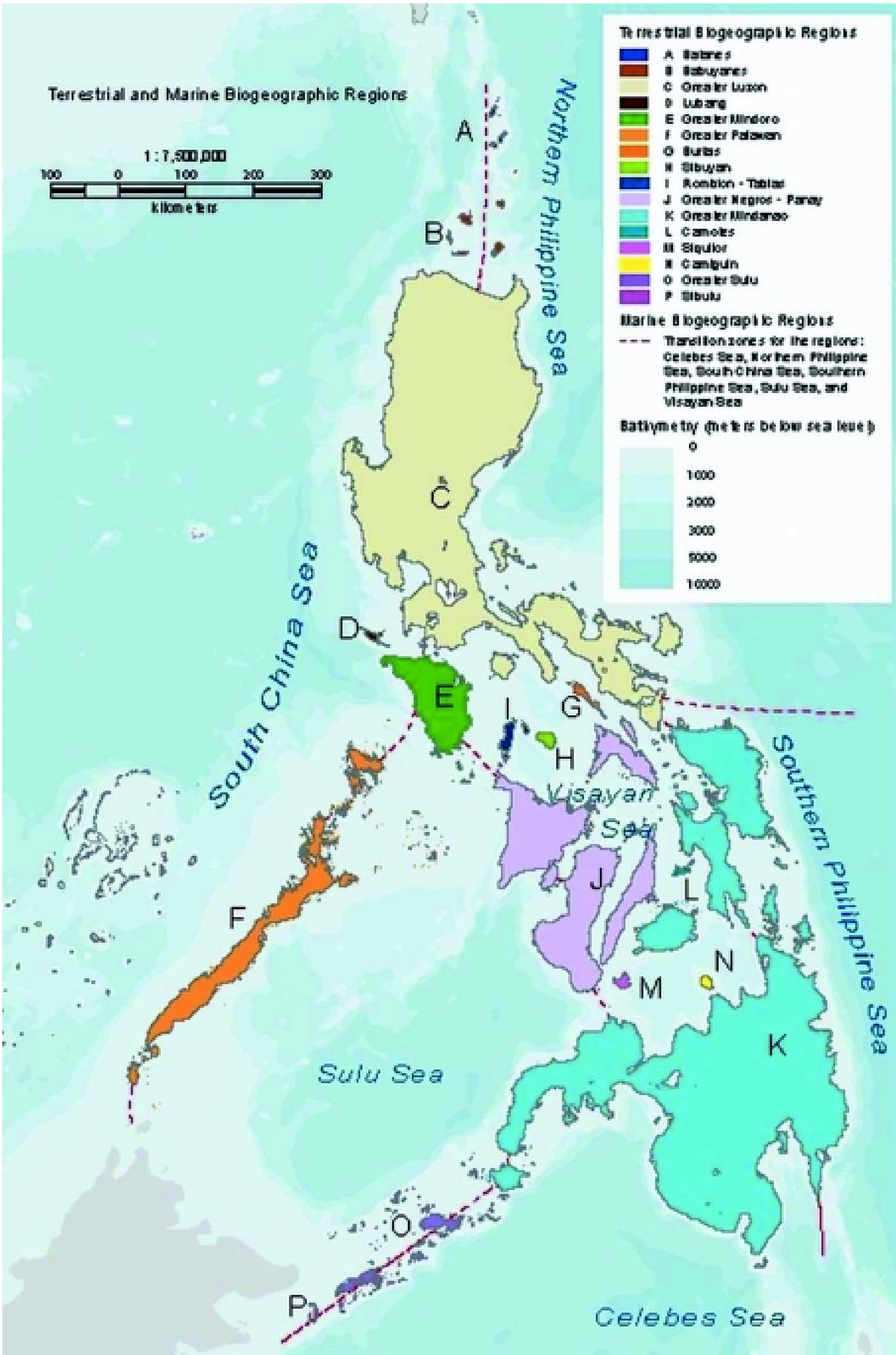

Figure 1. Biogeographic regions in the Philippines (after DENR-UNEP 1997)

Current FGR conservation activities

As defined by the law, protected areas in the Philippines are areas that are established to provide protection and conservation to the significant natural and cultural features of the country. The classification of the protected areas is as follows: national parks, wilderness areas, game refuges, bird sanctuaries and other reserves. The Parks and Wildlife Bureau (PAWB) of the DENR has classified the protected areas as follows (PAWB undated):

- National parks are *areas of public domain essentially of primitive or wilderness character which has been withdrawn from settlement or occupancy and set aside as such exclusively to preserve the scenery, the natural historic objects, the wild animals or plants therein and to provide enjoyment of these features in such a manner as will leave them unimpaired for future generations*.
- Wilderness areas are *lands of public domain, which have been reserved as such by law to preserve its natural condition, maintain its hydrologic quality and restrict public use in the interest of national welfare and security. This includes protection forest, mossy forest, critical watersheds, proclaimed watershed reservation and special forests, which are the exclusive habitats of rare and endangered Philippine flora and fauna*.
- Game refuges and bird sanctuaries are defined as *forest land designated for the protection of game animals, birds, and fish and closed to hunting and fishing in order that excess population may flock and restock the surrounding areas.*
- Other Reserves are *lands of the public domain, which have not been the subject of present system of classification and declared as needed for forest purposes*.

The National Parks in the Philippines are presented in Figure 2. General information about the National Parks in the Philippines by region is found in Appendix 1. The Conservation of Priority Protected Areas (CPPAP) was established in 1994 with funding assistance from the Global Environmental Facility (GEF) and World Bank to pilot the implementation of the National Integrated Protected Area System (NIPAS) in ten priority protected areas in the country (Manila 2000). The project has the following objectives:

a) Establish the ten IPAS (Integrated Protected Area System) priority sites as protected areas, pursuant to the NIPAS Law through presidential proclamation and Congressional Enactment.
b) Protect the biodiversity values and future sustainability of sites as PAs (Protected Areas).
c) Integrate the concerns of the local communities, local government units and non-government organizations in the management and development of the PAs.
d) Establish and protect the land tenure rights of indigenous communities and long established residents of the areas.
e) Develop a permanent funding mechanism for the management, administration and development of the PAs.
f) Develop sustainable forms of livelihood and restorative activities, which are consistent with biodiversity conservation.
g) Strengthen the capabilities of the DENR, PAMBs (Protected Area Management Boards), NGOs (non-governmental organizations), LGUs (Local Government Units), and local communities to be able to carry out their respective activities in the PAs.

The ten priority sites identified under the NIPAS Law are presented in Appendix 2, while the eight sites under the National Integrated Protected Areas Programme (NIPAP) are found in Appendix 3.

The Pagbilao Mangrove Swamp Experimental Forest was declared as a Genetic Resource Area by virtue of the DENR AO No. 56 Series of 1992. The major objectives of this order are to preserve the genetic diversity of the mangrove ecosystem and sustainably use it so that it provides livelihood and recreational amenities to communities and visitors and serves as site for research.

In the Makiling Forest Reserve, the Ecosystems Research and Development Bureau (ERDB, formerly the Forest Research Institute) of the DENR established the Los Baños Experiment Station (LBES). It houses a bambusetum with 38 exotic and endemic bamboo

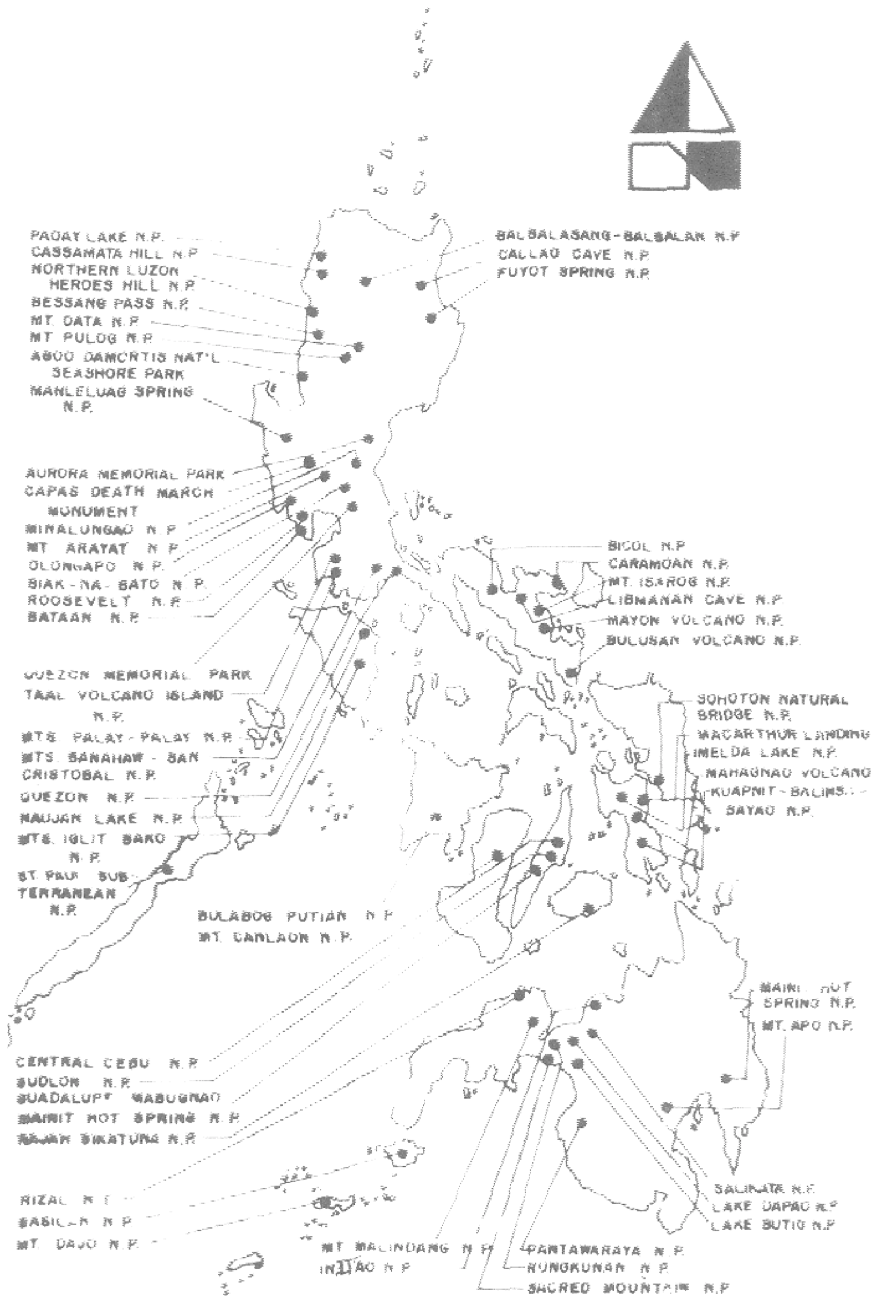

Figure 2. National Parks in the Philippines (PAWB undated)

species with 254 developed clumps. The rattan genebank contains 500 rattan accessions belonging to 50 species. The initial 41 species/varieties from the genera *Calamus, Daemonorops, Korthalsia,* and *Plectocomia* were collected from 27 sources throughout the country (Faylon 2002). A medicinal plants garden has 181 exotic and endemic medicinal plant species classified as: trees (77), shrubs (35), herbs (48), vines (13), liana (1), grasses (4) and palms (2). A clonal garden containing the following dipterocarp species: *Anisoptera aurea*, *Shorea contorta*, *S. guiso* and *Dipterocarpus grandiflorus* was also established. The LBES has a palmetum that has 13 exotic and endemic palm species (LBES Brochure).

The Philippines received an FGR Information Database (FGRID) software developed by the former ASEAN-Canada Tree Seed Center. Three main modules in the database software are: (1) sources of information, (2) a clonal registry and (3) a seed registry. (Coles 1993). The software was given to the DENR Forest Management Bureau, but no update is available as to whether the system was ever used or if relevant information data about the Philippines was keyed in.

Relevant natural resources management policies

The conservation and management of forest resources is synonymous with the conservation and management of biodiversity and genetic resources, and this is directly or indirectly enunciated in the Philippine Constitution.

The 1987 Philippine Constitution provides for the protection and advancement by the State of the right of every Filipino to a *balanced and healthful ecology in accord with the rhythm and harmony of nature*. Specifically, the Philippine Congress is required to determine the *specific limits of forest lands and national parks, marking clearly their boundaries on the ground and, thereafter, such forest lands and national parks shall be conserved and may not be increased nor diminished*, and the Congress is to determine *measures to prohibit logging in endangered forests and watershed areas*.

The Philippine Constitution declares further that *all lands of the public domain, waters, minerals, coal, petroleum and other mineral oils, all sources of potential energy, fisheries, forests or timber, wildlife, flora and fauna, and other natural resources are owned by the State*, except for agricultural lands. The equitable use of natural resources is pursued with the recognition and promotion of the *rights of indigenous cultural communities to their ancestral lands to ensure their economic, social and cultural well being* within the framework of unity and national development. Preference is given to Filipino citizens and corporations with major ownership by Filipinos in the exploration, development and utilization of natural resources and in the ownership of alienable lands. The State has full control and supervision of the exploration, development and utilization of natural resources either by directly undertaking such activities, or it may enter into co-production, joint venture or production sharing agreements with Filipino citizens, corporations or associations. The State also allows small-scale utilization of natural resources with priority to subsistence fishermen especially among local communities, for marine and fishing resources, both inland and offshore.

The sustainable use of natural resources is implied in the provisions on the conservation of natural resources. The Constitution mandates the pursuance of the goals of economic development and the preservation and protection of natural and indigenous resources. To provide direction to such commitments, the government formulated the Philippine Strategy for Sustainable Development (PSSD) in 1989 that served as a basic response towards the global call for sustainable development.

Past and present research and activities in conservation, utilization and management of FGR

Agroforestry, plantations and reforestation programmes

Plantations

Formal government reforestation efforts were started in 1916 in a badly denuded government land in Cebu. In 1986, the National Forestation Programme (NFP) was created to reforest 100 000 ha per year (both the government and private sectors) until year 2000; i.e. a total target of 1.4 million ha. A four-year accomplishment report showed that only 272 000 ha had been planted and the quality of the plantations was doubtful (DENR 1991). Government reforestation programmes accomplished to reforest in total 1 587 363 ha between 1960 and 2001 (Figure 3).

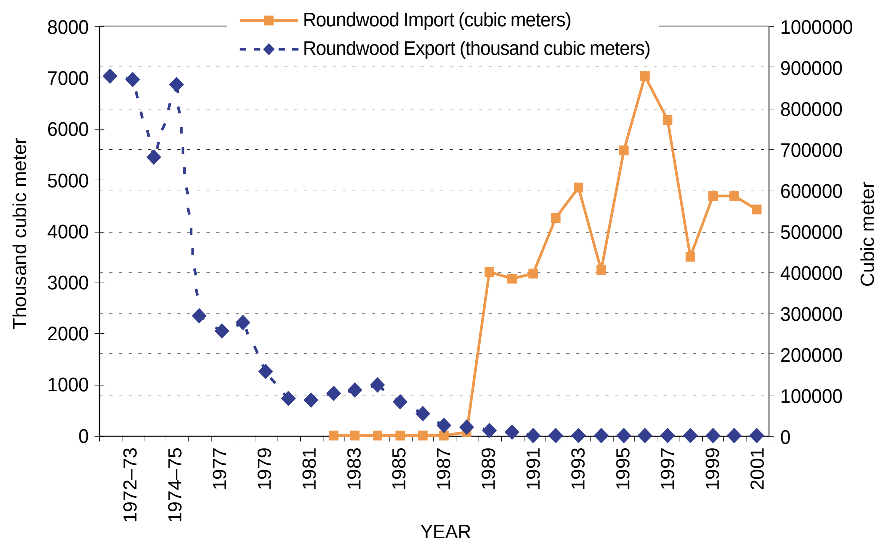

Figure 3. Reforestation and deforestation rates in the Philippines

Various reforestation programmes have been implemented in the Philippines and these are summarized in Table 3.

Table 3. Reforestation programmes implemented in the Philippines (Cruz *et al.* 2001)

Programme	Participants	Remarks
Presidential Decree No. 1153 (Tree Planting Program Decree[2])	All Filipino citizens 10 years and above	32 686 ha planted (1977–86)
Family Approach Reforestation	Families or other people within and around public forest lands	2-year labour contract for planting, planting, maintenance and protection
Contract reforestation	Private corporations, local government units, NGOs, communities and families	
Forest Land Management Program	Private corporations, local government units, NGOs, communities and families	Tenure security for 25 years renewable for another 25 years
Communal tree farm	Residents of a city community Barangay or members of a cooperative/organization	Tenure security for 25 years renewable for another 25 years
Socialized Industrial Forest Management Program	Individuals, single families, associations or cooperatives	
Industrial Tree Plantations	Corporations, associations	

For a thirty-year period (1971 to 2001), reforestation averaged 52 900 ha per year. Half of the plantations established were for protection purposes and the rest for production purposes. Commonly planted species included: *Acacia mangium*, *A. auriculiformis*, *Eucalyptus* spp., *Gmelina arborea*, *Paraserianthes falcataria*, *Swietenia macrophylla*, *Tectona grandis* and *Leucaena leucocephala* (JOFCA 1996).

Agroforestry

Agroforestry systems in the Philippines are very diverse. A brief summary of these systems is presented in Table 4. Table 5 presents the various agroforestry programmes implemented in the country.

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[2] Presidential decree requiring the planting of one tree every month for five consecutive years by every citizen of the Philippines.

Table 4. Agroforestry systems practised in the Philippines (Cruz *et al.* 2001)

System	Practices	Example
Agrisilvicultural systems	Alley cropping system	Sloping Agricultural Land Technology (SALT) model popularized by MBRLC in Bansalan, Davao del Sur
	Multi-storey system	Coconut-coffee-banana mix in Silang, Cavite
	Improved fallow system	Naalad style farming in Naalad, Naga, Cebu
	Taungya system	Family Approach to Reforestation scheme of BFD
	Trees planted as boundary marker, live fence, windbreak, live trellis	
	Agroforestry tree plantation integrated production system	SALT 3
Silvopastoral systems	Tree crop grazing system	Cattle allowed to graze in a mature *Aleurites moluccana* plantation (NALCO silvopastoral scheme)
	Protein bank (fodder bank) system	Intensive feed garden in IIRR, Silang, Cavite
Agrosilvopastoral systems	Simple agro-livestock technology	SALT 2 – a goat-based agroforestry system
	Agroforestry-aquaculture-livestock integrated production system	

Table 5. Agroforestry programmes implemented in the Philippines (Cruz *et al*. 2001)

Programme	Remarks
Integrated Social Forestry Programme (ISFP)	Umbrella programme for all social forestry-related activities of the DENR
Forest Occupancy Management (FOM)	Allowed forest occupants to develop the lands they were cultivating into agroforestry farms
Communal Tree Farm (CTF) Programme	Provides a 25-year CTF lease agreement to participating families who wish to establish tree farms and agroforestry plantation
Family Approach to Reforestation (FAR) Programme	Provides payment to forest occupants on a contractual basis for the establishment, maintenance and protection of forest plantation
Community-Based Forest Management Programme (CBFMP)	National strategy for sustainable forestry and social equity institutionalizing the community forestry in the country. The CBFMP unified several people-oriented forestry programmes of the government.
National Forestation Programme (NFP)	Three major components, namely: (a) reforestation of denuded forest lands with indigenous and exotic forest species; (b) rehabilitation of degraded watersheds through replanting and ANR and (c) timber stand improvement (TSI) which involves the removal and utilization of overmature, damaged and inferior trees to improve the growth of the residual stands
SALT technologies	Mindanao Baptist Rural Life Center in Bansalan, Davao del Sur
Community Forestry Programme (CFP)	Encourages communities to participate actively in the protection, rehabilitation and management of fragmented denuded uplands, residuals or logged-over stands and old growth forests
Livelihood Enhancement Thru Agroforestry (LEAF) Project	350 marginal upland farmers converted the slopes of Surigao del Sur into agroforestry farms
Community-Based Resource Management (CBRM)	Selected local government units which may avail of assistance towards developing and implementing community-based related projects such as agroforestry

Demand and supply of tree seed

National figures for seed demand and supply are very difficult to obtain. Poor recording system and little attention to germplasm materials are the common reasons for this. The only available figures are from the National Forestation Development Office for the year 1996–1997 (Table 6).

Table 6. Seed and seedling requirement of the National Forestation Development Office for the year 1996–97 (Zabala 1996)

Species	Area to be planted (ha)	Spacing (m)	No. of seedlings required*	Kg of seed required
Acacia auriculiformis	2650	2 x 3	5 742 550	226
Swietenia macrophylla	7126	2 x 3	15 442 042	14 477
Pterocarpus indicus	5042	2 x 3	10 926 014	9105
Gmelina arborea	4136	2 x 3	8 962 712	7469
Acacia mangium	3139	2 x 3	6 802 213	269
Eucalyptus camaldulensis	1261	2 x 3	2 732 587	1.0
Casuarina equisetifolia	1026	2 x 3	2 223 342	1.0
Pinus kesiya	843	2 x 3	1 826 781	6.5
Leucaena leucocephala	693	2 x 3	2 252 250	154
Melia azadirachta	331	2 x 3	717 277	50
Gliricidia sepium	303	2 x 3	984 750	100
Dipterocarp species	191	2 x 3	413 897	4139
Eucalyptus deglupta	186	2 x 3	403 062	1.0
Tectona grandis	95	2 x 3	205 867	207
Albizia procera	199	2 x 3	431 233	43
Paraserianthes falcataria	150	2 x 3	325 050	22
Albizia saman	120	2 x 3	260 040	325
Other forest trees	1780	variable	3 293 804	227
Rattans	2138	4 x 4	1 737 755	5617
Bamboos	1438	5 x 5	747 760	(vegetative)
Mangifera indica	1415	10 x 10	183 062	6417
Artocarpus heterophylla	184	8 x 9	33 120	50
Other fruit trees	1718	variable	3 216 676	48 249
TOTAL	**36162**		**69 629 844**	**97 214**

*Including 30% allowance for damages and mortality

In situ conservation

The Philippine government has mandated the Parks and Wildlife Bureau to consolidate all government efforts in the conservation of natural biological resources. An offshoot of this is the enactment of the NIPAS Law. To date, a total of 294 protected areas have been proclaimed under the NIPAS category with a total area of more than 4 million ha. Terrestrial ecosystems comprise majority of the areas, representing different types of forest formations and ranging from a small 1-ha forest park to the largest 47 861-ha national park (Fernando 2001).

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 the 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 the DENR and private planters. PICOP Resources Incorporated, (PICOP), Provident Tree Farms Incorporated (PTFI) and 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 is one of the first few logging concessionaires that established large scale forest plantations in the Philippines to support its pulp and paper mill in the early 1970s. The six species in PICOP's plantations include *Swietenia macrophylla, Pinus caribaea, Gmelina arborea, Acacia mangium, Paraserianthes falcataria* and *Eucalyptus deglupta*. PICOP's industrial tree plantations totalled more than 46 000 ha of mainly *P. falcataria* and *E. deglupta* (Reyes 1987). PICOP used to have a decent and active forest research and tree improvement programme for its plantations that included species provenance trials, progeny testing, and parent tree selection. However, due to several changes in company ownership these activities are at a standstill (Fernando 2001).

A collaborative effort of the 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 species selection and seed origin suitability study 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 x pellita, E. grandis x urophylla, 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).

For nearly a decade now, the Philippine government has banned timber harvesting in old growth forests, mossy forests and those above 1000 m elevation and with more than 50% slope. Many of these areas now form part of the NIPAS (Fernando 2001). However, most of the genetic resources of timber species are usually restricted to the lowland rain forests where much of the large-scale commercial logging in the Philippines 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, in cooperation with the DENR has launched a research project implemented by the Sustainable Ecosystems International Corporation (SUSTEC) funded by the International Tropical Timber Organization (ITTO). The project collected information that is useful in assessing biodiversity in the areas and in developing conservation measures for integration in a sustainable forest management plan for the logging company (Fernando 2001). A proposed 42 346 ha of protection areas was identified with support from the ITTO. The areas identified for this purpose are those with a high value for biodiversity conservation such as areas with high endemism and areas with high 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), the only fully developed botanical garden in the country and the first to be legislated through RA 3523 in 30 June 1963, maintains an arboretum of Dipterocarpaceae representing more than half of all the species known from 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 that would reflect the origin 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 and is currently 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 start an approved programme for conservation of biodiversity of high value crops, including indigenous palms and selected forest species (Garcia 1999). The 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.

The DENR has also established a seed storage and testing centre at its Central Office. The establishment of seven other seed storage and testing centres was planned in different regions around the country (FMB 1999).

Plant rescue

Scientists at the National Museum in Manila have started "Plant Rescue Operation" that 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

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), *P. falcataria*, (Umali-Garcia 1989), *Eucalyptus* hybrid (Siarot 1991), *Swietenia macrophylla, Vitex parviflora* (Umali-Garcia 1995), *Pittosporum pentandrum* (Oporto and Umali-Garcia 1998b) and *P. merkusii* (Garcia 1999)

Micropropagation

The status of the use of tissue culture propagation of various tree and plant species in the Philippines is summarized in Table 7.

Table 7. 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	Nutritional requirements for callus initiation established
Eucalyptus camaldulensis	Callus formation, shoot and root formation
E. deglupta	Plantlets acclimatized in the nursery
Pogostemon cablin	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 merrilli* *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

Except for *E. deglupta, P. falcataria* and *C. sumatranum*, the clones have not found their way in the nursery. An ongoing programme on forest biotechnology based at the University of the Philippines Los Baños (UPLB), College of Forestry and Natural Resources (UPLB-CFNR) focuses on tissue culture of industrial plantation species such as *A. mangium, G. arborea, P. indicus, P. falcataria* and *S. 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 (in Luzon). The project utilizes embryos and tissues from *in vitro*-germinated seeds as explants (Garcia 2002).

Tree improvement

Provenance trials

The DENR has started a number of species/provenance trials through its regional research offices. 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 showed better growth and survival than *Casuarina equisetifolia, Leucaena leucocephala*, *Gmelina arborea* and *Albizia procera*.

In line with the National Forestation Program Research and Development Projects, a project on "Establishment and Management of SPAs (Seed Production Areas)" was conducted. One study under the project was called "SPA's in Forest Plantation". In this 5-year study by Lustica and co-workers (1999) at Dumarao, Capiz, Iloilo and Aklan, information on the seeds and phenology of *Casuarina equisetifolia*, *C. rumphiana, Eucalyptus camaldulensis* and *S. macrophylla* were obtained. Another study under this project was called "National provenance trial for narra (*Pterocarpus indicus*)". A five-year study by Favila (1996) compared five different provenances of *P. indicus* at two locations (Leon National College of Agriculture, LNCA and Calinog Agricultural and Industrial College).

More provenance trials of *P. indicus* have been conducted by Matusalem (1993) in a volcanic ecosystem at Mt Mayon in Albay and by Lauricio (1997) at Bicol National Park. 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 a provenance trial in PICOP of 17 seedlots of *Acacia mangium* from Sabah (Malaysia) and Queensland. The study reported no significant differences in terms of average total height but highly significant difference was observed in terms of average dbh 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* x *A. 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* by Eusebio (1983) was conducted at Jalau Reforestation project in Calinog, Iloilo. There were nine provenances tested. The DENR has conducted provenance trials of *Pterocarpus indicus* (Matusalem 1993; Lauricio 1997; Favila 1996); *Casuarina equisetifolia, C. junghuniana, Acacia mangium, A. auriculiformis, A. crassicarpa, A. aulacocarpa, G. arborea, A. mangium x A. auriculiformis, Pinus caribaea* (Eusebio 1983); *Eucalyptus camaldulensis* (Agpaoa and Tangan 1981) and *Xanthosthemon verdugonianus* (Nasayao and German 1993). All these species are exotics except *P. indicus* and *X. verdugonianus.*

Another active area of research has been the research on mangrove ecosystems. A mangrove biodiversity inventory and assessment in Central Visayas included research to better understand the stand structure, phenology, species composition, pests and diseases as well as of silvicultural attributes and environmental factors affecting survival and growth of mangrove plantation and establishment of seed sources of selected mangrove and associated species. Provenance studies of various mangrove species in Western Visayas have also been conducted (Malabanan 1992). Rehabilitation of the NCR coastal areas has been studied by Esteban (1998) and documentation and assessment of mangrove reforestation using indigenous practices has been carried out in Bohol (Mantanilla and Melana 1992).

The UNDP/FAO Regional Project on Improved Productivity of Man-made Forests through Application of Technological Advances in Tree Breeding and Propagation (FORTIP) 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 Australian Tree Seed Center, CSIRO in cooperation with the FORTIP, ERDB, BFI and FMB established seed production areas of *Eucalyptus urophylla, Acacia mangium* and *A. crassicarpa* at Bansud, Mindoro, Malaybalay, Bukidnon and Baslay, Negros Oriental. The detailed information about the SPAs in Bansud is presented in Table 8.

Table 8. Seed production areas and seedling seed orchard established in Bansud, Oriental Mindoro

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

***Origin:** PNG = Papua New Guinea; IND = Indonesia; QLD = Queensland, Australia; MLAY = Malaysia
Source: ERDB terminal report for the project "ERDB-ATSC-FORTIP Seed Production Areas and Seedling Seed Orchard of *Acacia mangium* and *Eucalyptus urophylla* at Bansud, Oriental Mindoro"

A 1.5 ha clonal seed orchard of *Gmelina arborea* with 29 clones as well as hybridising 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 1994–95.

The National Forest Tree Seed Committee has identified seed production areas all over the country. Teams conducted a survey all over the country and identified 27 candidate plantations in ten regions. The species in the identified plantations included indigenous species (*Casuarina equisetifolia, Pterocarpus indicus* and *Vitex parviflora*) as well as exotics from different origins (*Swietenia macrophylla, Gmelina arborea, Eucalyptus camaldulensis Eucalyptus 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 dissolved later.

The Provident Tree Farms Inc. (PTFI) in southern Philippines ventured into an Industrial Tree Plantation License Agreement (ITPLA) in 1982 (Nuevo 1997). Challenged by the need to increase volume and quality of logs and fibre, this private company included tree improvement in its long-term management strategy. 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 high intensity selection of *A. mangium* from the best trees among the provenances introduced from Australia and Papua New Guinea. The PTFI also developed a technology for terminal shoot cloning 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 sticklings, which is sufficient to fulfil its planting stock requirements with some surplus for external demands (Nuevo 1997).

The DENR has selected over 50 plus trees of dipterocarps 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 seed production/collection, processing, development and marketing association was established in 1998 in Lantapan, Bukidnon. The Agroforestry Tree Seed Association of Lantapan (ATSAL) has grown from the initial 15 members to 60 members. The association has been instrumental in training thousands of farmers in seed 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 seed production and distribution system enabled smallholders to produce and market quality germplasm based on standardized methods (Koffa and Garrity 2001). The same authors described the approaches in maintaining diversity in germplasm sources in farming systems, namely: (a) work directly with genetic resources, which 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 (exotic and indigenous) tree seeds and thousands of seedlings to buyers from Mindanao, Visayas and even in Nairobi, Kenya. Since its foundation, ATSAL has earned P 3 million (US$ 60 000), which was distributed among farmer members and for the support of 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.

Non-timber forest products

An extensive research on genetic conservation and management of non-timber forest products (NTFPs) was conducted by the ERDS-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, Stenochloa palustris, Enhalus acoroides* (Balane 1994), *Scyphiphora hydrophyllaceae* (Sinohin *et al.* 1998) and anahaw (*Livistonia rotundifolia*) (Operio 1994). An integrated R&D 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 9 lists rattan plantations established by the ERDB. Table 10 gives information about certain woody and non-woody species used for medicinal purposes.

Table 9. List of rattan plantations established by the ERDB and by government and private entities (Maligalig 1988)

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

Table 10. Some important woody and non-woody species used for medicinal purposes (Palis 1995)

Species	Family	Part used	Medicinal Value
Aglaia formosana	Meliaceae	Leaf	Fever
Arcangelisia flava	Menispermaceae	Roots	Abortifacient
Calophyllum inophyllum	Guttiferae	Leaf	Chest pain
C. succirubra	Rubiaceae	Bark	Malaria
Cinnamomum mercadoi	Lauraceae	Bark	Headache/rheumatism
Cratoxylum celebicum	Guttiferae	Leaf/bark	Chest pain
Dipterocarpus grandiflorus	Dipterocarpaceae	Resin	Skin rashes
Eucalyptus deglupta	Myrtaceae	Bark	Stomach ache/fever
E. saligna	Myrtaceae	Bark/leaf	Stomach ache/fever
Mussaenda philippica	Rubiaceae	Bark	Stomach ache
Syzygium brewistylum	Myrtaceae	Bark	Fever
Trema orientalis	Ulmaceae	Bark/leaf	Cutwound, hemorrage

Use of biotechnology for characterization and protection of FGR

The first and only work on characterization of timber species using molecular markers in the Philippines is 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 and 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, and the predominantly outcrossing nature of the population was noted (De Guzman 1996). Pollen competition and/or early selection against selfed progenies 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 as well as more studies to elucidate mating patterns of other tropical trees were suggested (De Guzman 1996).

Socioeconomic conditions and issues related to the conservation, utilization and management of FGR

Socioeconomic threats to genetic resources

The exponential population growth of the country, aggravated by the inability of the government to implement meaningful population control programmes has caused significant segments of the society to migrate in the uplands. It has been estimated that of the 80 million Filipinos, 25% will live in the upland areas in 2003 (≈ 20 million people). The absence of sustainable livelihood options in these areas puts additional stress to the remaining natural resources, which become sources of "quick income". Kummer (1990) added that in-migration to the uplands will continue to increase due to the following reasons: (1) increasing poverty and overcrowding in the major urban areas; (2) increasing landlessness of lowland Filipinos; (3) technological change in the agricultural sector which is labour-replacing; and (4) the increasing percentage of agricultural land being devoted to non-food crops. Kummer further added that the economic difficulties in the country would put additional pressure on the mining and forestry sectors to generate the much-needed foreign exchange. Furthermore, the demand for alternative sources of energy, particularly fuelwood and dendrothermal plantations will increase the demand for natural resources. Increased mobility through new road infrastructures would make it easier for people to access even remote uplands. Based on these accounts and the current trends in the country, it appears that the threats to the FGR are tied up to the larger picture of poverty and poor economic development in the country.

Status of forest resources and utilization of trees

Logging operations and production of roundwood peaked in the 1970s, but showed a marked drop by the 1980s and was significantly low in the 1990s, as the supply from the natural forests had greatly diminished (Figure 4). On the other hand, production of processed wood products (lumber, veneer and plywood) was not noticeably high during the peak years of log production indicating that a only a small portion of the logs produced were

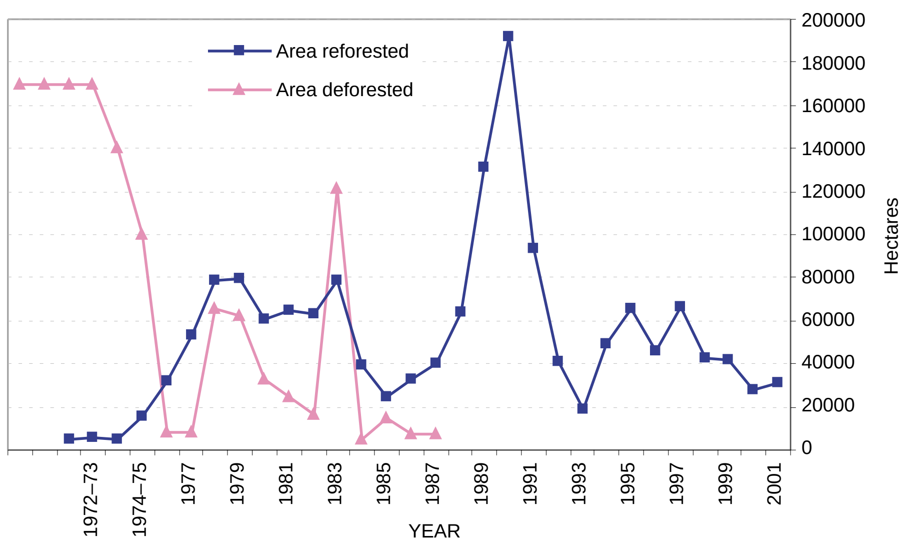

Figure 4. Production of roundwood and processed wood products from 1971 to 2001 (DENR 2001)

processed within the country. Nevertheless, production of the processed products also nose-dived with the decrease in supply of raw materials in the 1990s. These figures clearly indicate how quickly the wood resources of the country were depleted in less than a century.

Figure 5 indicates that the contribution of the forestry sector to the country's Gross National Product (GNP) used to be very significant at the peak of logging operations, but by the 1990s it has become insignificant. In spite of this, it must be mentioned that GNP reflects only those goods and services to which economic measures or instruments are currently used and accepted. The true value of the forests in terms of goods and services they provide for the society (especially to the rural poor) is not truly reflected in the current instruments for expressing the GNP.

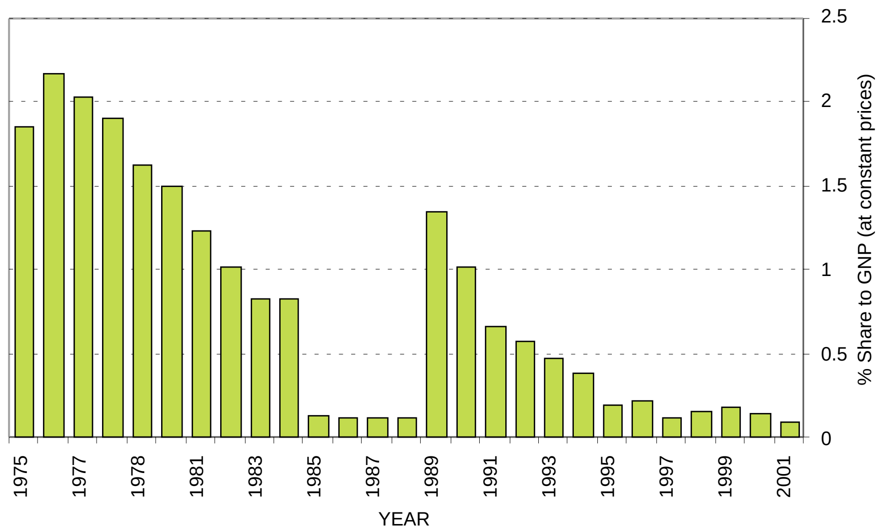

Figure 5. Percent share of forestry to the GNP at constant prices from 1975 to 2001 (DENR 2001)

The shrinking local supply of logs and the increasing demand for wood products has forced the country to import logs from other countries since the early 1990s. Figure 6 depicts the lamentable situation of how a former log exporter became a net log importer.

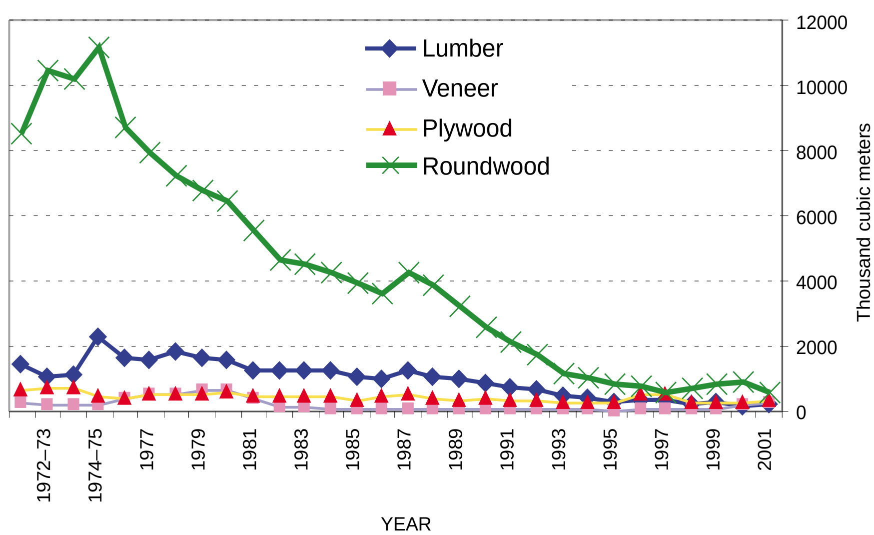

Figure 6. Roundwood import and export in the Philippines (DENR 2001)

Identification of threats

The rates of deforestation and reforestation in the Philippines (Figure 3) show the gravity of the environmental problem that threatens the country's FGR. Reforestation has feebly caught up with this enormous rate of deforestation, which peaked at almost 300 000 ha yr^{-1}. The reforestation rate has not been very consistent, indicating the lack of a strong, consistent and focused programme to turn the tide against forest destruction.

The massive destruction of forest ecosystems results in habitat fragmentation that displaces or threatens important pollinators of plants and trees. Bats, insects and birds that are important for the pollination processes in angiosperms are adversely affected by environmental upheavals. This is even aggravated by the archipelagic nature of the country where endemism is considered high. The multi-island character of the country makes these fragile ecosystems very vulnerable to forest destruction.

Simple species introductions were conducted earlier with *Swietenia macrophylla* and *Paraserianthes falcataria* (Moluccan sau) that are now considered naturalized exotics because these species have become components of industrial tree plantations. The only big mistake in adopting *P. falcataria* as a plantation species was the establishment of large plantations from only a single seed source. Except for the efforts done by PICOP in introducing the Solomon variety of *Paraserianthes falcataria* and acquisition of additional provenances, there has not been any effort done to broaden the genetic base of *Paraserianthes* and *Swietenia*. The outbreak of gall rust disease in Mindanao, which wiped out the Bukidnon plantations and infected all other areas in Luzon could be attributed to the narrow genetic base that was inherent in the said plantation (Garcia 1999).

The lack of knowledge of some rattan harvesters threatens certain species. An example is sika rattan (*Calamus caesius*), which is a monopodial and solitary rattan. Cutting their tops virtually kills the plant, unlike other species that reproduce in clumps. The increasing liking and demand for health drinks is also threatening some species. The bark of *Pterocarpus indicus* is now widely harvested for manufacture of herbal tea, which is claimed to have medicinal value. *Antidesma bunuis* (bignay), another indigenous tree species, is valued for its supposed aphrodisiac effects particularly for males.

Identification of exotic invasive forest trees

Very limited work has been done on invasive forest species in the Philippines. In three independent BSc studies in the Makiling Forest Reserve (Alvarez 2001; Castillo 2001; Phuntso 2002) it was found that the large-leaf mahogany (*Swietenia macrophylla* King) was encroaching into the natural forest. The studies also indicated that the species diversity in natural forests diversity dropped as mahogany gained. Phuntso (2002) found that extracts of mahogany inhibited the growth of *Pterocarpus indicus* wildlings. Mahogany was originally introduced to the reserve in 1913 from Calcutta, India, and has been widely planted by the government in reforestation projects and even in protected areas.

Links between forestry sector and FGR

The Philippine forests have been very vital source of genetic material for regular reforestation projects, agroforestry farmers and other tree planters in the country. Likewise, the diverse genetic resources of the Philippine forests have been important sources of ingredients or additives in various manufacturing and processing industry, such as the pharmaceutical industry.

Identification of national priorities

List of priority species for FGR conservation and management

Most of the conservation programmes in the Philippines focus on the ecosystem level. The NIPAS and NIPAP are a testimony to the thrust of preserving whole ecosystems and not simply species or even genes for that matter. This is certainly favourable as far as *in situ* conservation is concerned since the different genes are able to thrive and grow in the natural environment where they have developed and evolved over time. Thus, the priority sites and project areas identified in the aforementioned programmes (Appendix 2 and 3) are ideal for this purpose. Based on the official records, the DENR, which is the government agency responsible for environmental concerns such as FGR conservation, has not made any official list of priority species for conservation and management. Nevertheless, it has subscribed to the protection and conservation of ecosystems where endangered species can be found (Table 11). Furthermore, the DENR Administrative Order (AO) No. 78 was issued regulating the cutting of the following species: *Pterocarpus indicus* and other premium hardwood species, i.e. *Vitex parviflora*, *Dracontomelon dao*, *Diospyros philippinensis*, *Intsia bijuga*, *Samanea saman*, *Serialbizzia acle*, *Mastixia philippinensis*, *Wallaceodendron celebicum*, *Litsea leytensis*, *Madhuca betis*, *Diospyros pilosanthera*, *Toona calantas*, *Wrightia laniti*, *Tarrietia javanica*, *Pistacia chinensis*, *Sindora supa*, *Tectona grandis*, *Afzelia rhomboidea* and *Koompassia excelsa*. *Acacia* (rain tree) was later delisted in 1992 by virtue of DENR AO No. 46. Cutting of *Agathis philippinensis* is totally banned in any part of the country by DENR AO No. 74 Series of 1987. In essence, establishing regulation of harvesting or a total cutting ban is a policy move directed towards the conservation of the aforementioned species.

Zabala (1996) in his proposal for a National Tree Improvement Programme for the Philippines inferred the national priority species for breeding and propagation based on the projected increased demand for timber, pulpwood and fuelwood by tree farmers and industrial tree plantation developers. These are *Gmelina arborea, Swietenia macrophylla, Acacia mangium, Paraserianthes falcataria, Pterocarpus indicus,* Dipterocarp species, *Eucalyptus deglupta* and *Pinus kesiya*. Intuitively, if these are the priority species for tree improvement, it will follow that the conservation of their genetic resources is a priority.

Table 11. Some endangered forest tree species in the Philippines

As defined in the 1980 IUCN report (after ERDB 1999)*	Under the Provision of CITES (after Florido 1993)	After Fernando *et al*. 2001
1. *Agathis philippinensis* (almaciga)	1. *Agathis philippinensis* (almaciga)	1. *Afzelia rhomboidea* (Blanco) Vidal
2. *Serialbizia acle* (akle)	2. *Litsea leytensis* (batikuling)	2. *Agathis philippinensis* Warb.
3. *Areca ipot* (bungang-ipot)	3. *Heritiera sylvatica* (dungon)	3. *Dacrycarpus imbricatus* (Blume) de Laub.
4. *Dracontomelon dao* (dao)	4. *Podocarpus imbricatus* (igem)	4. *Glenniea philippinensis* (Radlk.) Leenh.
5. *Toona calantas* (kalantas)	5. *Intsia bijuga* (ipil)	5. *Heritiera sylvatica* Vid.
6. *Dracontomelon edule* (lamio)	6. *Toona calantas* (kalantas)	6. *Hopea malibato* Foxw.
7. *Wrightia lanitii* (lanete)	7. *Xanthostemon verdugonianus* (mangkono)	7. *Intsia bijuga* (Colebr.) O. Ktze.
8. *Calamus merrillii* (palasan)	8. *Pinus merkusii* (Mindoro pine)	8. *Litsea leytensis* Merr.
9. *Tectona philippinensis* (Philippine teak)	9. *Pistacia chinensis* (sangilo)	9. *Pinus merkusii* Jungh. & de Vriese
10. *Cinnamomum mindanaense* (Mindanao cinnamon)	10. *Sindora supa* (supa)	10. *Podocarpus costalis* Presl.
	11. *Afzelia rhomboidea* (tindalo)	11. *Sindora supa* Merr.
	12. *Hopea malibato* (yakal-kaliot)	12. *Tectona philippinensis* Benth. & Hook. f.
		13. *Toona calantas* Merr. & Rolfe
		14. *Xanthostemon verdugonianus* Naves

* Under the IUCN classification, all the species listed here belong to **CATEGORY B**, meaning these species are potentially threatened and are vulnerable. Their populations are steadily being reduced to a critical low number due to continued destruction of their niches or due to heavy collection of wild stocks for commercial purposes.

Criteria or justification for selecting the priority species

In the absence of an official list of priority species, the selection of the aforementioned species was based on their economic uses to the forest products industry and upland communities. Additionally, their current conservation status based on IUCN or CITES was also used as basis, as well as individual studies by biodiversity experts (Fernando *et al.* 2001).

Economic importance or value of the priority species

The ERDB (1999, 1993), which listed the CITES and IUCN classifications of endangered species also included a comprehensive list of the economic value of the identified species. Uses ranged from heavy wood construction purposes to light wood construction or furniture making (e.g. *Hopea malibato, Afzelia rhomboidea, Sindora supa, Pinus merkusii, Intsia bijuga*). There are also species identified for novelty purposes (*Litsea leytensis, Pistacia chinensis*) or for extractives (*Agathis philippinensis*). Clearly, the species should be valued both by the large and small-scale industries needing raw materials either as wood or tree parts, or extractives for their manufacturing or processing needs.

Institutional framework and capacity-building activities

Institutions and organization involved in FGR conservation and management

The Philippine Government encourages multi-sectoral involvement in the conservation and management of forest biological and genetic resources. Non-government organizations, academia and some local institutions and people's organizations aside from the government agencies form the core of institutions/organizations that are involved in the conservation of natural resources.

The national government

Department of Environment and Natural Resources (DENR)

The DENR, the lead government agency that is composed of six Staff Bureaus[3], is mandated to manage the country's natural resources pursuant to EO No. 192. The Forest Management Bureau (FMB) and the PAWB are mandated with the responsibility to oversee forestland use, management, reforestation and social forestry, and protected areas management. The ERDB performs the research functions of the DENR, while forest monitoring and education services are conducted by the Environmental Management Bureau (EMB).

Department of Science and Technology (DOST)

The DOST has the Philippine Council for Agriculture, Forestry and Natural Resources Research and Development (PCARRD), which is mandated to monitor and evaluate research on agriculture and forest resources. The PCARRD also prepares materials and other publications on the technologies for the management, conservation and protection of forests. The PCARRD recently formulated a National Biotechnology Research and Development Program aimed at improving yields and quality of selected crops through social marketing and technology transfer. Programmes that focus on capability building, acquisition of technologies, forestry and environment, among others, are DOST's priority areas for research and development.

Philippine National Museum (PNM)

The PNM is tasked with the collecting, identification and curing of biological specimens of all faunal and floral biodiversity for research information and training. It also serves as the largest depository of plant and animal collections. It also conducts projects on biodiversity inventory and conservation. It has established a Biodiversity Information Centre that is tasked with biodiversity data management and information dissemination.

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[3] Staff bureaus refer to the bureaus of the DENR responsible for the formulation of policies on environment and natural resources in contrast to Line bureaus, which are regulatory in nature.

Institutions with technological facilities

The National Mapping and Resource Information Authority (NAMRIA), the central mapping and land classification agency of the DENR, has remote sensing facilities. The Bureau of Soils and Water Management (BSWM) of the Department of Agriculture (DA) provides soil and land use maps, which can be integrated to generate forest and vegetation maps. The centres of biotechnology research are the National Institutes of Biotechnology and Applied Microbiology, University of the Philippines Systems and the Department of Science and Technology. The ERDB-DENR maintains a rattan genebank, bambusetum and palmetum at different locations. UPLB and UP Diliman also maintain a genebank of medicinal plants.

Other government agencies

Other agencies such as the Department of Tourism (DOT), National Power Corporation (NPC), Philippine National Oil Company (PNOC) and National Irrigation Administration (NIA) have jurisdiction on some of the country's national parks and watershed reservations throughout the country (Fernando *et al*. 2001).

Academic institutions

The University of the Philippines System (UPS), supported by its academic departments, research centres and institutions in various campuses, contributes to the basic and applied research on biodiversity conservation at all levels (gene, species and ecosystem level). The Makiling Centre for Mountain Ecosystems of the UPLB College of Forestry and Natural Resources (MCME-UPLB-CFNR) serves at the forefront of biodiversity conservation activities (Fernando *et al*. 2001). Likewise, other major state and private universities such as Silliman University, Mindanao State University, Western Visayas State University, Leyte State University, Central Mindanao University, Dela Salle University, University of San Carlos and Central Luzon State University also contribute to biodiversity research, conservation and management.

Other research institutions

The SEAMEO Regional Centre for Graduate Study and Research in Agriculture (SEARCA) based at the UPLB is a regional body aimed to foster cooperation among Southeast Asian countries on resource development, research and extension in sustainable agriculture and resource management (PAWB 1998).

The ASEAN Regional Centre for Biodiversity Conservation (ARCBC) coordinates all initiatives in enhancing the capacity of ASEAN on biodiversity conservation by setting up research agenda for the region. ARCBC's major components (networking, training, research and database) aim to intensify biodiversity conservation through improved cooperation in a comprehensive regional context, by assisting and setting-up a framework of institutional links among ASEAN member countries and between ASEAN and European Union partner organizations. The DENR is the executing agency for the project.

Non-government organizations (NGOs)

Non-government organizations also contribute to the promotion of biodiversity research. Although research projects conducted by this group are few and small in scale, NGOs have served as effective partners in research, being located on-site. They are also important potential users of research results in biodiversity management. There are also NGOs that provide funding to forestry projects implemented by other NGOs and people's organizations. These include the Foundation for the Philippine Environment, the Haribon Foundation, World Wildlife Foundation-Philippines, and the Philippine Business for Social Progress. Besides providing funding, these NGOs also educate the public on forest and natural resources conservation. The Philippine Centre for Plant Conservation and the Wildlife Conservation Society of the Philippines, both members of the scientific community, also conduct basic research on plant and animal species conservation.

National legislation, policies and strategies on FGR

The growing concern for the environment and proper utilization of the natural resources for economic development has resulted to the enactment of some policies advocating the protection of the country's resource base. Specific policies and legislations and their implementation are briefly mentioned below.

Act No. 315 and Republic Act No. 826

Enacted in 1932, Act No. 315 is one of the earliest legislations related to biodiversity conservation and management, providing for the establishment of national parks and declaring e.g. game refuges for 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. Through the Republic Act No. 826, a Commission on Parks and Wildlife was created in 1952 under the supervision of the President, 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 was enacted in 1975 and provides the major framework for the management, conservation and utilization of the forest resources in the country. PD 705 mandated the BFD with the responsibility for protection, development, management and preservation of national parks, game refuges and wildlife. The law declares occupation of national park system as well as recreation and vandalism activities therein illegal.

Executive Order No. 192

Through Executive Order No. 192, the DENR is tasked with the prime 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 (Garcia 1999). EO 192 created, among others, the PAWB that is mandated to consolidate all government efforts in the conservation of natural biological resources, specifically through institutionalisation of the NIPAS. The PAWB pursued the enactment of the NIPAS Law or Republic Act (RA) No. 7586 of 1992.

Republic Act No. 7586

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, which mandated the DENR for its implementation. Considered ambitious, it contained the twin objectives of biodiversity conservation and sustainable development against a backdrop of rapid loss of forest lands and other critical areas, lack of political will and social concern for park conservation and series of changes in the administration of national parks since the 1950s (DENR-UNEP 1997). The law has the following specific provisions:

1. Creation of a Protected Area Management Board (PAMB)
2. Identification of protected area categories
3. Establishment of a standard planning process
4. NIPAS administration by the DENR, specifically the PAWB
5. Establishment of the Integrated Protected Areas Fund (IPAF)
6. Recognition of ancestral rights and the policy of community sustainability
7. Institutionalisation of the environmental impact assessment

As early as 1998, 34 protected areas were proclaimed under the NIPAS category with a total area of 1 442 720 ha. The regional offices of the DENR also identified 25 old growth and mossy forests that have been proposed for inclusion in the protected area system (Garcia 1999). In the same year, the PAWB designed the Biodiversity Monitoring System (BMS). This is a standardized monitoring system designed to improve the information available for decision-makers in protected areas through the regular collection of data with focus on priority species and natural resources utilization (Molinyawe and Delos Reyes 2003). In 2000, the BMS was institutionalized through the issuance of the DENR AO No. 13 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 PA management. Information gathered through the BMS serves as a guide for the actions of the PAWB, protected area staff, local government units and communities in natural resource and protected area management. The BMS has been installed in 30 protected areas nationwide.

Executive Order No. 247

The need for a comprehensive policy to regulate the access to the genetic resources of the Philippines was felt as early as the mid-1980s. The government agencies that then regulated the collecting of biological specimens were, among others, the BFD for terrestrial species, the Bureau of Fisheries and Aquatic Resources for marine species and the Philippine National Museum. In 1987, the DENR's role in regulating collecting activities was pursued through the creation of the PAWB. In 1990, the government agencies and academic institutions adopted a Memorandum of Agreement (MOA) entitled *Guidelines for the Collection of Biological Specimens in the Philippines*, but it fell short of its objective of providing the government a regulatory framework for bioprospecting (La Viña *et al*. 1997). EO No. 247 enacted in 1995 is an attempt to remedy the inadequacies of the former system by establishing a comprehensive and effective regulatory framework for bioprospecting. EO No. 247, also called the Bioprospecting Law, prescribes the guidelines and establishes a regulatory framework for bioprospecting of biological and genetic resources, their by-products and derivatives for scientific and commercial and other purposes. This law is in line with the provisions of the CBD to which the Philippines is a signatory. The law declares that *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*.

Bioprospecting in ancestral lands and domains will be done with a prior informed consent (PIC) of the indigenous cultural communities. Bioprospecting activities and projects also require Academic or Commercial Research agreement between the government and those undertaking such activities. Limits on the quantity of samples/specimens to collect are set, and the collector is required to deposit at the PNM a complete set of specimens collected. The agreements also include benefit sharing in terms of royalties to the national government, local or indigenous community and individual person or designated beneficiary in case a commercial use is derived from the biological and genetic resources.

Republic Act No. 9147

This legislation is known as the Wildlife Resources Conservation and Protection Act, enacted in 2001, and provides for the conservation and protection of wildlife resources in protected areas and critical habitats. It also assigns jurisdiction to the DENR over all terrestrial plants and animal species and to the DA over all aquatic plants and animals. The DENR Secretary will determine whether any wildlife species or subspecies are threatened and classify them as critically endangered, endangered, vulnerable or other categories based on scientific data and internationally accepted criteria. The act also allows collecting of wildlife for scientific or breeding propagation purposes as well as for 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.

Other legislations and policies affecting genetic resources conservation

Presidential Decree No. 705

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 for the conservation, utilization, and development of natural resources to provide optimum yield on a continuing basis. This was followed by the DENR AO 45 (1992) that 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 access to and extraction of mangrove forest resources (DENR-UNEP 1997).

Republic Act No. 7303

Republic Act No. 7303 or 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 UPLB with leadership in plant biotechnology activities related to plant improvement, genetic resources conservation and *in vitro* mass production of planting materials.

Links with other initiatives

Some of the policies and national legislations were pursued as a response to fulfil the country's obligations to international agreements. Foremost among these agreements is the CBD, to which the Philippines is a signatory. Essential elements of the Convention include a commitment by governments to survey the natural living resources and to conserve sites noted for rich biological diversity, as well as threatened species and domesticated varieties (Umali 1993). The Convention also promotes access to biodiversity and genetic resources subject to prior informed consent of those who possess traditional knowledge of the genetic resources (Catibog-Sinha 1993; Ampeso 1993; Leonen 1993).

The Philippine government has been supportive of the provisions of the CBD even before its ratification in 1993. The DENR, through the PAWB pursued the preparation and legislation of RA7586 or the NIPAS law that provides for the establishment and management of the NIPAS. At present it has established and proclaimed 34 protected areas throughout the country with a total area of about 1 443 000 ha. Identification and evaluation of other possible protected areas has been continuing for future establishment as protected areas. The EO247 is also an offshoot of the CBD. Specifically, the EO247 complies with the provision on PIC and access to genetic resources by local communities where genetic resources are collected.

Other international agreements that are related to the conservation of biological diversity include (DENR-UNEP 1997; PAWB 1998):

- The Convention of International Trade in Endangered Species of Wild Fauna and Flora (CITES): CITES attempts to prevent commercial trade of plants and animals that are in danger of extinction and to control the trade of such species. The identification of these species provides legislation for their control and regulation.
- International Union for the Conservation of Nature and Natural Resources (IUCN): IUCN is an international body that monitors and assists member countries' efforts in protected areas management and establishment. The Philippines has been a member since 1962.

- ASEAN Declaration on Heritage Parks and Declaration on Environment: Mt. Ilit Baco National Park and Mt. Apo National Park were listed as ASEAN Heritage Parks to conserve endangered species – the Philippine tamarraw and the Philippine eagle, respectively. The declaration as heritage parks was signed in 1984 and the NIPAS law strengthened their status as protected areas.
- General Agreement on Tariffs and Trade (GATT): This international agreement requires adoption of the intellectual property rights under the Trade-Related Aspects of Intellectual Property Rights (TRIPS) accord. This agreement provides the option to patent plant varieties or to adopt an effective special form of protection. Major relevant laws related to this agreement are the RA 7308 or the Seed Industry Development Act and RA 7900 known as the High-Value Crops Development Act.

Biosecurity regulations and legislation regarding access, property rights and benefit sharing

The most significant law regarding biosecurity, access, benefit sharing and biodiversity of biological and genetic resources is the Executive Order No. 247, popularly known as the Bioprospecting Law, in compliance with the CBD. Article 15 of the Convention calls for Governments to take legislative, administrative or policy measures to facilitate access to genetic resources, with prior informed consent and provisions for sharing of benefits for the use of genetic resources (Catibog-Sinha 1993; PAWB 1998). The Philippines was one of the first to respond to this call through EO 247.

The EO 247 is a framework for regulating prospecting activities, requiring prior informed consent from the government and local communities, Protected Areas Management Boards and concerned private landowners. It also requires minimum terms for academic and commercial research agreements, benefit sharing, and an institutional structure that serves as an authority for regulating access (La Viña *et al.* 1997; PAWB 1998). Measures to regulate access are considered a primary means to promote benefit sharing. These benefits range from monetary to non-monetary benefits, subject to mutually agreed terms. Examples of these benefits are the transfer and development of technology including biotechnology.

Training and capacity building

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 likewise true for FGR conservation as these two concerns are closely related. Prior to 1996, there were hardly any researchers trained either in tree improvement or FGR conservation and management. 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 FGR conservation. The UPLB has a graduate programme focusing on Plant Genetic Resources Conservation, but most of the students and faculty involved are from the agricultural side, considering that the programme is based at the College of Agriculture. One professor from the CFNR is involved in the programme.

Public awareness efforts

The NIPAS programme contains proposals for intensive information, education and communication with local communities and the public in general. The DENR, for its part, 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. 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, which are not yet carried out today.

Proposals for regional and international collaboration

International and regional cooperation schemes

The following international and regional collaboration and cooperation schemes are proposed:

1. Human resources development for FGR conservation in the form of study tours, short-term trainings and post-graduate programmes
2. Establishment of IPGRI satellite offices to strengthen the institute's local presence in each country and to promote FGR conservation in each locality
3. Collaborative research through visits or scientist exchange programs
4. Establishment of a Centre for FGR Conservation or support to the national tree improvement programmes through technical assistance and equipment/ infrastructure grants
5. A sustained and vigorous information, education and communication programme that integrates species and genetic level conservation to the biodiversity conservation, particularly for policy makers and field managers

Conclusions

Summary of country priorities

The following is a summary of the priorities of the Philippines for FGR conservation and management:

a) Policy programmes on conservation and management of FGR integrating species and genetic diversity levels with ecosystem conservation, which is the current focus. This may include integration of genetic resources conservation in the community-based forest management areas.
b) Enactment of a Seed Law to regulate production, use and trade of high quality seeds and seeds of high value species.
c) Human resource development for FGR conservation in the strategic institutions (DENR, ERDB, state universities and colleges).
d) Establishment and implementation of a National Tree Improvement Programme to be based in an institution that will be provided with adequate support to sustain tree improvement activities.
e) Establishment of a FGR Conservation Centre. The University of the Philippines, College of Forestry and Natural Resources does not have a laboratory for molecular studies. The proposed centre would spearhead research and programmes – including policy advocacy – for effective national FGR conservation. The proposed centre should have proper equipment for a DNA technology laboratory. The centre could be housed in the existing Forest Biotechnology Laboratory. In addition, complementary human resource development is required to strengthen the present staffing pattern.

Research needs

a) Reproductive biology of priority commercial timber and non-timber forest species
b) Characterization of populations of endangered species and priority timber species using isozyme and DNA markers
c) Mating system and paternity analyses of priority species
d) Application of molecular/Quantitative Trait Loci (QTL) markers in selection and breeding for pest and disease resistance, wood quality and other traits
e) Bioprospecting
f) Community-based FGR conservation in Community Based Forestry Management areas

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Appendix 1

General information about the National Parks in the Philippines *(PAWB undated)*

Region	National parks		Game refuges and bird sanctuaries		Wilderness areas		Municipal forest parks		Barangay forest parks		TOTAL	
	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)	No.	Area (ha)
Philippines TOTAL	**62**	**480 794**	**7**	**939 886**	**10**	**22 996**	**36**	**202.55**	**64**	**115.8**	**179**	**1 433 944.35**
Region 1	8	27 456					5	48.08	8	9.02	**21**	**27 513.10**
Region 2	4	5011	1	6003	2	19 374	4	8.24	11	18.79	**22**	**30 415.03**
Region 3	9	37 070					5	13.51	4	7.81	**18**	**37 091.32**
Region 4	9	202 654	4	903 403	1	175					**14**	**1 106 232.00**
Region 5	6	24 811			3	465					**9**	**25 276.00**
Region 6	2	23 505									**2**	**23 505.00**
Region 7	4	23 577	1	480	2	567					**7**	**24 624.00**
Region 8	5	4060					1	3.88	1	6.84	**7**	**4 070.72**
Region 9	3	3323					1	2	8	28.03	**12**	**3 353.03**
Region 10	2	53 319			2	2 415	5	51.12	22	38.13	**31**	**55 823.25**
Region 11	2	53 643					15	75.72	10	7.18	**27**	**53 725.90**
Region 12	7	22 282	1	30 000							**8**	**52 282.00**
NCR	1	83									**1**	**83.00**

Appendix 2

General information about the ten priority sites for the National Integrated Protected Area System (NIPAS) (Manila 2000)

The ten priority sites, which were chosen on the basis of their biogeographical location, legal status, size, peace and order and the need for financial support are as follows:

1. **Batanes Islands Protected Landscapes and Seascapes**. The site can be described as a harsh, but beautiful land of gentle people. It is located at the northernmost part of the country and often battered by yearly typhoons. In the course of time rain and wind have carved a unique and picturesque land, which is home to the Ivatans. It is a flyaway for migrating birds that roost all over the islands, including in areas of human settlement.
2. **Northern Sierra Madre Natural Park**. This park encompasses the largest block of species-rich primary lowland evergreen rainforest in the Philippines. The extraordinary high bird diversity, e.g. Philippine eagle, led scientists to rate the park among the most important areas for the conservation of biodiversity.
3. **Subic-Bataan Natural Park**. Subic-Bataan is the home of the Negritos and Aetas. The park is the site of remaining vestiges of primary forests in the Zambales Biogeographic Zone that harbours high variety of birds and mammals (e.g. flying foxes/fruit bats).
4. **Apo Reef Natural Park**. Apo Reef is the largest atoll-formed reef in the country. It exhibits a variety of habitats and has one of the richest concentrations of marine-related organisms. Its three islands; Apo, Binanggan and Cayos del Bajo, serve as rook-run and homing grounds for migratory and resident birds species, especially the endangered Nicobar pigeon.
5. **Mt. Kanlaon Natural Park**. This is the only natural park in the Negros-Panay faunal region. This active strata volcano still harbours sizeable remnants of the fast disappearing tree species, such as the lowland dipterocarps. The cool climate around the park attracts cock breeders and orchids/cut flower growers in the buffer zone.
6. **Turtle Islands Wildlife Sanctuary**. This Sanctuary is the major nesting site of the globally endangered green sea turtle (pawikan). The islands also harbour outstanding geologic features like the mud volcanoes in Lihiman and Langaan Islands.
7. **Mt. Kitanglad Range Natural Park**. This natural park contains the second highest peak in the country, and harbours three important habitat types, namely, lowland evergreen rainforest, mid-montane forest and upper montane forest. It dominates the Bukidnon plateau and plays a vital role in the socioeconomic condition of the surrounding areas. Aside from being the homeland of indigenous people, it is also a major watershed that provides water for power generation, irrigation and domestic use to Bukidnon and other adjoining provinces of Mindanao.
8. **Mt. Apo Natural Park**. Mt. Apo is the Philippine's highest peak characterized by very diverse habitat types. It is the storehouse of biodiversity and of scenic spots, such as waterfalls, mountain lakes and sulphuric hot springs. It is the home of the endangered Philippine eagle.
9. **Agusan Marsh Wildlife Sanctuary**. This is the flood plain of the Agusan-Davao area in Eastern Mindanao. It is the area of confluence of different tributaries of the Agusan River, which drains the Diwata Mountain Ranges of Surigao provinces in the south. It also holds the largest expanse of freshwater wetland habitat types in the country. Moreover, it is said to be the wintering ground for hordes of migratory birds, crocodiles and some characteristic species like the soft-shell turtles. The floating houses of the Manobos are also a distinctive feature of the area.
10. **Siargao Islands Protected Landscapes and Seascapes**. Siargao Islands offer breath-taking sceneries comparable to the best in the world. Its white sandy beaches, blue lagoons and crystal clear waterfall make it a nature lovers' paradise. The extensive mangrove forest serves as sanctuary for vast number of organisms as well as buffer against the impacts of storms.

Appendix 3

General Information about the eight sites under the National Integrated Protected Areas Programme (NIPAP) (Manila 2000)

1. **Mt. Pulag National Park**. Mt. Pulag is the second highest peak in the country and the Park is home to the Kalanguyas/Ibalois. It is the habitat of dwarf bamboo found at its summit, cloud rat and Koch's pitta as well as mixed *Pinus kesiya*-dipterocarp vegetations at the lower elevations. The park has a number of mountain lakes, mummy caves and ancient burial grounds.
2. **Mt. Isarog National Park**. Mt. Isarog National Park is drained by 18 rivers and 5 creeks flowing partially through ground channels and a series of waterfalls, crystal caverns, gorges and canyons. It is the habitat of the unique fruit bats at 1966 meters above the sea level.
3. **Mt. Iglit-Baco National Park**. This park occupies an area of 77 000 hectares situated in the heart of Mindoro Island, which is home to a large number of threatened endemic wildlife, including the tamaraw and the Mindoro pine (*Pinus merkusii*). Moreover, the park is home to the Mangyan.
4. **Mt. Guiting-Guiting National Park**. The area was declared as a natural park in February 1996, covering 46 000 hectares of forest located in Sibuyan Island, Romblon Province. It has a unique forest with a density of about 1550 trees per hectare, which is one of the most dense in the country.
5. **Coron Island**. Coron Island is the home to the Tagbanuas. The island is surrounded by narrow sandy beaches with sheer vertical limestone cliffs extending as outcrops often up to two kilometres inland, which is ideal for swallow birds nest. It has eight brackish lakes.
6. **Malampaya Sound**. This site has an area of 10 000 hectares of dipterocarp forest, mangrove forest (with 8 mangrove species) and marine/coastal environments, which support several endemic and threatened species of dugong, estuarine crocodile, Irriwady dolphins and finless porpoises. It is home to the Bataks.
7. **El Nido Marine Reserve**. This reserve covers 95 000 hectares of forest and marine areas, comprising of six ecosystems that serve as habitats for 15 birds species as well as animal species, such as Palawan bear cat, civet cat and pangolin crocodiles, dugong (sea cow) and three marine turtle species.
8. **Mt. Malindang National Park**. This area is the home to the Subanen. About 60 per cent of the park is forested; eight rivers drain from it. A mountain lake (Lake Duminagat) is found at 2100 meters above sea level, which is the habitat of 16 threatened bird species, mammals and herpetofauna (snakes) as well as 16 key plant species. The very rare Philippine eagle has been sighted in this park.

Status of forest genetic resources conservation and management in Thailand

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Introduction

Thailand is situated in Southeast Asia, between the latitudes 5° and 20° N and longitudes 97° and 106° E with a total land area of 515 113 km^2 or about 52 million ha. The total forest area is 172 050 km^2 or approximately 33.4% of the country's total area (RFD 2001). This includes 164 865 km^2 of natural forest, 3551 km^2 of reforestation area and 3633 km^2 of secondary growth. The range of elevation is from sea level up to 2200 m. Climatic conditions vary from the lowland humid tropics to alpine and subtropical types. Annual rainfall varies from below 1000 mm in the north and the northeast to above 2500 mm in the south.

Thailand is topographically divided into five regions: the north, northeast, central, east and south. The northern region, which is hilly and mountainous, lies on the fringe of the Himalayan foothills, which give way to the plains of the northeast. The Chao Phraya River and its four main tributaries have formed the alluvial floodplain of the central region. The natural vegetation is extremely diverse. Thailand is one of the richest countries of the world in biological resources. This is attributed to the biogeographical location of the country, which is at the junction of the three main floristic regions, namely the Indo-Burmese, Indo-Chinese and Malesian regions (Smitinand 1989, cited by Boontawee *et al*. 1995). The Indo-Burmese floristic region prevails in the northern, northwestern and western parts of the country. The Indo-Chinese floristic region is found in the northeast, whereas the Malesian floristic type is found in the southern peninsular and in the eastern parts of the country. Therefore, the natural forest vegetation of Thailand ranges from upland pine forests on the border with Lao PDR and Myanmar in the north to lowland rain forests in the far south. It is estimated that more than 10 000 plant species make up the natural vegetation of the Kingdom (RFD 1996).

Forestry sector in Thailand

The majority of forestlands in Thailand is an asset of the state. At the present the government agencies responsible for forests are the Royal Forest Department (RFD) and the National Park, Wildlife and Plant Conservation Department (DNP). Since the founding of the Royal Forest Department in 1896 exploitation of timber, especially teak (*Tectona grandis* L.) from natural forests was carried out through a silvicultural selection practice with a minimum girth system. Teak trees with girth at breast height exceeding 212 cm were allowed to be harvested. For non-teak trees different minimum girth limits were set (RFD 1996). The silvicultural practices used in the past did not cause severe depletion of the forests. However, the country's forests have been subject to clearance and degradation for many years, though the current situation is more stable. Forests covered more than half of Thailand's land area in 1961 but they had been reduced to just over 33.4% by 2001 (RFD 2001). Demand for land for various uses, including subsistence farming and commercial agriculture, has been the main cause for deforestation. Rapid population growth has also elevated the demand for wood products and the consequent exploitation pressure on forests. Deforestation has had a severe impact on Thailand's environment and economy. Between 1981 and 1991 the rate of forest destruction was about 515 000 ha per year.

In an attempt to halt the loss and degradation of forests, the Government of Thailand imposed a logging ban in natural forests in 1989 and introduced a master plan for reforestation. The plan aims to bring back the forest cover to 40% of the nation's territory within the next 40 years. The aimed target will consist of protected forests (25%) for nature conservation, recreation and environmental protection and economic forests (15%) for production of timber and non-timber forest products (Sutthisrisinn and Noochdamrong 1998).

Scarcity of wood as well as lucrative wood prices have not stopped illegal logging despite the logging ban. Villagers also continue to clear new forest areas for agriculture. National reforestation schemes have to date had little discernible impact on deforestation. While the area of forests continues to decline, difficulties have arisen in promoting large-scale reforestation programmes. The area of plantations was about 1 139 982 ha in 2001. Between 1981 and 1990 the annual rate of plantation establishment was about 40 000 ha – less than 10% of the deforestation rate (RFD 2001). In recent years, the annual rate of plantation establishment has risen to 150 000 ha, about half of which is within the private sector. Reforestation activities have taken place mainly in the north and northeast regions of the country.

Thailand adopted a national forest policy in December 1985. The policy signals the dangers of environmental deterioration and the need to sustain wood supply in the future. These two main aspects are being addressed through improved protection of remaining natural forests, and a more dynamic approach towards plantation forestry. Private plantation activities have also been emphasized.

Tree planting has been a feature of Thailand's National Economic and Social Development Plans since 1961. Planting is carried out by the public as well as the private sector. The public sector comprises of RFD and state enterprises. In the private sector, planting is done by companies engaged in the establishment of tree plantations for industrial purposes and by community associations and individual farmers establishing woodlots and integrated land use systems. The private sector is expected to dominate tree-planting efforts in the future.

During the past 35 years, Thailand has gained a considerable amount of knowledge in tree improvement of a number of priority species. The genetic resources of several species have been conserved and developed. Twenty-three seed exchange zones have also been demarcated. It is inevitable that the present and future planting programmes will use a more diverse range of species, including many indigenous tree species. Conservation of forest genetic resources (FGR) of indigenous species must be extended. The availability of appropriate planting material of these species will enhance any tree planting effort, whether in multi-purpose forests, conservation forests or economic forests. These actions will contribute to environmental restoration and strengthening of the national economy, which in turn will contribute to the development of the region.

Conservation of forest genetic resources

Forest types of Thailand

The forests of Thailand have been classified into nine types:

i) Tropical evergreen forest
ii) Mixed deciduous forest
iii) Dry dipterocarp forest
iv) Swamp forest
v) Inundated forest
vi) Beach forest
vii) Pine forest
viii) Bamboo forest
ix) Mangrove forest

Table 1 below shows the types of forests in different regions in 2000.

Table 1. Forest areas by type and region in 2000 (in km^2) (RFD 2001)

Forest type	North	Northeast	Central	East	South	Total
Tropical Evergreen	19 833	7658	4210	6214	14 634	**52 589**
Mixed Deciduous	66 291	8889	14 439	1159	12	**90 791**
Dry Dipterocarp	8062	7929	698	24	–	**16 713**
Swamp	–	–	1	1	287	**289**
Inundates	–	362	–	–	4	**366**
Beach	–	–	–	–	114	**114**
Pine	93	42	–	–	1	**136**
Bamboo	158	380	771	107	10	**1426**
Mangrove	–	–	120	227	2094	**2441**
Total forest area	**94 477**	**25 260**	**20 239**	**7732**	**17 156**	**164 865**
Total land area	**172 271**	**167 715**	**67 216**	**36 509**	**71 402**	**515 113**

Background related to forest conservation

Conservation movements in the United States and Canada raised public awareness in Thailand and in 1941 the Forestry Act was passed. This first Act concerned with logging operations and collection of non-wood forest products, timber stamp, sawn wood control, penal provisions, transitory provisions and other miscellaneous items. The Forestry Act was followed by the National Park Act 1961, which covers the determination of national park lands, national park committee, protection and maintenance of national parks, penal provisions and transitory provision. The National Reserved Forests Act 1964 includes the determination of national reserved forests, control over and maintenance of the national reserved forests, penal provisions and transitory provisions. In 1992, the Wildlife Preservation and Protection Act was passed. This Act concerns with general provision, the national wildlife preservation and protection committee, hunting, propagation, possessing and trading in the wildlife, their carcasses and carcass products, importing, exporting, passing through and moving wildlife as well as wildlife check-points, public zoos, areas and places under prohibition of wildlife hunting, the competent officer, penal provisions and transitory provisions.

The system of protected areas in Thailand was established in 1962 with the designation of Khao Yai as the country's first national park. By 2001, the system has expanded to include 102 national parks with the total area of 52 263 km^2, 67 forest parks (in total 870 km^2), 55 wildlife conservation areas (34 897 km^2) and 48 non-hunting areas (2379 km^2). Additional parks and wildlife conservation areas are being proposed for incorporation into the system. These protected areas function as *in situ* conservation areas and FGR are generally well preserved because laws and regulations are strict. Furthermore, botanical gardens and arboreta have also been established. National conservation areas in Thailand are presented in Table 2 below.

Table 2. Natural conservation and recreation areas in Thailand, 1997–2001 (km^2) (RFD 2001)

	1997		1998		1999		2000		2001	
	Units	Area	Units	Area	Units	Area	Units	Area	Units	Area
National parks	82	42 332	87	44 182	96	48 927	102	52 226	102	52 263
Forest parks	66	860	65	867	66	851	68	852	67	870
Wildlife conservation areas	44	32 011	46	32 671	48	33 433	53	34 848	55	34 897
Non-hunting areas	43	2972	44	3101	49	3304	49	3304	48	2 379
Botanical gardens	15	56	15	56	15	58	15	58	15	58
Arboreta	49	30	53	34	53	35	54	36	54	36
Total	**299**	**78 261**	**310**	**80 911**	**327**	**86 608**	**341**	**91 324**	**341**	**90 503**

Since the 8th National Economic and Social Development Plan (1997–2001) Thailand has included conservation and rehabilitation of natural resources into a development plan to protect both the urban and rural environments. Local people as well as community organizations have been urged to play a more active role in the management of natural resources and the environment. Economic instruments have been used for controlling and supervising utilization and management in this respect. Furthermore, more efficient use has been promoted so that natural resources could be used to the greatest possible advantage for the economy as a whole, while minimizing the negative environmental impacts. Thailand has also played a greater role in regional and international levels in natural resources management.

Objectives of the Plan were: i) to ensure that utilization of natural resources is counter-balanced by rehabilitation and protection programmes and ii) to promote more effective management with the collaboration of different sectors of society, so as to achieve greater balance in ecosystems and the environment. Opportunities would be provided for local people and organizations to play a greater role in natural resources and environmental conservation within their own communities, with support from the public sector, academic experts, NGOs and business enterprises.

Strategies for natural resources and environmental management

The National Economic and Social Development Plan proposed the following major strategies to achieve the objectives set for natural resources and environmental management:

A. Rehabilitation of natural resources and environments

- Manage the rehabilitation of degraded and abandoned land to increase agricultural output and to minimize negative environmental impacts. Attention should be given to former mining sites, former shrimp ponds and farmlands abandoned because of unfavourable soil conditions, such as soil salinity, soil acidity and coastal-type soil.
- Reduce the volume and distribution of pollution in local environments by proper management of various types of pollution, such as community and industrial waste and hazardous substances so that they do not pose a threat to public health and living conditions.
- Support the establishment of a comprehensive waste treatment and disposal system, comprising of comprehensive wastewater treatment and garbage disposal.
- Promote the development of waste disposal technology and green technologies to be applied to the production processes to minimize environmental impacts. Such technology will include prototypes that may be put into commercial production. In addition, promote analysis and evaluation of technology for appropriate environmental management that can be transferred for effective application.

B. Promotion of the participation of local people and communities in natural resource and environment management

- Expand the public sector's role in promoting wider participation in natural resource and environmental management.
- Develop information networks on natural resource and environmental conservation.
- Provide more opportunities for local communities and people to participate.
- Proper management of natural resources and the environment.

C. Improving natural resource and environment management

- Establish systematic management of water resources.
- Coordinate land use policy and management consistent with and appropriate for the development potential of each area.
- Ensure sound management of community environment and green areas.
- Conserve natural and heritage sites.
- Promote a holistic, systematic approach to natural resource management.
- Improve systems for the prevention and relief of hardship and suffering caused by natural disasters.

- Improve the efficiency of public agencies involved in natural resource management, including the control and resolution of environment problems.
- Enlarge the Kingdom's role in international cooperation on environmental protection.

Past and present activities in the field of conservation, utilization and management of forest genetic resources

Thailand has long been involved in the process of FGR conservation. The process was started with Thai-Danish cooperation in tree improvement, i.e. teak in 1965 and pine and fast growing species improvement in 1969 (Sumantakul 2001). Good progress in the improvement, conservation and utilization activities have been made since then. Over the years, large teak plantations that have been developed as seed stands, provenance and clonal test plots as well as seed orchards, which were managed by the teak improvement programme, have established a broad base for future genetic replenishment. However, the above stands and plots were not established for the explicit purpose of *ex situ* conservation.

Ex situ conservation of tropical pines was initiated in 1973. The programme included both indigenous and selected Central American tropical pine species. Approximately 800 ha of provenance *cum* seed stands have been established in the highlands of northwest Thailand. This also included provenance stands for *Eucalyptus camaldulensis*. *In situ* conservation activities were initiated with a lowland source of *Pinus merkusii* in 1977. *Ex situ* conservation of eight hardwood species was initiated in 1987 (FORGENMAP 2002).

In situ conservation of lowland *Pinus merkusii*

Due to changes in circumstances, *Pinus merkusii* is not used as a plantation species in Thailand at the present. However, the species is suitable for reforestation of poor and degraded soils as well as for community forests.

The natural stands, especially in the northeastern part of the country, have been heavily exploited as a source of resin and fire sticks. Many good stands are fragmented and declining. The lowland stands that showed the best performance in provenance trials are threatened with extinction. In order to conserve the gene pool, two populations from different parts of the distribution area have been protected and managed. These are at Nong Khu, Surin province that started in 1977 with an area of 100 ha. The mixed dry dipterocarp/dry evergreen/lowland *P. merkusii* stand at Khong Chiam in Ubon Ratchathani, with an area of about 960 ha, was also protected in 1987 and is managed in order to conserve the entire ecosystem. The objectives of *in situ* conservation of *Pinus merkusii* include:

- To secure its ability to evolve and adapt to the environmental changes
- To maintain the basis for future selection and breeding activities as well as for seed sources with broad genetic base

Future conservation programme of lowland *Pinus merkusii*

Identification of populations

The following specific criteria shall be applied for the identification of conservation stands of *Pinus merkusii:*

- Genecological variation: selection can be based on knowledge of variation in specific characters among stands, e.g. morphological traits and genetic diversity assessed by molecular markers.
- Population size: must be large enough to conserve the genetic variation and provide conditions for adequate regeneration.
- Legal conservation status: legally protected occurrences preferred.
- Socioeconomic context: areas without serious human pressure, i.e. in protected areas and reserved forest areas where local people can participate in the management.
- Economic or commercial importance.
- Management options and costs of protection and management: intervention to ensure adequate regeneration should be possible.

Preliminary selection of stands for *in situ* conservation of *Pinus merkusii*

Based on the above criteria, stands in each genecological zone have been proposed for *in situ* conservation as shown below in Table 3. The details of each genecological zone have been described by Theilade *et al*. (DFSC 2000).

Table 3. *In situ* conservation stands of *Pinus merkusii* in the different genecological zones in Thailand (DFSC 2000)

Genecological zone #	Name and location of the stand
1	Paa Chumchon Khao Son, Phetchaburi
2	Phu Toei National Park, Suphan Buri
3a	Mae Sod, Tak
3b	Om koi Plateau, Omkoi; Huay Bong, Hod, Chieng Mai
3c	Doi Phra Luang, Tak
4	Khun Yuam, Mae Hong Son
5	Ban Wat Chan, Mae Cham, Chieng Mai
6	Doi Phu Kha, Nan
7a	Thung Salaeng Luang National Park, Lom Sak, Phitsanulok
7b	Phu Kradeung, Loei
8	Khong Chiam and Buntharik, Ubon Ratchathani

Possible conservation measures and management options

Some stands in each genecological zone have been proposed as *in situ* conservation stands. However, these measures are unlikely to be sufficient to safeguard the genetic base of *Pinus merkusii*. Additional conservation measures and management options in each zone are proposed and tabulated below in Table 4.

Table 4. Conservation measures for *Pinus merkusii* in Thailand

Genecological zone #	Conservation measure	Management option
1	Establishment of *ex situ* stands by using planting material (seedling or grafting) from 3 populations.	Control (if possible stop) cutting trees, resin tapping and fire stick chipping.
2	–	Protect against uncontrolled forest fires in order to enhance regeneration. Raise seedlings or wildlings in the nursery for enrichment planting.
3–7	Monitoring and applying active conservation efforts to the selected stand in order to safeguard particular stands.	Control/eliminate fire stick cutting and resin tapping.
4–5	Establish forest areas as Managed Nature Reserves.	Establish a sustainable management system of the forest jointly among foresters, local NGO and local hill tribes.
8	Establish *ex situ* / *circa situ* stands with seed collected from a broad representation of remaining unrelated phenotypes. Create a large pool containing a mix of all lowland sources.	Protect the stands against forest fires in order to enhance regeneration through the removal of inflammable materials around seedlings, followed by controlled burning. Raise seedlings or wildlings in the nursery for enrichment planting. Control fire stick cutting and resin tapping. Engage communities in an active "Partnership in conservation" Programme.

Final selection of stands where active conservation efforts should be implemented

It was confirmed and recommended that the lowland stands of *P. merkusii* at Khong Chiam, Nong Khu and Buntharik in north-eastern Thailand should be conserved as *in situ* conservation areas. Furthermore, the lowland stand at Paa Chumchon Khao Son in the southwest should be surveyed and sought to be conserved. *Ex situ* conservation should be considered as a complementary conservation strategy for four stands.

Ecosystem conservation

The rapid depletion of natural forests in Thailand during the past four decades caused a tremendous loss of genetic diversity of plants, animals and micro-organisms through the reduction of forest areas. Many tree species are endangered and some are rare at present. Therefore, conservation of ecosystems is vital for the existence of economically important plant and tree species for potential future use, including various fields of research, recreation, and tree improvement as well as mitigation of climate change.

Realizing the importance of ecosystem diversity, and to comply with Convention on Biological Diversity (CBD), *in situ* conservation of FGR through "ecosystem conservation" has been initiated in Thailand in 1999.

Objectives of ecosystem conservation

Objectives of ecosystem conservation include:

- Maintain the natural habitats of economically important species, endangered species as well as rare species and allow for natural regeneration for the diverseness of their genetic diversity
- Utilize the stands as gene pools for selection and tree improvement
- Use the sites for studies on genetic diversity, population evolution, ecosystem, flowering biology and seed production
- Serve as habitats for wild animals, plant species, undergrowth and medicinal plants.
- Serve as sites for field tours and recreational purposes
- Maintain the balance of nature and mitigation of climate changes

Methodology of ecosystem conservation

The Silviculture Research Division, RFD has initiated the Ecosystem Conservation Programme. At present, eight forest types in the national reserve forests and national parks and wildlife sanctuaries have been selected within the country. Each type is represented by three to four locations for ecosystem conservation and 15 locations have been marked out and mapped. The number of species has been counted from four permanent sample plots of 100x100 m in size. Line plot design has been used for counting in mangrove forests. Other studies, such as density, frequency, dominance and relativity studies will be done in the near future. Table 5 below shows accomplishments in the past three years.

Table 5. Details of the Ecosystem Conservation Programme in Thailand (Anon 2002)

No.	Forest type	Location	Area (ha)	Plot no.	No. of species
1.	Wet evergreen	Khao Luang National Park,	48/64	1	107
		Lansakar district, Nakhon		2	115
		Si Thammarat		3	95
				4	98
2.	Wet evergreen	Hala-Bala Wildlife Sanctuary,	400	1	116
		Sukirin district,		2	126
		Pattani		3	130
				4	100
3.	Wet evergreen with	Vieng Kosai National Park,	80	1	72
	Hopea odorata	Wang Chin district,		2	58
		Phrae		3	55
				4	63
4.	Mixed deciduous	Mae Yom National Park,	96	1	47
	with teak	Long district, Phrae		2	66
				3	61
				4	66
5.	Mixed deciduous	Um Pang Wildlife Sanctuary,	560	1	30
	with teak	Um Pang district, Tak		2	41
				3	36
				4	39
6.	Mixed deciduous	Mae Yuam National Reserve,	760	1	45
	with teak	Mae Sarieng district,		2	38
		Mae Hong Son		3	56
				4	46
7.	Dry evergreen	Mae Salid-Pong Daeng	480	1	76
		National Reserve,		2	70
		Ban Tak district, Tak		3	66
				4	79
8.	Dry evergreen	Khao Pu Luang National Reserve,	160	1	60
		Wang Namkhiew district,		2	56
		NaKhon Ratchasima		3	48
				4	61
9.	Dry evergreen	Klang Aow Forest Park,	192	1	53
		Bang Sapan district,		2	38
		Prachuab Khiri Khan		3	57
				4	63
10.	Pine with Quercus	Nam Naoh National Park,	480	1	17
	P. kesiya	Nam Naoh district,		2	26
	P. merkusii	Phetchabun		1	36
11.	Dry dipterocarp	Phupan National Park,	160	1	32
		Muang district,		2	35
		Sakon Nakhon			
12.	Dry dipterocarp	Huay Mae Dee	104	1	49
		Forest Protection Unit,		2	52
		Huay Kha Khaeng Wildlife sanctuary,		3	34
		Ban Rai district, Uthai Thani		4	41
13.	Dry dipterocarp	Phu Khao Kaew and Dong Pak	480	1	26
	with pine	Chom forests,		2	19
		Pak Chom district, Loei		3	19
				4	20
14.	Peat swamp	Bang Nara Watershed forest,	160	1	43
		Sungai Kolok district,		2	41
		Narathiwat			
15.	Mangrove	Kung Kraben forest,	128		8
		Thamai-nayai-arm district,			
		Chantaburi			

Ex situ conservation

Thailand joined the FAO-coordinated *ex situ* FGR conservation programme in 1973. Some exotic tree species have been conserved in *ex situ* conservation stands at many locations in the country. Appendix 1 shows details of the *ex situ* conservation stands in Thailand.

Ex situ conservation of selected hardwood species

The depletion of forest areas in the past four decades caused a shortage of timber production of dipterocarps and various tree legumes. Wood for general construction as well as for furniture and indoor flooring is becoming scarce. The species are endangered and genetic material is needed in the planting programmes. To ensure a good quality seed supply as well as to safeguard base populations for future breeding programmes, the establishment of conservation stands for important dipterocarp species and tree legumes has been undertaken. A programme for *ex situ* conservation of eight major timber species was implemented during 1989–93 by the RFD in collaboration with the Danida Forest Seed Centre (DFSC). Danida provided some budget and technical assistance while the research field stations of the RFD undertook the maintenance of the stands. However, it should be noted that no detailed genecological studies were made before the stands were established. Objectives of the programme included:

- Safeguarding the threatened gene pool of specific species
- Development of base populations with a broad genetic base for future selection for tree improvement programmes
- Development of documented and well-managed sources of seed supplies for plantation programmes in the future
- Provision of material for further genetic and silvicultural studies as well as investigations on management of FGR

Species for the *ex situ* conservation programme included eight major timber species in the families Dipterocarpaceae (*Dipterocarpus alatus, Hopea odorata* and *Shorea roxburghii*) and Leguminosae (*Afzelia xylocarpa, Dalbergia oliveri, D. cochinchinensis, Pterocarpus macrocarpus* and *Xylia xylocarpa* var. *kerrii*).

Locations

The *ex situ* conservation stands were established at the following sites: Silviculture Research Centre No.3 (Kanchanaburi), Silviculture Research Centre No. 5 (Kamphaeng Phet), Sakaerat Gene Conservation Station (Nakhon Ratchasima), Phitsanulok Experimental Station (Phitsanulok), Nong Khu Gene Conservation Station (Surin), and Ubon Ratchathani Gene Conservation Station (Ubon Ratchathani). The stations' responsibility was to undertake seed source surveys, selection of mother trees, seed collection, seedling preparation, site preparation, planting, maintenance and stand protection.

Five endangered seed sources with promising records from each species were surveyed and evaluated for their potential based on genetic variation, state of degradation and phenotypic appearance. Better than average phenotypes of 30 trees were selected and marked for seed collecting. Seeds sufficient to produce at least 500 seedlings were collected on an individual tree basis. The family identity by means of tagging of each seedling was maintained throughout the nursery phase. Seedlings were root pruned as required and hardened prior to field planting.

Seedlings of the different families were arranged to ensure a uniformly balanced family mix. Seedlings were planted in blocks of species and sources. For each individual source, the target area was set at 10 ha. 2x4m spacing was applied in planting. The total area of conservation stands planned for six locations was 400 ha. The aim was to develop each species in 4–5 sources of each minimum 30 families, in total 120–150 unrelated phenotypes. Plantings were established as monoculture plantations and as time passed the weaknesses of monocultures became obvious: poor vigour, susceptibility to diseases and pest attacks etc. In particular, species originating from mixed tropical forests proved vulnerable. The idea of mixed species planting has been gaining greater acceptance in Thailand and elsewhere in recent years.

A summary of the status of the various gene conservation stands is shown in Table 6 (FORGENMAP 2002).

Table 6. Summary of gene conservation stands in different research stations in Thailand in 1999

Species	Site no.										TOTAL	
	1		2		3		4		5			
	Area (ha)	No. of trees	Area (ha)	No. of trees	Area (ha)	No. of trees	Area (ha)	No. of trees	Area (ha)	No. of trees	Area (ha)	No. of trees
Dipterocarpus alatus	16	30	26	14	10	–	10	–	–	–	62	44
Dalbergia cochinchinensis	16	25	10	–	10	–	10	–	10	13	56	38
Xylia xylocarpa var. *kerrii*	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	25	10	–	–	–	10	28	40	53
Dalbergia oliveri	20	30	4	–	10	–	–	–	–	–	34	30
Hopea odorata	16	25	26	5	10	–	–	–	–	–	52	30
Total											**356**	**386**

Remark: Site 1: Silviculture Research Centre No. 5

Site 2: Sakaerat Gene Conservation Station

Site 3: Nong Khu Gene Conservation Station

Site 4: Ubon Ratchathani Gene Conservation Station

Site 5: Silviculture Research Centre No. 3

Tree improvement activities

Tree improvement activities in Thailand began in 1965 with teak (*Tectona grandis*) with assistance from the Danish International Development Agency (Danida). This work was extended to tropical pines and eucalypts in 1969. However, plantation programmes in the country led to the establishment of national tree seed centres with the assistance of the Danish Cooperation for Environment and Development (DANCED) in 1997. Several seed production areas and seed orchards for the species have been established in the country.

Socioeconomic conditions and issues related to the conservation, utilisation and management of forest genetic resources

It is estimated that 60% of Thai citizens are farmers. Therefore, Thailand is a predominantly agricultural country. However, industrialization of agriculture is limited, consisting mainly of primary processing units. Forests are used mainly as a source of products for construction timber, posts and poles, fuelwood, food, fodder, shade and shelter, as well as services such as recreation and soil and water conservation.

Rapid population growth in the past, modern development and uncontrolled human activities are the main causes of the dwindling of the forests. However, the establishment of national parks, forest parks and wildlife sanctuaries has secured the conservation of these resources. Those areas are under more strict laws and regulations (the National Park Act 1961 and Wildlife Preservation and Protection Act 1992). Table 7 below shows changes in regional forest area between 1988 and 2000. Natural conservation and recreational areas as of 1997–2001 are shown in Table 2.

Table 7. Changes in regional forest area between 1988–2000 (km^2) (RFD 1999; RFD 2001)

Region	1988	1991	1993	1995	1998	2000*
North	80 402	77 143	75 231	73 886	73 057	98 059
North-east	23 693	21 799	21 473	21 265	20 984	26 955
Central	17 244	16 616	16 408	16 288	16 049	21 426
East	7 834	7 691	7 634	7 591	7 507	8 232
South	14 630	13 449	12 808	12 455	12 125	17 378
Total	**143 803 (28.03%)**	**136 698 (26.64%)**	**133 554 (26.03%)**	**131 485 (25.62%)**	**129 722 (25.28%)**	**172 050 (33.40%)**

* Area includes forest plantations and secondary growth forests.

Though the Royal Thai Government imposed a total logging ban in the natural forest in 1989, deforestation is still continuing, however, with a slower pace than between 1973 and 1985 when it was estimated to be 1% each year.

Afforestation and reforestation activities

The first plantation activities in Thailand were initiated in 1906 with teak in the north. Thereafter small areas were planted annually up to 1960, reaching a total of approximately 8500 ha of which 70% was planted with teak.

Since 1961, the planting programme has gradually been increased, covering a total of 633 000 ha by 1986. From 1981 onwards the annual planting programme has covered about 71 000 ha of which 38 000 ha are private plantings. Main regions for planting activities have been the North (55%) and Northeast Thailand (18%). However, losses of plantation areas have occurred due to encroaching by farmers, fires and natural disasters, though record of exact area lost is not available.

Tree planting programme has been a permanent item of the National Economic and Social Development Plans since 1961 (see Table 8). The target areas have gradually expanded, but, the actual planting programmes have not been able to meet the targets. At that time (1961) the target was to keep 50% of the total area of the country as forests.

Table 8. The Forest Plantation Programme in Thailand according to the National Economic and Social Development Plans (NESDP 1961-2006)

Plan number	Total afforestation in 5-year plan periods (ha)
First Plan (1961–66)	12 480
Second Plan (1967–71)	112 000
Third Plan (1972–76)	194 000
Fourth Plan (1977–81)	400 000
Fifth Plan (1982–86)	240 000
Sixth Plan (1987–91)	Not specified but aimed at 40% forest cover
Seventh Plan (1992–96)	Not specified but aimed at 25% of conservation areas and 80 000 ha of community forest
Eight Plan (1997–01)	Not specified but aimed at 25% of conservation areas
Ninth Plan (2002–06)	Not specified but aimed at 25% of conservation areas

Thailand adopted a National Forest Policy in December 1985 with the aim to stop deterioration of the environment and to maintain a sustained wood supply for the future. In this policy, more emphasis is put to improve protection of the remaining natural forests, and plantation forestry. Private afforestation activities are strongly encouraged. This national policy adopted a long-term target for forest coverage equivalent to 40% of the country's land area.

A Master Plan for Reforestation was made because of the needs to address the serious problem of deforestation and to reach the desired target for forest coverage. The long-term objectives of the Master Plan are:

1. To create improved wood production based on sustained yield to cover domestic demands as well as export needs
2. To reduce further environmental degradation and, if possible, improve the situation by using forests for protection against soil erosion and flooding

The targeted forest cover of 40% is expected to be reached in 2031. The targets of the Master Plan are shown in Table 9 below.

Table 9. Targets of the 1991–2031 Master Plan (RFD 1993)

Land category	Present status (1991)		Target 2031	
	mill. ha	%	mill. ha	%
Conservation forest	8.72	17	7.70	15
Production forest	5.64	11	12.82	25
Total forest area	14.36	28	20.52	40
Non-forest area	36.95	72	30.79	60
Total land area	51.31	100	51.31	100

The species to be planted are anticipated to be teak, indigenous hardwood species, *Acacia* species, eucalypts species, *Casuarina* species, neem, rubber, lowland pine, highland pine, and mangrove species. Conservation of genetic resources of the species for future uses is, therefore, of utmost importance in Thailand. Demand for superior seeds and improved planting materials will be very high. Good policy for the utilization and management of FGR shall lead to the success of the planting programmes.

Identification of national priorities

Criteria and justification for selecting the priority species

Determining priority species for genetic resources conservation needs careful consideration. Limited resources are available for conservation activities in Thailand. However, the main criteria for assessing which tree species ought to be prioritised for inclusion in forest genetic conservation and management programme are described below (FORGENMAP 2002):

1. Socioeconomic importance

The commercial importance of the species and the extent to which it is in demand for planting are important considerations. The importance of species for maintaining ecosystem functions and services, such as watershed protection may also be taken into account. A ranking system for these criteria is shown below:

5 Highest priority – very widely planted
4 Very high priority – widely planted in some regions
3 High priority – widely planted in at least one region
2 Moderated priority – some planting in at least one region
1 Low priority – limited planting in at least one region
0 Not planted
n.a. Unknown/not sure

2. Level of within-species variation

Species with higher levels of genetic diversity will require increased conservation effort. In Thailand, the following ranking system has been developed for within-species variation:

5 Very widespread species in 3–4 regions; high level of genetic variation reported or inferred
4 Widespread species present in 3–4 regions; moderately high level of genetic variation reported or inferred
3 Intermediate; present in two regions; moderate level genetic variation reported or inferred

2 Localized species (several to many populations in one region)
1 Very limited variation (only 1–2 populations found in limited geographic area)
n.a. Unknown/not sure

3. Level of threat or risk

Species with populations at risk or under threat from any cause will warrant greater conservation action. The World Conservation Union (IUCN) has set the following risk or endangeredness categories for species:

- Critically Endangered: A taxon is *critically endangered* when it is facing an extremely high risk of extinction in the wild in the near future.
- Endangered: A taxon is *endangered* when it is not critically endangered but is facing a very high risk of extinction in the wild in the near future.
- Vulnerable: A taxon is *vulnerable* when it is not critically endangered or endangered but it is facing a high risk of extinction in the wild in the medium-term future.
- Lower Risk: A taxon that has been evaluated and found not to be threatened (as above). Includes three sub-categories:
- *Conservation dependent*: A taxon, which is in the focus of a continuing taxon-specific or habitat-specific conservation programme targeted towards the taxon in question, the cessation of which would result in the taxon becoming threatened within a period of five years
- *Near threatened taxa*: which are not conservation dependent, but which are close to qualifying for vulnerable (see above criteria)
- *Least concern*: these taxa are neither conservation dependent nor near threatened.

In Thailand, the following ranking system for threat levels has been presented:

5 Threatened at species level
4 Highly threatened at ecotype level (at risk of extinction in one major occurrence in near future, < 10 years)
3 Threatened at ecotype level (at risk of extinction in one major occurrence in next 10–30 years)
2 Threats to several populations, but slight or no risk of extinction in any major occurrence in foreseeable future
1 Minor threat to some populations
0 No known threat to any population
n.a. Unknown/not sure

Economic importance or value of the priority species

The species with the following socioeconomic importance and use are to be listed as priority species (FORGENMAP 2000):

1. Timber production
2. Posts, poles and roundwood
3. Pulp and paper
4. Fuelwood and charcoal
5. Non-wood products (gums, resins, oils, tannins, medicines, dyes, etc.)
6. Food
7. Fodder
8. Shade and shelter
9. Agroforestry systems
10. Soil and water conservation
11. Amenity, aesthetic and ethical values
12. Others

Priority species for FGR conservation and management in Thailand

Detailed information on the socioeconomic importance, genetic variation and endangeredness is only available for a few Thai tree species. Accordingly, a different approach needs to be adopted for prioritising tree species for conservation action. The steps for identifying and clarifying priority species for the existing conservation programmes have been as follows:

1. A preliminary listing and ranking of important indigenous species was developed. This listing and ranking was based on the inclusion of the species in the previous RFD programmes, such as the Seed Management programme, Gene Bank programme; identification as priority species for planting, i.e. economic plantation species, and species identified for conservation in the 1998 FORGENMAP/RFD workshops. This list includes 89 species.
2. Review and refinement of this list was done by a working group of Thai forest experts at Kasetsart University (on 8/5/2000). Priority tree species for conservation were mainly identified on the basis of perceived threat, and to lesser extent on the level of within-species variation, as there was limited information on the subject. Appendix 2 shows a list of priority species for Thailand, conservation activities and recommended actions for genetic conservation.

Institutional framework

Major governmental bodies: their function and policies in conservation

The Ninth National Economic and Social Development Plan

Thailand had extravagantly exploited its abundant natural resources, without proper management, for national development process during the last four decades. Rehabilitation of natural resources and the environment was unable to keep pace with the problems of rapid degradation (NESDB 2002).

The 9th Plan emphasizes improvements in management practices to restore the equilibrium in the utilization and conservation of natural resources and the environment. It will promote the sustainable use of natural resources in order to support national economic development, enhance self-reliance, upgrade the quality of life of the Thai people and enhance the resilience of communities and the country. Thus, sustainable resource use will be the basis of future national development. Popular participation by all social sectors in the management of natural resources and environmental conservation will be encouraged (NESDB 2002).

Objectives of the 9th Plan put emphasis on restoring the proper balance in the use, preservation, and rehabilitation of natural resources. Effective control mechanisms over resource use shall be instituted. The Plan targets to reform the management of natural resources and increase participation of local people in the management and monitoring of environmental protection. According to the plan, forest reserves shall cover an area of not less than 25 percent of the whole Kingdom while the mangrove forest shall cover an area not less than 1.25 million rai (200 000 ha). A holistic management approach towards the rehabilitation of coastal environments as well as forest areas will be adopted.

The Royal Forest Department (RFD)

Since the designation of Khao Yai as Thailand's first national park in 1962, the conservation area has expanded to include 341 protected areas including 15 botanical gardens and 54 arboreta, covering more than 90 563km^2, or about 17.57% of the country's land area (see Table 2 for details). More parks and sanctuaries are being proposed for incorporation into the system.

The RFD was reorganized and restructured by the Government Body Restructuring Act 2002. The original Department has been split into three parts, i.e. the Royal Forest Department, the National Park, Wildlife and Plant Conservation Department, and the

Marine and Coastal Resources Department. However, policies related to forestry are still unchanged.

In the period of the 5th National Economic and Social Development Plan, The Cabinet approved the National Forest Policy drafted by of the National Forest Policy Committee on December 3, 1985. It comprises in total 20 broad key statements. Some of the important statements relevant to and used as the guidelines for actions in the management and conservation of forest resources are as follows:

- Thailand intends to have at least 40% of the country land surface to be covered by forests. Out of this percentage, 25% shall be designated as 'economic' forest, and 15% as 'conservation' forest. (Economic forests are used primarily for timber production and other non-wood forest products. Conservation forests in Thailand are equivalent to protected areas as defined by the IUCN. For instance, National Parks fall under the IUCN protected area Category II, Wildlife Sanctuaries under Category I, etc).
- All public sector and stakeholders including local people and ethnic minorities are collectively responsible for the protection, management and use of forestland and its resources.
- Land use zoning suitable for the country would be a principal tool for FGR conservation
- Provide conservation education and environmental awareness to the general public through media and other logical means.

In order to achieve the policy goals and objectives, forestry programmes and projects must be devised accordingly and updated periodically. These programmes and projects shall be integrated into the country's National Economic and Social Development Plan for implementation and subject for evaluation and revision.

The policy statements mentioned above have thus far provided a framework for the conservation actions focusing on forestland and its natural resources. For example, the RFD, a major implementing agency, has drawn up a national forest land-use plan comprising the economic forest zone and the conservation forest zone. The RFD had expanded its conservation forest or protected area system to fulfil the national policy by designating more forest areas during the past two decades. Currently, the percentage of conservation forest is well over the number prescribed in the policy. In addition, public participation in the conservation of forest resources has been addressed in a number of newly enacted laws including the new national constitution. Several forestry programmes related to forest resources conservation have been devised and integrated into the National Economic and Social Development Plant since 1987 or the 6th Plan onward.

In response to the 1985 National Forest Policy which required the long-term management and development plans to maximize the social, economic and environmental benefits of the forest, the Thai Forestry Sector Master Plan (TFSMP) was drafted with funding supported by the Finnish International Development Agency (FINNIDA) in 1993. The TFSMP guides long-term development in the forestry sector, taking into consideration socio-ecological, technological and institutional aspects. Conservation of forest resources and biodiversity guidelines proposed in the Master Plan are under the people and forestry environment programme. The programme concerns the conservation of representative ecosystems and diverse biological resources in protected areas, as well as conservation of biological resources outside the protected areas.

The Office of Environmental Policy and Planning (OEPP)

The Office of Environmental Policy and Planning (OEPP) is the key centre and leader of the coordination in natural resources and environmental administration and management of the country in order to encourage national sustainable development. Economic utilization of the environment must be based on conservation, social equity and better quality of life of people. At the same time it encourages the efficiency of integrated system for environmental quality administration and management by administrative and management decentralization from central Government to local authority. It also builds up public awareness and encourages the public to participate in environmental quality prevention, remedy and rehabilitation. The OEPP also acts as the regional leader in environmental management and implementation of the policy according to the environmental obligations with foreign countries. According to its roles the OEPP has three Sectors: Environmental Policy and Planning Sector, Environmental Quality Management Sector and Regional Environmental Management Sector.

The policies related to conservation of forest resources include the Policy and Prospective Plan for Enhancement and Conservation of National Environmental Quality (1997–2016), policy on natural resources, policy on natural and cultural environments, policy on environmental education and promotion. There are three Divisions under the Environmental Policy and Planning Sector.

Specifically, the Environment Quality Management Sector handles the biological resources management tasks through the Division of Natural Resources and Environmental Management and Coordination. In accordance with the framework of the CBD, through this division the OEPP compiled and formulated the Biological Diversity Report of Thailand**.** Furthermore, it also formulated the National Policy, Measures and Plans on the Conservation and Sustainable Biological Diversity (1998–2002), which was approved by the Cabinet in 1997 and has become a Principle framework for biodiversity conservation and management in Thailand. The Regulation on Biological Diversity Utilization and Conservation, also approved by the Cabinet in 1997, aimed at creating coordination among agencies to get access to the biological resources and the negotiation for the benefit that Thailand should receive from the utilization of national biological resources with justice and equity.

The OEPP under the supervision of the Steering Committee on Implementation of National Action Plan for Sustainable Development (Agenda 21) has formulated the Policy and National Action Plan for Sustainable Development of Thailand. It is proposed that Thailand's forest cover shall be increased to 50% of its land surface. At least 30% is to be designated as conservation forest, and 20% as economic forest, to ensure that the demands of economic and social development are met, and to maintain the environmental balance. The policy calls for efforts to protect, preserve and conserve flora, fauna, aquatic life, and other living organisms in forestlands.

Policy and Prospective Plan for Enhancement and Conservation of National Environment Quality (1997–2016) has two main aspects: policy on natural resources and policy on pollution. Under the policy on natural resources, it has been proposed to increase efficiency in the use of natural resources; enhance administration and management of natural resources by systematic decentralization of power; support the application of resource economics for effective management of natural resources; amend the legal and regulatory framework enabling support for more effective administration and management of natural resources and recognition of rights and responsibilities of local people to demonstrate ownership of resources. It further proposed to support the study, research, and establishment of a standardized database network for natural resources and to increase conservation awareness of senior Government officers, politicians at all levels, private sector, and general public, in order to integrate concepts for natural resources development and conservation, ensuring their movement in the same direction (OEPP 1997).

Thailand has not ratified the Convention on Biological Diversity (CBD), although the Cabinet approved CBD ratification in 1997. However, implementing many activities advocated in the Convention has been progressing. Formulation of the National Policy, Measures, and Plans on the Conservation and Sustainable Biological Diversity was approved by the Cabinet on July 15, 1997. This policy proposed several new and additional initiatives to existing relevant institutions in order to support the protection of biodiversity of the country. The main focus of the national strategy was directed towards emphasizing and enhancing present responsibilities of the implementing institutions. The strategies on the conservation and utilization of biological diversity are prioritised into seven strategies.

These are:

Strategy 1 – Building the capacity of institutions and their staff on the conservation of biodiversity.
Strategy 2 – Enhance efficiency in management of protected areas to ensure sustainable protection of overall biodiversity at local level.
Strategy 3 – Improve incentives for conservation of species, population and ecosystems.
Strategy 4 – Conservation of species, populations, ecosystems.
Strategy 5 – Control and monitor processes and activities that threaten existence and richness of biodiversity.
Strategy 6 – Encourage the management of biodiversity in the environment and traditional culture.
Strategy 7 – Promote cooperation between international and national agencies/ institutions in conservation and sustainable utilization of biodiversity.

The measures for *in situ* conservation of biodiversity are emphasized in Objectives 4.1 of the Strategy 4 (*Improve capacity in the conservation of species, population and genetic diversity in natural habitats*) Objectives 2.1 (*To ensure that the protected areas are capable to conserve rare and endangered species and ecosystems*), 2.3 (*To increase capacity in protected areas management*) and 2.4 (*To improve the conservation of protected areas*) also focus on *in situ* conservation. In addition, several measures from the remaining strategies are supportive to conservation *in situ* of biological diversity.

The measures related to *ex situ* conservation of biodiversity are found in Objective 4.2 (*Improve capacity of the ex situ conservation to enable biodiversity conservation, promote public education and support sustainable development*) of the Strategy 4. In addition, several measures mentioned under *in situ* conservation provide support to *ex situ* conservation.

Department of Environment Quality Promotion (DEQP)
In 1992, according to the revision of the Enhancement and Conservation of National Environmental Quality Act, the Office of the National Environmental Board was replaced by three new environmental Departments: the Office of Environmental Policy and Planning (OEPP), the Pollution Control Department (PCD) and the Department of Environmental Quality Promotion (DEQP) (DEQP 1994). This governmental body relates to forest resources conservation in terms of promoting and building public awareness as well as increasing public education in conservation of forest resources.

The National Science and Technology Development Agency (NSTDA)
The National Science and Technology Development Agency (NSTDA) is a funding and research organization established under the Science and Technology Development Act, of B.E. 2534 (1991) on December 30, 1991. The NSTDA is an autonomous organization operating under policy guidance of its own board, chaired by the Minister of Science, Technology and Environment. The NSTDA operates outside the normal framework of state-enterprise and civil service. The agency has adopted a broad and systematic approach towards enhancing the entire Science and Technology sector in support of national economic and social development.

NSTDA's target is to improve production and service, as well as backing research aimed at commercial application. Three specialized centres; Genetic Engineering and Biotechnology (BIOTEC), Metal and Materials Technology as well as Electronics and Computer Technology come under the NSTDA umbrella. In addition, its Technology Information Access Centre provides on-line information services from important databases worldwide. The NSTDA maintains close associations with public and private research institutions and works together to organize training courses and technical seminars for human resource and institutional commercialisation, as well as for promoting public welfare.

Genetic Engineering and Biotechnology Centre (BIOTEC)

The Genetic Engineering and Biotechnology Centre (BIOTEC), originally known as NCGEB, was first set up under the Ministry for Science, Technology and Energy on 20 September 1983. After the establishment of the NSTDA in 1991, BIOTEC became one of the NSTDA centres, operating autonomously outside the normal framework of civil service and state enterprises. The main objectives of BIOTEC are to induce dynamics in research, development and application of biotechnology in order to support technology development and adoption in both public and private institutions. Activities are not limited to high technology, but also focus on medium and basic level technology, particularly when used for building up the country's skill resource, or adapting technology appropriate for Thailand's development.

The Biodiversity Research and Training Programme (BRT) is a special programme established under BIOTEC to provide support and funding for research into and management of Thailand's biodiversity resources. The BRT Programme addresses the need for research and training to assess the biodiversity remaining in the Kingdom and to investigate the present and potential benefits of biodiversity for human life. Some examples of research projects supported by BRT include: Study of plant diversity in Phu Phan National Park; Biodiversity of plants at Ton Nga Chang, Southern Thailand; Plant diversity at Khun Korn Waterfall Forest Park, Chiengrai; Evaluating the status of genetic resources of *Tectona grandis* using molecular markers and Cytogenetic study of Euphorbiaceae in Thailand.

Thailand Biodiversity Centre is also a new special program under BIOTEC established in January 2000 as a result of the Prime Minister decree on biodiversity conservation and utilization. The centre collaborates with other organizations in order to manage biodiversity of Thailand and expands collaboration around the world. Its main functions are to serve as a data base centre and disseminate information related to biodiversity conservation to researchers and public in general as well as to raise public awareness and public participation on biodiversity conservation through workshops and publications.

Institutional issues

Several institutional restructuring schemes affecting forest conservation have been proposed. Finally according to the Government Body Restructuring Act 2002, national parks, wildlife conservation and watershed conservation are under the National Park, Wildlife and Plant Conservation Department, Ministry of Natural Resources and Environment. However, the Office of Environmental Planning and Policy, the Department of Environmental Quality Promotion and the Department of Marine and Coastal Resources are under the same Ministry. The Royal Forest Department is in the process of transferring to the Ministry of Natural Resources and Environment.

National acts, regulations and resolutions dealing with conservation

The relevant Forest and Environmental Acts and other regulations and resolutions related to forest conservation are as follows:

Forestry Act B.E.2484 (1941)

This Act regulates operation and non-wood forest product collection.

National Park Act B.E. 2504 (1961)

This Act prescribes the determination of National Park land, protection and maintenance of National Parks and penalties.

National Reserved Forest Act B.E. 2507 (1964)

This Act prescribes the determination of National Reserved Forest, control over and maintenance of the National Reserved Forest, penalties and transitory provisions.

Wildlife Preservation and Protection Act B.E. 2535 (1992)
This Act prescribes chapters including: appointment, roles and responsibilities of the National Wildlife Preservation and Protection Committee; hunting, propagating, possessing and trading in the wildlife, their carcasses and carcass products; importing, exporting, passing through, moving the wildlife and wild life check point; a public zoo; area and place under prohibition of wildlife hunting; the competent officer; penalties.

Enhancement and Conservation of National Environment Quality Act B.E.2535 (1992)
This is Act gives directives on appointment and responsibilities of National Environmental Board; Environmental fund; Environmental protection; Pollution control; Promotional measures, Civil liability, and Penal provisions.

Sub-District Administration Act 2537 (1994)
Determine roles and responsibilities of Sub-district organization (Or-Bor-Tor) including natural resources and environmental management. Under section 67, Or Bor Tor has to protect, and rehabilitate natural resources and environment in their areas.

Ministry Resolution: Watershed Classification 2528, 2529 (1985, 1986)
Regarding land-use practices in the watershed area, the Government also developed a set of resource utilization and management practices for each operating unit within each major watershed class (WSC).

Community Forest Act
In addition to all above, a Community Forest Act is now being drafted under consideration of the Cabinet a) to act as a tool in environmental protection and development, b) to provide a framework for utilizing natural resources sustainably in order to protect the forest ecosystem, c) to underline and support the roles of communities that protect, use and develop forests their traditional ways and d) to promote cooperative processes between the State and communities. There are conflicting ideas regarding the issue of the location of community forests. Agreement has not yet been reached on whether areas within protected areas can be used as community forests. Thus, the Community Forest Act is still pending for final agreement.

Proposal for regional and international collaboration

The growing concern over the long-term sustainability of forest ecosystems, species and genetic resources has led to the development of national policies and plans in many countries. However, most programmes have been confined to national boundaries and, thus have faced limitations. Many tree species have regional or global ranges while a good number of introduced species may have developed into well-adapted land races and become economically important outside their original ranges. Therefore, conservation as well as improvement programmes may be a common interest to several countries. To create collaboration in the use of the limited FGR as well as to avoid overlapping and duplication of efforts, it is essential to establish some kind of link or network at regional and global levels. As an example, Thailand initiated a regional cooperation programme in 2000, seeking financial support from an international organization.

The project “Management of the Phatam Protected Forest Complex to Promote Cooperation for Trans-boundary Biodiversity Conservation between Thailand, Cambodia and Laos” aims at strengthening the management planning for the Phatam Protected Forest Complex and to develop strategies for trans-boundary biodiversity conservation. This project was proposed by Thailand. The Project life is two years, being executed through a joint committee and receiving major financial support from the ITTO. The Project terminated at the end of September 2003 resulting in a plan and strategy for biodiversity conservation for the three countries.

Regional as well as international collaboration in FGR conservation may be established in the form of networking. Some active networks in the region at present include, for example, International Neem Network, the International Network on Bamboo and Rattan (INBAR) and TEAKNET. These networks can be used as models for the proposed Asia-Pacific Forest Genetic Resources Programme. However, many important issues have to be discussed and clarified. They include, for example:

1. Common species identification and/or priority species
2. Standard methodology for conservation (*in situ*, *ex situ* or other)
3. Access to genetic resources and exchange of tree germplasm
4. Material transfer agreement
5. Research coordination and dissemination of research results
6. Information exchange
7. Benefit sharing in case of commercial uses/development of FGR of partner countries
8. Intellectual property rights
9. Financial support for the sustainability of the network, etc.

The above undertakings may take a long time. However, it is beneficial for member countries to play a regional as well as international role because economically valuable goods and products, including many environmental services may be derived from the FGR of the region.

Conclusion

Country priorities

Rapid depletion of the natural forests in Thailand is a root cause of serious problems in the country's environment and economy. The logging ban was imposed to remedy the situation, and a Master Plan for reforestation was also introduced. The Plan aims at bringing back the forest cover to 40% of the nation's land area within the next 40 years. It is foreseeable that this target can be reached through improved protection of the remaining natural forests and increased plantation forestry measures. Proper FGR conservation and management will play a vital role in plantation activities.

Thailand has obtained substantial amount of know-how in forest tree improvement of some economically important species during the past 35 years with the assistance of the Royal Danish Government. The genetic resources of many species have been conserved and developed (e.g. teak, pines and some hardwood species). It is anticipated that future planting programmes, both public and private, will use a greater diversity of species including both indigenous and exotic ones. Conservation of genetic resources of individual priority species has to be expanded for future usage in producing high quality planting materials.

Thailand has identified priority species as listed in Appendix 2. However, due to the great diversity of vegetation, more species may be included to the list later.

Research needs

It is important that detailed information of individual tree species will be available for decision-making. The following research needs can be identified:

- Research on taxonomy
- Research on the importance of species for maintaining ecosystem functions and services, such as watershed protection
- Research on the level of within-species variation
- Research on the level of threat or risk of extinction of species
- Research on the use of genetic markers in conservation
- Research on participatory systems on conservation or partnership conservation
- Research and/or collation of information on biological and demographical characteristics, etc.

Needs for international collaboration

Though efforts and resources have been put into many programmes in Thailand, some constraints are still limiting the advancement of many programmes. It is evident that more achievements can be obtained if outside assistance and international collaboration are available. Therefore, Thailand needs international collaboration in the field of FGR conservation and management.

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Appendix 1

Details of* ex situ *conservation stands for exotic species in Thailand (DFSC 1997)

Site	Species	Provenance	Seed lot	Year of establishment	Area (ha)
Nong Krating Seed Production Station, Om Koi district, Chiang Mai	*Pinus caribaea*	La Brea Colon	S2043	1979	n.a.
		La Mosquito	S2046	1979	n.a.
		Culmi	S2280	1981	n.a.
		Poptun	S2045	1979	n.a.
		Lololo Island	S2047	1981	n.a.
		Poptun	S2045	1981	n.a.
		Culmi	S2276	1982	n.a.
	P. oocarpa	Jocotan	S3130	1979	n.a.
		Mal Paso	S3129	1979	n.a.
Ubon Ratchathani Gene Cons. Station, Khong Chiam district, Ubon Ratchathani	*P. caribaea*	Alamicamba	PIC 2278/ DFSC/1033/82	1985	n.a.
Tatoom Experimental Station, Tatoom district, Surin	*Eucalyptus camaldulensis*	Gibb River	PIC S4040 CSIRO 10558	1977	n.a.
		Petford	PIC S4039	a) 1978	n.a.
			CSIRO 10911	b) 1980	n.a.
		Gibb River	PIC S4040 CSIRO 10558	1980	n.a.
Huay Bong Experimental Station, Hod district, Chiang Mai	*E. camaldulensis*	Gibb River	CSIRO 10558	1978	n.a.
		Petford	PIC S4039 CSIRO 10911	1977	4.4
		Gibb River	CSIRO 10558	1997	5.5
		Petford	CSIRO 12186	1979	n.a.
	P. oocarpa	Yucul	PIC 3119 OFI 2/76	1978	n.a.
		Mt.Pine Ridge	PIC 3118 OFI 10174	1977	4.8
		Mal Paso	S 3129	1979	6.8
		Dipilto	S 3073	1975	n.a.
		Lagunilla	S 3092	1981	11.8
		Yucul	PIC 3119 OFI 2/76	1977	5.9
		San Rafael	PIC 3254 DFSC 1022/82	1984	5.9
		Mt. Pine Ridge	PIC 3074	n.a.	n.a.
	P. caribaea	Los Limones	PIC 2041 61a	1978	18
		Los Limones	PIC 2277	1984	n.a.
		La Mosquito	S 2046 71a	1979	21.3
		San Carlos	S 2044 35a	1979	n.a.
		Alamicamba	PIC 2033 OFI 6/74 FAO/UNEP21A	1975	n.a.
		Alamicamba	PIC 2278 DFSC 1033/82 21b	1986	5.5

Site	Species	Provenance	Seed lot	Year of establishment	Area (ha)
		Culmi	S 2280 DFSC 1058/82 101+92 a	1985	8.8
		Alamicamba	PIC 2040 OFI 6/74 58	1977	5.3
		Los Limones	PIC 2041 OFI 24/75 56 a	1977	3.5
		Santa Clara	PIC 2279 DFSC 1049/82 107a+b	1984	8.8
		Los Limones	PIC 2277 106	1983	n.a.
Intakin Experimental Station, Mae Taeng district, Chiang Mai	*P. caribaea*	Poptun	DFSC 1134/83	1987	n.a.
Pine Improvement Station (Mae Sanaam), Hod district, Chieng Mai	*P. caribaea*	San Rafael	PIC 3254 DFSC 1022/82	1984	n.a.
		Alamicamba	S 2278 DFSC 1033/82	1984	n.a.
		Honduras	S 2028	1973	n.a.
Nong Khu Gene Conservation Station, Sang Kha district, Surin	*P. oocarpa*	Cuba	S 2030	1973	21
		Los Limones	S 2277	1983	n.a.
		Los Limones	PIC 2281 DFSC 1056/82	1989	n.a.
		Los Limones	PIC 2281 DFSC 1056/82	1988	n.a.
		Guatemala	S 3070	1973	n.a.
	P. oocarpa	Guatemala	S 3062	1973	n.a.
		Yucul	S 3256	1984	n.a.
		San Rafael	S 3254 DFSC 1021/82	1984	n.a.
		Mal Paso	PIC 3255 and PIC 3129, DFSC 5519	1987	n.a.
		Yucul	DFSC 1021/82 or OFI 2/76n.a.	1981	n.a.

n.a. = data not available

Appendix 2

Information on the priority species for Thailand

Priority level and species	Areas managed for conservation (ha)			Areas managed in natural forest for production (ha)		Areas managed in plantation for production (ha)		Recommend actions for genetic conservation	References and reports
	In situ	*Ex situ*	Seed production	Timber	Non-timber	Timber	Non-timber		
TOP PRIORITY									
Afzelia xylocarpa		40						Establish more *ex situ* conservation efforts	FORGENMAP 2002
Dipterocarpus alatus		72						Establ. more *ex situ*	FORGENMAP 2002
Hopea odorata		52						Establ. more *ex situ*	FORGENMAP 2002
Pterocarpus macrocarpus		36						Establ. more *ex situ*	FORGENMAP 2002
Tectona grandis		1894	1221					Strict protection	Unpublished report of TIP (2001)
VERY HIGH PRIORITY									
Alstonia scholaris								Establish *ex situ*	
Aquilaria crassna								Establish *ex situ*	
Dalbergia cochinchinensis		56						Establ. more *ex situ*	FORGENMAP 2002
Dalbergia oliveri		34						Establ. more *ex situ*	FORGENMAP 2002
Intsia palembanica								Establ. *ex situ*	
Mangifera spp. (wild species)								Establ. *ex situ*	
Millettia kangensis								Establ. *ex situ*	
Pinus merkusii	1060	13	5.7					Establ. more *ex situ*	Unpublished report of PIP 2001
Wrightia tomentosa								Establ. *ex situ*	
Xylia xylocarpa var. *kerrii*		50						Establ. more *ex situ*	FORGENMAP 2002

Priority level and species	Areas managed for conservation (ha)			Areas managed in natural forest for production (ha)		Areas managed in plantation for production (ha)		Recommend actions for genetic conservation	References and reports
	In situ	*Ex situ*	Seed production	Timber	Non-timber	Timber	Non-timber		
OTHER PRIORITY									
Azadirachta excelsa								Establ. *ex situ*	
Chukrasia spp.								Establ. *ex situ*	
Cotylelobium melanoxylon								Establ. *ex situ*	
Dipterocarpus tuberculatus								Establ. *ex situ*	
Durio mansoni								Establ. *ex situ*	
Fagraea fragrans								Establ. *ex situ*	
Gmelina arborea								Establ. *ex situ*	
Holoptelea integrifolia								Establ. *ex situ*	
Hopea ferrea								Establ. *ex situ*	
Manglietia garrettii								Establ. *ex situ*	
Mansonia gagei								Establ. *ex situ*	
Azadirachta indica								Establ. *ex situ*	
Melientha suavis								Establ. *ex situ*	
Parashorea stellata								Establ. *ex situ*	
Parkia speciosa								Establ. *ex situ*	
Pinus kesiya		233	42.8					Establ. more *ex situ*	Unpublished report of PIP 2001
Shorea henryana								Establ. *ex situ*	
Shorea roxburghii		36						Establ. more *ex situ*	FORGENMAP 2002
Tetrameles nudiflora								Establ. *ex situ*	
Toona ciliata								Establ. *ex situ*	

Status of forest genetic resources conservation and management in Vietnam

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Introduction

Vietnam is a tropical country, located in Southeast Asia, between latitudes 8° – 23° N, with a total land area of about 330 000 km^2. The forest area as of December 1999 is presented in Table 1.

Table 1. Total forest areas of Vietnam as of 1999 (Central Board for Forest Statistics 2001)

Total forest area	10 915 592 ha (Forest cover 33.2%)
Natural forest	**9 444 198 ha**
Protection forest	4 812 671 ha
Special use forest	1 463 746 ha
Production forest	3 167 781 ha
Plantation forest	**1 471 394 ha**
Protection forest	537 997 ha
Special use forest	61 122 ha
Production forest	872 275 ha

Based on utilization objectives, the forest area is classified into three types as shown in Table 2.

Table 2. Total forest areas of Vietnam as of end December 1999 based on utilization objectives (Central Board for Forest Statistics 2001)

Special use forest	1 524 868 ha
Protection forest	5 350 668 ha
Production forest	4 040 056 ha

The objectives for forest development until 2010 are indicated in Table 3:

Table 3. Objectives for forest development in Vietnam

Targets	2001 – 2005	2006 – 2010
National forest cover	39%	43%
Special use forest	1.6 mill ha	2.0 mill ha
Protection forest	5.4 mill ha	6.0 mill ha
Production forest	6.2 mill ha	8.0 mill ha

The forestry sector plays an important role in agriculture as well as in the economy of Vietnam. In the early 1990s, the total volume of roundwood exploited from natural forest was about 2–4.5 million m^3 per year. Most of the current requirement for wood is being met from plantations and imports, only 300 000 m^3 is harvested from natural forests. Fuelwood and non-timber forest products (NTFPs) are also very important for the life of the Vietnamese people. Export value of processed wood has been approximately US$ 250 million per year during the past 5 years and is expected to exceed one billion by the year 2005.

Vietnam has an abundant and diverse forest flora, which is not very well studied. According to Flore Generale L'Indo-Chine (Lecomte 1907–1951), there are more than 7000 plant species belonging to 1850 genera and 290 families. Of these, 64 genera (3%) and 2084 species (27.5%) are endemic to Vietnam. However, according to the Ecological and Biological Resources Institute (Tran Dinh Ly 1993), there are 11 000 species in more than 2500 genera within only Ptesidophyta, Gymnospermae and Angiospermae. The National Action Plan of Biodiversity (MOSTE 1995), lists about 12 000 plants, 275 mammals, 800 birds, 180 reptiles, 80 amphibians, 2470 fish and 5500 insect species. The uniqueness of flora and fauna is high with 40% of all species being endemic. The flora of Vietnam also contains many species that originated from three surrounding floristic areas of:

- Indo-Malesian flora: Plant species from southern origin typically represented by species of Dipterocarpaceae
- Chinese flora: Species from northern origin represented by species of Gymnospermae, Betulaceae, Ericaceae, Fagaceae, Juglandaceae, Lauraceae, etc.
- Indian–Myanmar flora: Species of western origin represented by species of Bombacaceae, Combretaceae and Lythraceae

The Vietnamese have been using tree species for thousands of years for food, fodder, medicine, construction materials, ornaments and other purposes. In 1993, the Ecological and Plant Resources Institute named about 1900 useful tree species in Vietnam, which belong to about 1000 genera and 230 families (Tran Dinh Ly 1993). However, this figure may increase with more thorough studies and surveys in the future. For medicinal plants alone, recent surveys and studies have shown that there are about 3200 species used for disease treatment (Vo Van Chi 1997). The available plant species have been divided into 7 categories by their uses (Table 4).

Table 4. Groups of plant species as divided by Vu Van Chuyen *et al*. (1987)

Timber	1200 species
Paper, fibre	100 species
Essential oils	500 species
Vegetable oil	260 species
Tannin	600 species
Dye	200 species
Medicinal plants	1000 species

Many valuable plant species have been freely cut and collected and hence are in danger of becoming extinct. This is true for animals as well. The fact that large forest areas are becoming scarce is posing a major threat to the survival of animals dependent on such habitats. There is an urgent need to conserve biodiversity and forest genetic resources (FGR).

Conservation of forest genetic resources

Conservation is the proper management option for biological resources to obtain sustainable benefits for the present and future generations, without endangering the existence of the plant and animal species and their habitats. The objectives of conservation should include:

- Maintaining ecological processes and other support systems of the living biosphere, including water and soil resources
- Conserving genetic diversity within species and populations
- Using natural resources in a sustainable manner

It is clear that conservation of FGR plays an important and necessary role in environmental protection and sustainable forest management. Our objective should be to "conserve for development and to develop for conservation". Conservation is not only preservation – it should integrate measures to protect and sustainably use FGR.

The forest area of Vietnam has declined remarkably as a result of the long war, shifting cultivation and inappropriate harvesting practices. According to a French researcher P. Maurand (1943), approximately 43% of the total land area was covered by forest in 1943.

Forest cover was reduced to 27.1% by 1980 and 26.2% by 1985 (Ministry of Forestry 1991). Thanks to the efforts of the nation in general and the forestry sector in particular, the rate of deforestation has now been reduced considerably. As a result of forest rehabilitation programmes, the total forest cover has increased to 33.2% in 1999.

Timber exploitation from natural forest has also been reduced while protection forests and special use forests have been included in a forest restoration programme. Native tree species have been and will be widely used to sustain and to conserve the FGR of indigenous tree species of Vietnam. The Government of Vietnam also requires the use of native tree species in production forests in order to diversify the species for plantation establishment.

However, there is an urgent demand for additional forest restoration and regeneration measures in order to fulfil the objective of the Five Million Hectare Reforestation Programme (5MHRP) by 2010. Uses of different exotic and indigenous tree species in plantation activities are very clear but there are many obstacles and challenges that require more attention and practical solutions from researchers and managers. After many years of forest development work using both exotic and indigenous tree species, the forest area of Vietnam has exceeded 1.5 million ha again in 1999. Table 5 provides a list of some important species used in forest plantations in Vietnam.

Table 5. Area of forest plantations of some important species in December 1999 (Central Board for Forest Statistics 2001)

No.	Species	Area (ha)	No.	Species	Area (ha)
1.	*Eucalyptus* spp.*	348 001	17.	*Chukrasia tabularis*	9044
2.	*Acacia* spp.*	228 073	18.	*Vernicia/Aleurites* spp.	9146
3.	*Casuarina equisetifolia**	43 884	19.	*Melia azedarach*	8354
4.	*Tectona grandis**	11 583	20.	Palms	7766
5.	*Khaya senegalensis**	4777	21.	*Bruguiera*	5156
6.	Dipterocarpaceae species	26 924	22.	*Avicennia*	5107
7.	*Pinus* spp.	218 056	23.	*Sonneratia*	4700
8.	*Melaleuca cajuputi*	114 837	24.	*Canarium album*	2502
9.	*Rhizophora apiculata*	80 216	25.	*Afzelia xylocarpa*	2467
10.	Bamboo	73 852	26.	*Tarrietia javanica*	972
11.	*Styrax tonkinensis*	64 734	27.	*Camellia oleosa*	645
12.	*Manglietia glauca*	50 023	28.	*Fokienia hodginsii*	335
13.	*Cinnamomum cassia*	27 270	29.	*Erythrophleum fordii*	309
14.	*Illicium verum*	18 085	30.	*Castanopsis*	307
15.	*Cunninghamia lanceolata**	13 866	31.	*Liquidambar formosana*	92
16.	*Cassia siamea*	10 163			

* = introduced species (the rest being native to Vietnam)

Demand and supply of tree seed

Availability of good-quality germplasm is of importance in planting programmes including production forests, protection forests and special-use forests as well as scattered plantings. In order to effectively carry out the 5MHRP by 2010, national germplasm programmes have been developed. The aim of these programmes is to gradually supply high quality germplasm with diversity in type and to terminate the use of germplasm of unknown origin in increasing the productivity of commercial forests in the future.

According to the tasks and plans in the 5MHRP, during 1999 and 2000 on average 200 000 ha per annum were planted and another 300 000 ha per annum have been projected to be planted during the period 2005–2010. If an estimated one thousand seedlings are planted per hectare and in addition, many seedlings are used for scattered tree-planting efforts, there will be a need to produce millions of seedlings in nurseries. A suitable nursery system must be established on a national scale in order to supply high-quality seedlings for key planting areas and for farm forests while genetic variation should also be taken into consideration.

One of the preconditions for the 5MHRP to be successful is that supply of sufficient and high quality germplasm would be guaranteed. This is a demanding task including planning of germplasm production areas (seed stands, seed orchards), collecting, storage, pre-processing, transportation, supply, exchange, import and production of seedlings. Up to 1993, the Central Forest Seed Company (CFSC) established 73 ha of clonal seed orchards, 906 ha of seedling seed orchards and 1200 ha seed production areas. Since 1994, the areas for seed production for some important tree species include 1000 ha for *Pinus kesiya*, 400 ha for *P. merkusii* and 160 ha for *Tectona grandis*.

Information from the CFSC shows that seeds collected from seed production areas satisfy only 15–20% of the demand. The remaining is collected from natural forests or unplanned forests, from unknown and uncontrolled provenances or scattered trees. This practice has a negative impact on the productivity and quality of plantations, resulting in low rate of germination, low survival rate and/or low productivity of plantation forests.

In order to improve the quality of planting materials, the Minister for Forestry has issued in 1993 the Directive No. 08 on germplasm in order to establish seed production areas. Many germplasm projects have been approved and carried out and initial results are available. In addition, awareness on the importance of using good-quality germplasm has been increased. Supply of germplasm is not restricted to seed, seed production areas and seed orchards only, but expanded to new concepts. Newly established production units make use of cutting techniques and production of hybrids and plantation forests are commonly established using tissue culture technique. Besides deciding on the type of germplasm for forest planting purposes, provincial agencies also focus on planning of genetic resource conservation areas for rare and valuable species, i.e. species that have a high potential value but have not been planted on a large scale yet.

Endangered species

Deforestation and shifting cultivation are the main causes of forest fragmentation that may lead to a decline in natural populations of species and a loss of genetic diversity, and even extinction. Some examples of endangered tree species in Vietnam include (Nguyen Hoang Nghia 2000b):

- *Pinus dalatensis*. This species is found only in a few areas such as Mat Station (Da Lat City), Lac Duong (Lam Dong province) and Mang Giang (Gial Lai province). The population at Mat Station, which was where the first samples of *P. dalatensis* were collected, is now almost extinct. Only two trees remain along the riverbank at Uyen Uong Waterfalls.
- Many important populations of *Erythrophloeum fordii* in Bac Giang, Lang Son, Phu Tho and Son Tay have disappeared.
- *Aquilaria crassna*, which used to be distributed throughout Vietnam, is now found only in Ha Tinh, Tay Nguyen and Phu Quoc.
- *Glyptostrobus pensilis* is in danger of extinction. Only two populations remain: 32 trees at Trap Ksor and about 230 trees at Ea H'Leo (Dac Lac). Some of these trees are able to produce seeds but fail to germinate and hence there is no natural regeneration.
- Only some 50 individuals of *Taxus chinensis* and *Pinus kwangtungensis* remain in the country.
- Less than 250 individuals of *Taxus wallichiana* have been found in Lam Dong province.
- *Shorea falcata* is represented by only six trees at Song Cau (Phu Yen province) and seven trees at Cam Ranh (Khanh Hoa province), with twenty more coppices.
- *Hopea cordata* is represented by about 100 young saplings at Cam Ranh (Khanh Hoa) and cannot be found in any other areas.
- *Hopea reticulata* is found in only one area, namely Ca Na Mountain at 290–300 m asl and is represented by 192 individuals only.

Past and present activities in the field of conservation, utilization and management of FGR

Conservation methods applied in Vietnam

The research project on conservation of FGR, managed by the Forest Science Institute of Vietnam (FSIV), has received continuous funding from the Ministry of Science and Technology (MOST, former MOSTE) since 1988. Strategic orientation and the selection of conservation methods and priority species have received special attention. Priority species have been divided into the following groups (Nguyen Hoang Nghia 1997):

1. Threatened species with high economic value
2. Threatened species with high scientific value
3. Precious native species for reforestation
4. Valuable exotic species for reforestation

In situ conservation is the primary method used by the project, applied in combination with establishment of *ex situ* conservation stands. The following steps are taken to conserve FGR:

- Inventories (botanical and genecological surveys)
- Collecting, evaluation and documentation of information
- *In situ* and/or *ex situ* conservation
- Utilization

Although conservation of genetic resources and nature conservation (conservation of natural habitats in national parks and nature reserves) have some similarities, there are also important differences between them. The purpose of nature conservation is to protect entire ecosystems found in certain environments; however, this approach does not pay special attention on the conservation of genetic diversity as such. The ecosystems to be selected for nature conservation are sometimes more easily identified while the genetic variation that needs to be conserved is very difficult to recognize and identify.

There are also differences between genetic conservation of agricultural crops and forest tree species. Agricultural crops are generally annual species with orthodox seed and storing seeds in genebanks is the main conservation method, while for forest tree species, conservation in the form of living individuals or populations (*in situ* and *ex situ* conservation stands) is more appropriate. The total number of important agricultural crops (such as rice, maize, wheat etc.) is limited, while the number of forest tree species that would need to be conserved may be very large. In addition, trees have a wide and scattered distribution range and, therefore, conservation efforts cannot focus on one provenance or population only. Most agricultural crops were domesticated over a long period of time while very few forest tree species can be considered domesticated. Therefore, efforts to establish *ex situ* conservation stands or plantations face many difficulties.

In situ conservation

In 1943, the forest area of Vietnam was estimated to be about 14.3 million ha, or 43% of the total land area (Maurand 1943). Owing to war, shifting cultivation, land clearances, unsustainable logging and repeated burning, forest cover shrank at a rate of about 100 000 ha each year. Efforts to protect the natural habitats of Vietnam began in 1962 with the creation of Vietnam's first national park at Cuc Phuong. In 1972, a Decree on Forest Protection established a forest ranger system with about 10 000 rangers across the country.

On the basis of the Decision No. 194/CT of the Council of the Ministers in 1986, the government decided to establish a network of special-use forests covering 87 protected forest areas. The government issued laws for forest protection in 1991 and for environment protection in 1994, along with other decrees and decisions to create a legal framework for establishing and managing special-use forests. Vietnam's Tropical Forest Action Plan (TFAP), which was issued in 1991, has also contributed to integrated planning of forest management. The first volume of the Vietnam Red Data Book was published in 1992 and included 347 endangered animal species. The second volume, which was published in 1996, included 350 rare and endangered plant species.

According to the Strategy for Management of Nature Reserve System in Vietnam (Anon 2003) as of February 2003, Vietnam has a system of 121 nature reserves, which includes national parks, nature reserves and landscape protection areas. Tables 6 and 7 provide current statistics on the nature reserve system in Vietnam.

Table 6. The nature reserve system in Vietnam in 2003

Category	Name	Number	Area (ha)
I	National Parks	25	883 391 ha
II	Nature Reserves	59	1 388 010 ha
II a	Nature Reserves	46	1 262 147 ha
II b	Species / Habitat Reserves	13	125 863 ha
III	Landscape Protection Areas	37	206 892 ha

Table 7. A newly developed system for nature reserves in Vietnam

Category	Name	Number
I	National Parks	32
II	Nature Reserves	53
III	Species/Habitat Reserves	29
IV	Landscape Protection Areas	19

Ex situ conservation

Since the French rule, arboreta have been established in Vietnam, for example, in the 1940s arboreta were established in Eakmat (Daklak) and Trang Bom (Dong Nai) for some species such as *Afzelia xylocarpa, Pterocarpus macrocarpus, Dipterocarpus alatus, Hopea* spp., *Tectona grandis* etc. During the past 10 years, some more arboreta have been established. These include many species for each representative area. Cau Hai arboretum (Phu Tho) of the FSIV has more than 250 tree species and 35 bamboo species. Some of the most important arboreta are presented in Table 8.

Table 8. Some arboreta established in Vietnam in the 1990s

Location	Number of species	Area
Cau Hai, Phu Tho	250 tree species and 35 bamboo species	20 ha
Trang Bom, Dong Nai	120 tree species and 10 bamboo species	8 ha
Lang Hanh, Lam Dong	20 rare and valuable tree species	10 ha
Mang Linh, Lam Dong	40 rare and valuable tree species	10 ha
Cuc Phuong, Ninh Binh	100 tree species	100 ha

Ex situ conservation stands have also been established during the past ten years in some forest stations of the FSIV for certain important tree species (Table 9).

Table 9. *Ex situ* conservation stands established by the FSIV since 1990

Species	Number of seed sources	No. of trees or area planted
Erythrophleum fordii	8	2.5 ha
Dipterocarpus retusus	4	2.0 ha
Madhuca pasquieri	2	6 ha
Calocedrus macrolepis	2	2000 trees
Fokienia hodginsii	1	2000 trees
Taxus wallichiana	4	1000 cuttings + 100 seedlings
Dalbergia annamensis	1	1000 trees
Afzelia xylocarpa	5	1400 trees
Dalbergia cochinchinensis	2	2600 trees
Pterocarpus macrocarpus	2	2000 trees
Dalbergia mammosa	1	2000 trees
Shorea falcata	1	3000 trees

Introduction of species, tree breeding and propagation

The Vietnamese people have been successfully planting some native and exotic tree species, including *Pinus massoniana, Cunninghamia lanceolata, Castanea mollissima, Cinnamomum cassia, Illicium verum* etc. The French people initiated importing exotic species and planted species such as *Eucalyptus, Tectona grandis, Khaya senegalensis, Grevillea robusta* and *Casuarina equisetifolia* all over Vietnam. They also started to plant some species outside their natural distribution. Such species include *Erythrophleum fordii* in Trang Bom (Dong Nai), Lang Hanh (Lam Dong) and Dan Chu (Hoa Binh); *Cinnamomum camphora* was planted in both lowland and highland, and *Hopea odorata* was planted in North Vietnam.

During the 1920s and 1930s, a French forester named Paul Maurand brought *Dipterocarpus alatus* and *Hopea odorata* seedlings from natural forest to be planted in Trang Bom Forest Station (Dong Nai). Three different methods were applied:

- Pure plantation; density up to 20 000 trees/ha
- Band planting (1931). (This resulted in low growing trees due to competition with natural forest.)
- Mixed planting with supporting trees such as *Indigofera teysmannii* and *Cassia siamea*

The first method was not very successful due to high density, which required additional silvicultural measures. Trees planted with the second method were successful only when climber cutting was applied. The third method was successful. At present, other leguminous species such as *A. auriculiformis* can also be used as support tree species.

Before 1975, about 20 *Acacia* and 50 *Eucalyptus* species were imported into Vietnam and planted in e.g. Lang Hanh and Mang Linh (Lam Dong). However, these plantations were not allocated and designed to be species trials.

Since 1970s, complete sets of seedlots have been imported, and numerous organizations have established species and provenance trials for many species such as *Eucalyptus* (120 provenances of 15 most important *Eucalyptus* spp.), *Acacia* spp. (70 provenances of 5 lowland species; 15 provenances of ten dry-zone species and 20 provenances of 20 temperate species), *Casuarina* (international provenance trial), *Pinus caribaea* (10 provenances of 3 varieties: var. *hondurensis, bahamensis* and *caribaea*), *Azadirachta indica* (international provenance trial) and the species of Meliaceae (international provenance trial for *Chukrasia tabularis* and *C. velutica*).

Not many provenance trials have been carried out for indigenous tree species thus far. However, some work has been initiated with *Pinus merkusii, P. massoniana, P. kesiya, Manglietia glauca, Styrax tonkinensis* and *Chukrasia tabularis*. Breeding activities for indigenous species are still restricted to *Pinus merkusii* (for high resin yield), *P. massoniana, P. kesiya* and *Manglietia glauca* (for growth). Many highly important local species have not yet been included into tree improvement programmes and trials.

Until recently, germplasm supply had to rely on natural forests, newly established seed production areas and seed orchards. At present, very effective techniques, such as propagation through cuttings and tissue culture are also applied. The latter highly advanced technique has been applied for *Eucalyptus* (for high productivity clones), *Acacia* (including *Acacia* hybrids), *Casuarina* (mainly for cutting and partly for tissue culture). In addition, many species have been successfully propagated using cutting technique. These include *Dipterocarpus alatus, Hopea odorata, Camellia oleosa, Calocedrus macrolepis, Fokienia hodginsii, Dacrydium elatum, Cinnamomum balansae, Rhodoleia championii,* etc.

Identification of national priorities

Priority species for FGR conservation and management

Priority species for Vietnam are presented in Appendix 1. Regional and national workshops have been organized by the FSIV or projects in Vietnam to discuss the list of species to be used in forest rehabilitation. Recently, a list provided by Danida Tree Seed Project contains almost 200 tree species for both conservation and production forest (Schmidt and Nguyen Xuan Lieu 2000).

Criteria for selecting priority species

Criteria for selecting priority species for commercial planting (Nguyen Xuan Lieu 2000) are as follows:

- Fit into the objectives of the planting programme
- Bring high benefits
- Have large and stable market
- Availability of seed sources and propagation methods
- Availability of planting and tending technique

Priority conservation areas and species are selected according to the following criteria (Nguyen Hoang Nghia 2000b):

- Level of diversity
- Representativeness
- Endemism
- Degree of endangerment
- Scientific and economic value

Economic importance or value of the priority species

Most of the priority species (Nguyen Xuan Lieu 2000) are of very high economic importance. They provide high quality timber that is used for furniture, handicrafts and construction and there is a high demand in the domestic market. Table 10 provides a list of important products and value of some priority species.

Table 10. Important products and economic value of some priority species

Scientific name of species	Important products	Economic value
Pinus merkusii	Resin, timber	Average
Hevea brasiliensis	Resin, timber	High
Dipterocarpus alatus	Timber, resin	High
Hopea odorata	Timber, resin	High
Chukrasia tabularis	Timber	High
Erythrophleum fordii	Timber	High
Canarium spp.	Timber, fruit	High
Melaleuca cajuputi	Wood, essential oil	High
Rhizophora apiculata	Wood	High
Styrax tonkinensis	Timber	Average – high
Manglietia glauca	Timber	High
Michelia mediocris	Timber	High
Cunninghamia lanceolata	Timber	Average
Pinus kesiya	Timber	Average
P. massoniana	Timber	Average
Cinnamomum cassia	Bark, essential oil	High
Illicium verum	Fruit	High
Aquilaria crassna	Agarwood	Very high
Dendrocalamus membranaceus (bamboo)	Stem	Very high
Phyllostachys pubescens (bamboo)	Stem	Very high
Calamus platyacanthus (rattan)	Stem	Very high

Institutional framework and capacity-building activities

Institutions involved in FGR conservation and management

The Forest Science Institute of Vietnam (FSIV) is the leading institution for FGR conservation research in Vietnam. The FSIV is also a focal point for research on FGR conservation and management and is carrying out a research project titled "Conservation of Forest Plant Genetic Resources in Vietnam" supported by the MOST. The FSIV and its research centres are also involved in the establishment of arboreta, living tree collections, *ex situ* conservation stands as well in guiding both *in situ* and *ex situ* conservation. Species-provenance trials and breeding programmes are also carried out by the FSIV.

The Central Forest Seed Company (CFSC) is working on the establishment of some seed production areas. Recently, with support from a Danida-project, the CFSV established genetic conservation stands for certain species. The Forest Inventory and Planning Institute (FIPI) is working on baseline inventory work, such as species lists and planning for nature reserves in Vietnam. Other research institutes and universities may also be involved, but they do mostly inventory work and basic research.

National legislation, policy and strategy on FGR

The main documents and important stages in the history of forest conservation in Vietnam are given in the Table 11. Legislation regarding access, property rights and benefit sharing of FGR has not been formulated. The National Assembly is planning to discuss a new Biodiversity Law during the period 2002–2007.

Table 11. Development of the legislative system for FGR conservation and management in Vietnam

1962	Decision to establish the Cuc Phuong National Park
1972	Decree for forest protection to establish the forest ranger system
1986	Decision No. 194/CT to approve 87 protected forests. Ministry of Forestry Decision No. 1171/QD for management regulations of special-use forests
1987	Formulation of a national program on conservation of genetic resources started by MOSTE
1988	Research project on conservation of forest plant genetic resources started by the Forest Science Institute of Vietnam (FSIV). Land Laws, modified in 1993
1989	Ministry of Forestry (MOF) Decision No. 276 to ban exploitation of 38 wild plant and animal species Member of RAMSAR Convention
1991	Laws for forest protection and development. National Plan for Environment and Sustainable Development. Tropical Forestry Action Plan (TFAP)
1992	Decree No. 18/HDBT to ban exploitation of 13 plant species and 36 animal species and to limit exploitation of 19 plant and 10 animal species. Vietnam Red Data Book, Volume 1 (Animals) published
1993	Convention on Biological Diversity (CBD) signed
1994	CBD ratified. Laws for environmental protection approved and issued. CITES signed
1995	Biodiversity Action Plan (BAP) of Vietnam issued
1996	Vietnam Red Data Book, Volume 2 (Plants) published
2001	Decision No. 08/2001/QD/Ttg to issue the regulation for management of special-use forests, protection forests and production forests as natural forest

Training and capacity building

Many national and international projects have organized training courses on biodiversity issues, but not on FGR. With funding from the Government as well as international sources, the FSIV organized some training courses on biodiversity, which contained some FGR elements. These are as follows:

- Conservation of biodiversity and FGR; APAFRI-TREELINK, Hanoi
- Vegetative propagation for clonal forestry and gene conservation; APAFRI-TREELINK, Hanoi

- Conservation of biodiversity and FGR; FSIV, Hanoi
- Vegetative propagation for clonal forestry and gene conservation; FSIV, Da Lat
- Conservation of biodiversity and FGR; FSIV, Da Lat

Conclusions

Conservation and development of FGR is recognized as an important issue in Vietnam. However, tree species are widely distributed; therefore collaboration between countries in the region is important. Besides exchange of documents, information and methods, germplasm can also be exchanged to broaden the genetic resources of each country. International cooperation is required for both research and development work. APFORGEN programme, within the framework of APAFRI and IFGRI should become a good coordinating body for regional collaboration in sharing experiences and fostering joint research projects which can bring benefits to the countries involved.

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Appendix 1

Information on priority species for the APFORGEN Inception Workshop

Priority species	Areas managed for conservation (ha)			Areas managed in natural forest for production of … (ha)		Areas managed in plantations for production of … (ha)		Recommend actions for genetic conservation	References and reports
	In situ	***Ex situ***	**Seed production**	**Timber**	**Non-timber**	**Timber**	**Non-timber**		
1. *Afzelia xylocarpa*	X	3	2						
2. *Anisoptera costata*	X	2							
3. *Aquilaria crassna*	0	1							
4. *Cassia siamea*	0		X						
5. *Casuarina equisetifolia*	0		X						
6. *Chukrasia tabularis*	X	2							
7. *Dalbergia bariensis*	X	3							
8. *D. cochinchinensis*	X	1							
9. *Dipterocarpus alatus*	X		200						
10. *Fagraea fragrans*	X	0	0						
11. *Gonystylus bancanus*									
12. *Hopea odorata*	X		350						
13. *Litchi chinensis*	X								
14. *Melaleuca cajuputi*	X		100						
15. *Pinus kesiya*	X		1000						
16. *P. merkusii*	0		160						
17. *Pterocarpus macrocarpus*	X		30						
18. *Shorea cochinchinensis*	X	0	100						
19. *S. roxburghii*	X	0	100						
20. *S. stenoptera*									
21. *Sindora cochinchinensis*	X								
22. *Tarrietia javanica*	X								
23. *Tectona grandis*	0	0	160						
24. *Toona sureni*	X								
25. *Xylia xylocarpa*	X	2	100						

Priority species	Areas managed for conservation (ha)			Areas managed in natural forest for production of … (ha)		Areas managed in plantations for production of … (ha)		Recommend actions for genetic conservation	References and reports
	In situ	*Ex situ*	Seed production	Timber	Non-timber	Timber	Non-timber		
List of priority bamboo & rattan species (Rao *et al.* 1998)									
1. Bamboo		X	x						
2. *Phyllostachys pubescens*	0	0	X						
3. *Dendrocalamus membranaceus*	X	X							
4. Rattan		X	X						
Additional priority species									
1. *Acacia* spp.			X						
2. *A. mangium*			X						
3. *Calocedrus macrolepis*		X							
4. *Cinnamomum cassia*		X							
5. *Cunninghamia lanceolata*		X							
6. *D. mun*		X							
7. *Eucalyptus* spp.			X						
8. *E. camaldulensis*			X						
9. *E. urophylla*			X						
10. *E. grandis*			X						
11. *Erythrophleum fordii*		X							
12. *Fokienia hodginsii*		X							
13. *Gmelina arborea*		X							
14. *Keteleeria fortunei*		X							
15. *P. caribaea*			X						
16. *P. massoniana*			X						
17. *Swietenia macrophylla*			X						
18. *Taxus wallichiana*		X							

INVITED PAPERS

The potential for using molecular markers to facilitate gene management and the *in situ* and *ex situ* conservation of tropical forest trees

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Introduction

As a consequence of depletion of forests due to deforestation and over exploitation, many forest trees and other plants in the tropics have become seriously threatened and are in the focus of conservation concerns. Due to the destruction and fragmentation of their habitats, populations of many species have been reduced and become isolated. These populations generally face considerable risk from the effects of environmental variation, demographic stochasticity and reduced genetic diversity (Meffe and Carroll 1997). The status of genetic resources of forest tree species can be explored by investigating the extent of genetic variation and mating system of each species. The extent and distribution of genetic variation within tree species are of fundamental importance to their evolutionary potential and chances of survival. Therefore, assessments of genetic variation are of key importance for developing effective conservation strategies (Holsinger and Gottlieb 1991; Newton *et al.* 1999). This serves the concept of the World Conservation Union (IUCN) for recognizing genetic diversity as one of the three levels of diversity requiring conservation (McNeely *et al.* 1990).

Concept of conservation

Sound strategy for the conservation of genetic resources of a species starts with the identification of clearly defined conservation objectives. Secondly, genetic resources must be selected mainly based on the available knowledge of spatial patterns of genetic variation. The choice of a conservation method refers to the physical preservation of genetic information, usually by preserving the selected organisms. The final step of a conservation programme is the regeneration of the resource (Hattemer 1995; Finkeldey and Hattemer 1993).

Finkeldey (1998) pointed out that inventories using gene markers are the most important experiments for the selection of genetic resources since centres of genetically differentiated populations can be identified by such inventories. However, it is also possible to identify populations containing otherwise rare or even unique alleles in high frequency. The occurrence of localized common alleles also points towards valuable genetic resources (Brown 1978). Therefore, the combination of different methods is recommended for the identification of forest genetic resources that need to be conserved.

After the genetic diversity within and among populations of any species has been investigated, genetically most diverse populations with relatively high outcrossing rates (for outcrossing species) should be chosen as the sources for gene conservation. Since forest trees live longer than annual or crop plants, high genetic diversity and outcrossing rate would guarantee higher possibility of their survival, viability, longevity, disease and insect resistance for the present and forthcoming generations under the unpredictable and changing environment (Changtragoon and Szmidt 1997).

The combination of marker-aided population genetic analysis and information about adaptive and quantitative traits as well as forest ecosystems would allow comprehensive conservation programmes for individual species in each forest type (Changtragoon 2001).

Type of molecular markers for the detection of genetic variation

Szmidt (1995) pointed out that the biological function of a plant relies on an intimate interplay between three distinct genomes: nuclear, chloroplast and mitochondrial. All these genomes harbour genes, which are vital to growth, photosynthesis, respiration and other biological processes. Therefore, studies of genetic variation should consider all these three components of plant genetic system. Furthermore, each of these components harbours different structure, RNA, regulatory genes and non-coding sequences and has a different mode of inheritance, which may affect the extent of population differentiation among biparental nuclear and uniparental (chloroplast and mitochondrial) inherited genes for the same set of populations. Therefore, the location of molecular markers and their distribution in the genomes as well as their potential adaptive significance (strongly adaptive or near neutral) should be taken into consideration (Karp *et al.* 1996; Szmidt 1995). Therefore, use of molecular markers that can detect the potentially adaptive genetic diversity are recommended (Krutovskii and Neale 2001; Szmidt 1995; Szmidt and Wang 2000). Karp *et al.* (1996) also suggested that in any assessment using molecular markers, attention should first be focused on the specific questions being addressed and on whether or not the choice of markers, sampling strategy and data analysis adequately address it.

Different molecular markers have been developed to investigate the genetic variation of plants and forest trees in the past few decades. Isoenzymes are codominant markers that have been used in forest genetics since the 1960s. They are still used in some laboratories due to their low cost and have useful applications, such as estimation of mating system and genetic diversity. Later on, DNA markers have been developed. Since the 1980s, RFLPs (restriction fragment length polymorphisms) have been applied in forest genetics and breeding. In the early 1990s many new DNA techniques and markers were developed such as PCR (polymerase chain reaction) based markers, namely RAPD (randomly amplified polymorphic DNA) and AFLPs (amplified fragment length polymorphisms). Nowadays DNA markers such as PCR-RFLPs, microsatellites (SSRs), AFLPs and RAPD markers are widely used to determine genetic diversity of forest populations because they can detect more polymorphic loci than isoenzymes (Szmidt 1995; Changtragoon 1998). Using microsatellite (SSRs) markers is also an alternative method for estimating mating system and gene flow in forest trees since they are codominant and can detect higher variation than isoenzyme markers. However, the disadvantages of this marker include its high cost and the long time needed to develop one marker. Moreover, microsatellite markers cannot be used across species.

Recently, the innovation of automated DNA sequencing and PCR techniques combined with the worldwide availability of plant and forest tree genes and DNA sequence-databases through internet facilitates the development of new molecular markers for determining genetic variation of forest trees at specific functional and regulatory genes, regions of DNA and (nuclear, chloroplast and mitochondrial) genomes, namely SAPs (specific amplicon polymorphisms), ESTPs (expressed sequence tag polymorphisms) and SNPs (single nucleotide polymorphism). The details of the mentioned molecular markers and their application can be found from Amaral (2001), Harry *et al*. (1998), Karp *et al.* (1997), Kristensen *et al*. (2001), Krutovskii and Neale (2001), Ratnam (2001), Wang and Szmidt (2001), Szmidt (1995) and Szmidt and Wang (2000). FAO (2001) stated that ESTPs are the most informative markers in terms of gene function among the most recently developed ones and are the first genetic markers that offer real potential for detecting adaptive genetic diversity broadly. Many EST sequences are available for several forest tree species, such as *Pinus radiata*, *P. taeda*, *Picea abies*, *Eucalyptus* spp. and *Populus* spp. The example of the application of some molecular markers on investigation of genetic variation in some forest trees is presented in Table 1.

Table 1. Examples of the application of molecular markers in investigation of genetic diversity and variation in some forest trees

Application	Species markers	Molecular	References
1. Genetic diversity and variation			
	Acacia mangium	RFLPs	Butcher *et al.* 2000
	Acacia mangium & A. melanoxylon	Isoenzyme	Moran 1992
	Azadirachta spp.	Isoenzyme	Changtragoon *et al*. 1996
	Melaleuca cajuputi	Isoenzyme	Changtragoon and Szmidt 1997
	Pinus merkusii	Isoenzyme	Changtragoon & Finkeldey 1995
	Pinus merkusii & P. kesiya	Isoenzyme	Szmidt *et al.* 1996
	Populus balsamea	Isoenzyme	Hamrick *et al*. 1992
	Pterocarpus macrocarpus	Isoenzyme	Liengsiri *et al*. 1995
	Quercus robur	Isoenzyme	Muller-Starck *et al.* 1992
	Abies alba	Cp (RFLPs)	Ziegenhagen *et al.* 1995
	Pinus attenuata	RFLPs	Strauss *et al.* 1992
	P. radiata	SSRs	Cato and Richardson 1996
	Pinus merkusii & P. kesiya	Cp (RFLPs)	Szmidt *et al.* 1996
	Pinus spp.	Cp (RFLPs)	Wang & Szmidt 1994
	Quercus robur & Q. petraea	RFLPs	Kremer *et al.* 1991
	Calamus palustris	RAPDs	Changtragoon *et al.* 1997
	Eucalyptus	RAPDs	Rossetto *et al.* 1999a
	Melaleuca alternifolia	SSRs	Rossetto *et al.*1999b
	Avicennia marina	AFLP & SSRs	Maguire *et al.* 2002
2. Mating system			
2.1 Selfing rate			
– 50 %	*Pinus merkusii*	Isoenzyme	Changtragoon & Finkeldey 1995
– 16 %	*Pinus sylvestris*	Isoenzyme	Yeh 1989
– 10.8%	*Pinus sylvestris*	Isoenzyme	Szmidt 1984
2.2 Pollen contamination in seed orchard			
– 21-89%	*Pseudotsuga menziesii*	Isoenzyme	Wheeler & Jech 1992
– >50%	*Pinus sylvestris*	Isoenzyme	Wang *et al*. 1991
3. Species and clone identification			
3.1 Species	*Azadirachta* spp.	Isoenzyme	Changtragoon *et al.* 1996
	Populus spp.	Nu (RFLPs)	Wagner 1992
	Pinus densiflora & P. sylvestris	Cp (RFLPs)	Szmidt and Wang 1993
	Pinus merkusii & P. kesiya	Cp (RFLPs)	Szmidt *et al*. 1996
	Pinus sylvestris & *P. mugo*	Cp (RFLPs)	Filppula *et al.*1992
	Asian *Pinus* spp.	Cp (RFLPs)	Wang and Szmidt 1993
	Quercus spp.	RAPD	Moreau *et al.* 1992
	Picea mariana & P. rubens	RAPD	Perron *et al.* 1995
	American and Mexican pines	RAPD	Furman *et al.* 1997
	Avicennia	RAPD	Parani *et al.* 1977
	Mangroves	PCR-RFLPs	Parani *et al*. 2000
3.2 Clones	*Acacia auriculiformis*	Isoenzymes	Changtragoon and Woo 1996
	Azadirachta indica var. *siamensis*	Isoenzyme	Changtragoon 1996
	Eucalyptus spp.	RAPD	Kiel & Griffin 1994
	Picea glauca	RAPD	Hong *et al.* 1992
	Picea sitchensis	RAPD	Van de Ven and McNicol 1995

Potential of molecular markers to facilitate forest gene conservation management

Molecular genetic markers hold great promise for several conservation applications, including approaches to measuring fundamental parameters important in conservation, such as effective population size, past bottlenecks, sex-specific gene flow or founder contribution. They also can be used to infer the historical and geographical relationships between groups (Hedrick 2001). The use of molecular markers has revolutionised studies of mating system, pollen movement, seed dispersal and genetic processes. Results of such studies are of considerable practical significance in relation to conservation and breeding programmes, such as population sampling, seed orchard design and management, controlled pollination methods and clonal forestry programmes for conservation and breeding (Haines 1994). Molecular markers may be used in four types of measurements needed for effective *ex situ* and *in situ* conservation of plants, namely: identity, similarity, structure and detection of genetic background of individuals, accessions, populations and taxa (Karp *et al.* 1996).

The application of molecular markers to facilitate genetic conservation in the tropics should be made in two steps. Firstly, they can be used to evaluate the status of genetic background of *ex situ* plantations and *in situ* sites that are established based on conventional silvicultural practices for any forest tree species. They can be used to check whether they contain correct clones and ramets and have sufficient genetic diversity for the conservation as representatives of the species' gene pool. If not, remedial measures could be taken according to the information guidelines provided by molecular genetic investigation.

Secondly, they can be applied to evaluate the status of genetic resources of species for which conservation plots have not yet been established, but that are planned to be included in conservation programmes. This can be done by determining the mating system, genetic variation within and among populations and as well as gene flow. In this manner, molecular markers can be used to guide as to how and where to collect samples for *ex situ* conservation and to determine/identify suitable sites for *in situ* conservation. However, to maximize the latter application, the method should be combined with an ecogeographic survey and measurement of adaptive traits.

The potential of the application of molecular markers for the management of forest genetic conservation could be summarized as below:

1. To clarify the identity of taxa and their relatedness as well as to infer their evolutionary histories
2. To correctly identify clones and ramets in genebanks to avoid mislabelling, duplication and contamination
3. To evaluate the amount, extent and distribution of genetic diversity within and between populations
4. To estimate mating system (selfing and outcrossing rate) and gene flow
5. To evaluate the status of genetic resources as the criteria for *ex situ* and *in situ* conservation from genetic information provided
6. To maximize the efficiency of management of conservation by combining adaptive traits, ecogeographic and genetic survey for both collection programs for *ex situ* conservation as well as for identifying sites for *in situ* conservation

Therefore, the answer to questions such as how to manage, which and how many materials should be manipulated and where the genetic resources should be established or protected, depends on whether the genetic background of particular species which we want to conserve is really known (Changtragoon and Szmidt 1993).

Case studies of the application of molecular markers in Thailand

Two case studies of the application of molecular markers in some forest trees as a guideline for genetic conservation management in Thailand are presented:

Genetic diversity of *Pinus merkusii* in Thailand

A genetic inventory in 11 natural populations of *Pinus merkusii* in Thailand revealed only little genetic diversity at 14 isozyme gene loci (average $d_T = H_e = 0.058$) as shown in Table 2. Allelic differentiation among populations was also small (d = 0.034), but higher than the differentiation reported for many other conifers, if measured as a proportion of the total variation ($F_{st} = 0.104$). Genotypic structures of seed samples were characterized by a deficiency of heterozygotes relative to Hardy-Weinberg expectations in most populations, while the genotypic structures of seed trees, which represent the adult forest stand, did not differ significantly from Hardy-Weinberg proportions. Estimation of outcrossing rates revealed extraordinary high proportion of selfing ($0.017 < t_m < 0.65$) for 9 out of 10 analysed populations, which accounts for the high inbreeding coefficients (Table 3). Scarcity of foreign pollen available for fertilization of ovules due to low population density, poor synchronization of flowering periods and over-mature character of most stands resulting in limited flower production are probable reasons for this result (Changtragoon and Finkeldey 1995).

Table 2. Genetic variation within *Pinus merkusii* populations in Thailand

Population	N	PPL (95%)	A/L	Ho	He
Ban Wat Chan 1	126	21.4	1.6	0.019	0.038
Ban Wat Chan 2	108	21.4	1.6	0.037	0.048
Khun Yuam	126	7.1	1.4	0.006	0.029
Omkoi	139	21.4	1.7	0.042	0.076
Pitsanuloke 1	180	21.4	1.8	0.063	0.088
Pitsanuloke 2	156	14.3	1.4	0.032	0.048
Nong Khu	150	21.4	1.6	0.051	0.070
Pooniyom	120	7.1	1.3	0.030	0.039
Huey Tha	138	35.7	1.6	0.061	0.109
Kong Chiam	108	21.4	1.5	0.044	0.055
Buntarik	180	14.3	1.6	0.025	0.042
Average	**139.18**	**18.8**	**1.6**	**0.037**	**0.058**

N : Sample size
PPL : Percentage of polymorphic loci
A/L : Average number of alleles per locus
Ho : Average observed heterozygosity
He : Average expected heterozygosity

Table 3. Estimation of outcrossing rates of *Pinus merkusii* in Thailand

Population	tm
Ban Wat Chan 1	0.444 ± 0.322
Ban Wat Chan 2	0.593 ± 0.202
Khun Yuam	0.017 ± 0.013
Omkoi	0.422 ± 0.120
Pitsanuloke 1	0.644 ± 0.154
Pitsanuloke 2	0.395 ± 0.095
Nong Khu	0.455 ± 0.115
Pooniyom	0.767 ± 0.145
Huey Tha	0.468 ± 0.077
Kong Chiam	0.843 ± 0.087
Buntarik	0.400 ± 0.088

Recommendations for genetic conservation of *Pinus merkusii*

In situ conservation

In situ conservation of *P. merkusii* is very important. Priority populations to be conserved are:

- Huey Tha (highest diversity)
- One more population from the Northeast (Nong Khu or Kong Chiam)
- One population from the North (e.g. Ban Wat Chan)

Ex situ conservation

Ex situ conservation has a complementary role to play. Several *ex situ* conservation stands should be established, because:

- Protection is easier if the locations are properly chosen, and
- Inbreeding might be lower than in natural populations due to a high density of stands and better flowering (uniform age structure).

It is suggested that 3-6 *ex situ* conservation stands should be established, at least one in each main region (North, Central, Northeast Thailand). Seeds should be harvested from approximately 20 trees of 3 populations within each region. Since the genetic diversity is low, this number is regarded as sufficient to contain most of the genetic information of *P. merkusii* in Thailand. Seeds from the same region should be bulked and be planted in small *ex situ* conservation stands (1 ha each), preferably at two sites, which are easy to protect within each region. Thus, only 6 ha of *ex situ* plantations needs to be established (Changtragoon and Finkeldey 1995; Changtragoon 2001).

Genetic diversity of teak (*Tectona grandis*) in Thailand

Fifty-one RAPD loci were identified and used to evaluate genetic diversity in fifteen natural populations of teak (*Tectona grandis*) in Thailand. Partitioning of genetic variation into within and between population components revealed that about 21% of the total variation was attributable to differences between populations. The number of polymorphic loci in most of the investigated populations was very high with the average of 70% of polymorphic loci (Table 4). Significant differences in allelic frequencies were found for most pairwise comparisons between populations (Changtragoon and Szmidt 2000). The outcrossing rates ranged between 82–97% (Table 5). However, within a population, there were differences in outcrossing rates among families. Despite the high average outcrossing, there was some inbreeding in each family and population, which should not be ignored (Changtragoon 2001).

Table 4. Genetic diversity estimates *Tectona grandis* populations investigated in Thailand

Population	Sample size	Polymorphic loci in %	Gene diversity
Pongsaree,Chiengrai	45	58.8	0.205
Mae Saaeab,Phrae	41	82.4	0.343
Chiengdoa,Chiengmai	20	78.4	0.335
Hod,Chiengmai	33	82.4	0.367
BanmaiMaetha,Lumpang	20	80.4	0.373
Thumpathai,Lumpang	18	68.6	0.334
Pratupa,Lumpang	34	84.3	0.345
Maesaraeng,Maehongson	30	84.3	0.365
Lansang 1,Tak	30	80.4	0.347
Lansang 2,Tak	20	62.8	0.278
Maemue 1,Tak	21	82.4	0.353
Nampad,Utradit	18	50.9	0.226
Thaepnimit,Utradit	36	92.2	0.371
Kangpalom, Kanchanaburi	20	27.4	0.110
Wangnamwon, Kanchanaburi	22	72.6	0.297
Average	**27**	**72.6**	**0.310**

Table 5. The estimates of outcrossing rate in *Tectona grandis* in Thailand.

Population	tm	ts
Banmai Maetha, Lampang	0.968 + 0.008	0.942 + 0.009
Hod, Chiangmai	0.884 + 0.020	0.884 + 0.022
Kaeng Palom, Kanchanaburi	0.903 + 0.030	0.897 + 0.011
Mae Saeab, Phrae	0.859 + 0.059	0.886 + 0.036
Pongsaree, Chiangrai	0.975 + 0.021	0.959 + 0.014
Pratupa	0.958 + 0.014	0.917 + 0.006
Mae Saerang	0.823 + 0.104	0.852 + 0.054
Wangnamwon	0.922 + 0.045	0.917 + 0.029

tm = multi-locus estimate, ts = single locus estimates

Recommendations for conservation of teak

These results suggest that natural populations of *T. grandis* in Thailand are highly differentiated genetically implying that multiple sources of materials from at least one population of each province in the northern and central part of Thailand for both *in situ* and *ex situ* conservation purposes may be required. Based on the fact that there is a high outcrossing rate, it is suggested that teak seed collection should be made separately by family and population basis. Seed sources and years of collections should be well registered so that based on ancillary information, seed sources could be screened before preparing seedlings for *ex situ* gene conservation. For example, seed sources from highly inbred families could jeopardize the long-term fitness of progeny by lowering the seedling survival percentage or by increasing the susceptibility to pest and disease incidence. Therefore, care needs to be exercised in eliminating such seed stocks from *ex situ* gene conservation units (Changtragoon 2001).

Constraints and limitation

There are some limitations, which should be considered before starting any programme employing molecular markers for genetic conservation of tropical forest tree, especially in the developing countries. First of all, the questions and objectives of a study should be clearly specified. Second, understanding the nature of each molecular marker is necessary whether they are codominant or dominant markers and which markers can be determined in nuclear and/or organelle (chloroplast and mitochondria) genomes. Therefore, the choice of markers and purpose of their application should be properly matched. Thirdly, knowledge on how to analyse and manage the molecular data as well as how to interpret the results should be sufficient. Last of all, laboratory facilities such as equipment, water quality, electricity, expertise and manpower as well as financial support should be considered in order to decide whether it is realistic to use those markers for a particular purpose.

The question that is often raised in international forest genetics conferences is which techniques and markers would be the best for use in forest population genetics and conservation. It is not difficult to answer this question, but to find the financial support to facilitate and handle the equipment and laboratory needed for these techniques is more difficult especially for developing countries due to lack of financial support and expertise. The greatest disadvantage in developing countries, such as Thailand is the cost of equipment and chemicals, which are about 2-4 times higher than in developed countries due to extra transportation costs and taxes (Changtragoon 1998).

Future plans and possibilities

The priority forest tree species in Thailand as well as in the Asia Pacific region should be identified at different levels according to their importance and conservation status: first their ecological and economic value and, second, their status of distribution and existence; whether they are specific to a certain location, whether they are fragmented, threatened or endangered. As soon as the species are identified, the survey of genetic variation and mating system as well as geneflow of particular species can be planned and initiated. The survey will take about at least 2 years. However, this will largely depend on which molecular markers are used and as well as on the budget, human resources and facilities provided. One should keep in mind that most of the available molecular markers can detect only neutral genetic variation. Therefore, use and application of molecular markers, which can detect potentially adaptive genetic diversity is encouraged. In addition, combining molecular markers with other methods, such as ecogeographic surveys and adaptive traits (mostly morphological characterization) measurement for assisting in the selection of tropical forest trees for *ex situ* and *in situ* conservation and management, is also recommended.

As new molecular markers have been developed very fast but are still relatively costly, close collaboration and training within and among the developing countries in the region would be an alternative way to initiate the application of molecular markers for the management of gene conservation programme of tropical forest trees in the Asia-Pacific region more efficiently.

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The role of *ex situ* conservation of trees in living stands

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Introduction

Protected areas are important contributions to forest conservation; protecting many forest values and represent considerable achievement towards conserving forest genetic resources (FGR). It is clear, however, that existing protected areas are not, in themselves, sufficient to achieve or sustain all forest conservation goals. Many are in wrong places, of inadequate size, too disconnected from their surrounding environment and inadequately protected from pressures which compromise their conservation value (Kanowski 2001). It is estimated that more than 8 000 tree species are endangered according to the World Conservation and Monitoring Centre (for details, see www.unep-wcmc.org). Only about 12% of these are recorded in protected areas and only 8% are known to be in cultivation (IUCN 1999). At the same time, habitat destruction is occurring at increasing rates all over the world. If we are to believe the habitat-species curves and there are no reasons not to, thousands of species will disappear during the coming decade. Nowhere on earth is habitat destruction as imminent as in tropical forests. Thousands of tree species will depend on conservation outside protected areas, that is in managed forests, agricultural landscapes, or *ex situ* in botanical gardens, arboreta, seed banks or field genebanks. This paper presents experiences with *ex situ* conservation of tropical trees in living stands (field genebanks) and discusses some of the inherent opportunities and drawbacks.

The aim of ex situ conservation stands

The purpose of *ex situ* conservation stands is to keep genetic resources in a secure area for future utilization. However, *ex situ* conservation in this pure form is rarely found. Some botanical gardens and arboreta have started collections of threatened species mainly for conservation purposes but these collections often consist of very few individuals and do not represent the genetic diversity in the species/population. In forestry, *ex situ* conservation stands often consist of a larger number of individuals but the long-term objective is most often, if not always, combined with an immediate and far more utilitarian purpose.

Humans have always moved valuable plant materials whenever they migrated to new areas. However, it was first with the colonial period during 1850-1950 that an era of plant exploration and introduction of unprecedented extent began. During colonial times numerous *ex situ* populations of tropical trees were established to test promising exotic or indigenous species. The first rubber trees in Singapore and the teak and *Cinchona* plantations in India were all *ex situ* plantings but established at a time where no one had to worry about conservation. This contrasts with today, where natural forests are diminishing and, often it is uncertain whether a given natural stand will be available in a decade or two. Consequently, most *ex situ* plantings of trees, in particular tropical trees, could function as ‘gene conservation stands’ or ‘field genebanks’ as well.

The most frequent functions of *ex situ* stands in forestry are to serve as seed sources, for utilization in tree breeding programmes, for testing of promising exotic or indigenous tree species or for research and educational purposes. Most plantings termed ‘*ex situ* conservation stands’ are established with one or more of these objectives in mind.

It is estimated that only about 100 tree species are conserved adequately *ex situ*. These are almost exclusively species whose genetic resources have been assembled for domestication programmes, with which almost all substantive *ex situ* forest conservation activities are associated (NRC 1991).

Early, and some recent experiences with ex situ *stands*

Hardwoods in Indonesia

During the early 20th century, the Dutch established plantings of a number of hardwoods in Indonesia. The Dutch hardly conceived these plantings as conservation stands. At the time of establishment these plantings were meant as silvicultural trials to evaluate species for plantations. Nevertheless, these stands of which many are 60 years old by now, may provide valuable experience on establishment and management of *ex situ* conservation stands. Indeed, today the Indonesian stands are often referred to as *ex situ* conservation stands in the literature (Subiakto *et al*. 2001; Sidiyasa *et al*. 2001).

Since 1937, the Forest Research Institute, then the Forestry and Nature Conservation Research and Developmental Center (FNCRDC) established eight demonstration forests in western Java, which harbour dipterocarp collections of 5 genera and 41 species from Sumatra, Bangka, Java, Kalimantan and Maluku. Various studies have been conducted from these demonstration forests including growth, yield, pest and disease as well as flowering patterns. Currently, dipterocarp stands at the demonstration forests have become important seed sources for planting programmes. Thus, even though actually designed for research purposes, some of the plots are now considered valuable field genebanks.

Table 1. Selected dipterocarp collections at FNCRDC demonstration forest (for full list, see Subiakto *et al*. 2001)

Species	Planting site	Planting year	Origin	Number of trees left	Natural regeneration
Dipterocarpus gracilis	Darmaga	1957	Sumatra	16	Few saplings
D. haselthii	Carita	1957	Java	8	Few saplings
D. tempehes	Haurbantes	1940	Kalimantan	21	None
Dryobalanops lanceolata	Haurbantes	1954	Kalimantan	2	No fruit, flowering only
-do-	Pasir Hantap	1973	Kalimantan	6	No flowering yet
-do-	Darmaga	1987	Kalimantan	0	None
Hopea bancana	Haurbantes	1954	Sumatra	57	Few saplings
H. mengarawan	Haurbantes	1954	Sumatra	4	Plenty
-do-	*-do-*	1958	Sumatra	34	Few
-do-	*-do-*	1974	Sumatra	0	None
Shorea acuminatisima	Haurbantes	1940	Kalimantan	2	No fruit, flowering only
S. javanica	Pasir Awi	1958	Java	0	None
S. laepifolia	Haurbantes	n.a.	n.a.	0	None
S. leprosula	Haurbantes	1940	Kalimantan	3	Plenty
S. macrophylla	Haurbantes	1940	Kalimantan	0	Plenty regeneration, poles up to 20 cm dbh.

As there is an increasing trend of encroachment and illegal logging even in protected areas, it has been argued that the safest way to conserve dipterocarp species is by *ex situ* conservation (Subiakto *et al*. 2001). However, as the demonstration forests also show, maintenance of dipterocarps *ex situ* is by no means simple (Table 1). Besides the loss of a number of stands, the majority of remaining stands has been reduced to very few trees. To serve the purpose for conservation, these stands will have to be infused with new materials in order to maintain a minimum of genetic variation.

Furthermore, most of the stands have reached maturity, which raises the question about regeneration. For some stands this will be easy as plenty of natural regeneration is found within the stand. But for most stands there are only few seedlings or none at all. How are these stands going to be regenerated and what will be the costs?

For some species regeneration may be overcome by simply collecting seed to establish a new plot. But some species will prove problematic to regenerate. This is amply illustrated by a species like *Dryobalanops lanceolata.* Three *ex situ* stands of this species were established in three different sites (Table 1). One stand was lost, one stand, established in 1973, is down to 6 trees but has not flowered yet. In the third and oldest stand established in 1954, flowering is observed but no fruiting. This either shows how many years some of these long-lived trees take before flowering is initiated or it shows that flowering and fruiting is somehow disrupted in the new environment. How is the conservation officer going to proceed from here?

Tropical pines from Central America

Natural populations of *Pinus caribaea*, *P. oocarpa* and *P. tecunumanii* in Central America are under intense pressure from agriculture, grazing, overexploitation and fire. Therefore, a network of *ex situ* conservation stands of the three pine species was established in the late 1970s (FAO 1985). DFSC and FAO recently assessed the stands in 8 different countries to assess their conservation status. A total of 135 *ex situ* conservation stands totalling 950 ha, were included in the study. The survey showed that stands had been successfully established and had relatively good survival. About 20% of the stands were lost. Fire was the overriding cause of lost and disturbed stands while encroachment and illegal cutting damaged a number of stands to varying degree. The majority of stands were smaller than the 10 ha recommended at the time of establishment. Nonetheless, most stands were considered to have a sufficient number of individuals to secure an acceptable level of genetic variation.

About half of the *ex situ* stands fulfilled requirements for isolation from possible contaminating pollen sources. In most countries several stands were planted at one site, typically close to research or conservation stations. To group stands at one site provided advantages in terms of protection and management, but made it difficult to secure appropriate isolation.

Flowering and seed setting was generally very poor. The poor environmental match of many provenances may have reduced their reproductive potential. Secondly, stands were rarely thinned which restricted crown development and thereby flowering.

Poor isolation from contaminating pollen sources and limited cone setting restricted the use of the stands as seed sources. Therefore, regeneration of the stands seems doubtful. The costs involved and the poor prospects for recovering part of the expenses by seed sales will hamper the interest of institutions to regenerate the stands at the end of their rotation (Theilade *et al.* 2001).

Regeneration – the bottleneck for *ex situ* conservation stands

Comparing the experiences from the Indonesian *ex situ* stands with that of tropical pines established some 30 years later, it is interesting to note astonishing similarities in what went well and what failed.

For both dipterocarps and tropical pines it proved possible to establish stands over a wide range of conditions and to some degree maintain the populations over several decades though samples must be duplicated at different sites to prevent losses. In both programmes it was difficult to ensure that data on stands were maintained. Most importantly, the two programmes both pointed to the uncertainty of regeneration as the main problem of *ex situ* conservation stands. The question of regeneration of many *ex situ* conservation stands still remains to be properly addressed (Cohen *et al.* 1991). Regeneration protocols have to be developed and practices implemented as older collections mature. Otherwise, there will be no security for their genetic resources, and *ex situ* conservation stands may become *ex situ* morgues.

Figure 1. *Ex situ* conservation stand of tropical pines in Zambia.

Figure 2. Assessing the success of *ex situ* conservation of tropical pines.

Suggestions for developing ex situ *populations*

Considerations on establishment of *ex situ* conservation stands

Tree species have an extraordinary diversity of reproductive systems. These differences are considered to be major determinants of genetic patterns within populations. The kind of reproductive system influences the minimal viable population sizes needed for conservation (Wilcox and Murphy 1985). In brief, self-pollinating and vegetatively reproducing species will vary more genetically between than within breeding populations (Allard 1960). But among outbreeders, especially dioecious species, the reverse is true even though differences in gene frequencies between reproductively isolated populations increase over time. In self-pollinating species, representative samples of a wide range of breeding populations should be sampled, but individual samples need to be represented by comparatively few individuals. For outbreeders, individual populations should be well sampled, but fewer representatives of different populations will generally be necessary (Ashton 1988).

It is generally agreed that most genes do not vary at the population, or even species, level (Ashton 1988). Most variable alleles are sufficiently abundant to be adequately sampled and conserved without danger of chance extinction through random drift in artificial populations as small as 50 (Marshall and Brown 1975) to 100 (Frankel and Soulé 1981) randomly selected individuals. However, such small sample size will not sample rare alleles and the importance of these in the long-term survival of species or populations is unknown.

Burdon (1988, 1995) discusses issues involved in developing *ex situ* populations. The number of mother trees collected from and the final size of the *ex situ* stand will of course depend on the objective of the stand and funds available. For example, Johnson *et al*. (2001) suggests that a minimum of 50 unrelated individuals per population be used to establish a genetic resource population. This would ensure the capture of genes with frequencies of 0.1 and greater. In order to ensure adequate conservation of the sampled material each sampled mother tree needs to be represented by a number of progeny in the conservation stand. For example, 50 unrelated individuals could be established in stands of 30 progenies per mother tree, that is, 1500 stems per stand. It should be noted that it is the final number of stems at the time of rotation that will be important rather than the number planted. Therefore, natural loss and thinning should be factored in at the time of planning population size.

In addition to the above genetic considerations, it must be ensured that stand sizes are kept at a manageable level and that the burden of future management and regeneration is within the capacity of the institution in charge. Multiple stands should be established to spread the risk of losing a population (cf. Table 1). If regeneration plans depend on wind pollination rather than controlled pollination, which is most often the case, larger stands should generally be considered to ensure that the pollen component in the next generation is from the appropriate population. FAO (1992) provides general guidelines for the establishment of *ex situ* conservation stands using common plantation practices.

The number of mating individuals varies greatly from one flowering episode to another. In species with mass fruiting, such as in the Malesian dipterocarp forest, adequate sampling for *ex situ* collections requires collecting seeds in the years when the maximum number of individuals contributes to the reproductive episode.

Attention must be given to matching of seed sources to planting site to optimise chances for survival and a good seed set but also to preserve the specific features of the gene pool. Movement to ecologically different sites will trigger selection away from the specific feature of the sampled gene pool.

Finally, *ex situ* stands should be established in ways facilitating a long rotation cycle. The longer the life of a stand, the longer it will be before they need regeneration and replanting.

How to maintain genetic diversity in field genebanks?

For both *in situ* and *ex situ* conservation the aim is to maintain the genetic diversity. How does a conservation officer maintain the genetic diversity in *ex situ* populations? Managers of breeding populations face the same question and valuable experience is available from there. Breeding programmes aim to manage breeding populations to better hold on to genetic variation while still obtaining genetic gain. Making wise decisions in early generations are crucial in maintaining the genetic variation later (Johnson *et al.* 2001).

One way to maintain the genetic variation is to substructure the genetic resource population in subpopulations. Used in multiple population breeding it refers to having many subpopulations of relatively small size (20-50) designed to maintain genetic diversity. While specific alleles may be lost due to drift from a population, as an effect of sampling or selection, each population will lose different alleles. As a result, each population may end up with a different set of genes.

Many breeding programmes are using their first generation selections (Kang *et al*. 1998) or progeny tests (Purwanto 2001) as gene resource populations. Because progeny tests will not survive indefinitely, methods are discussed to regenerate stands to maintain populations in the long term as multiple populations, as suggested for *Pinus taeda* by Namkoong *et al*. (1997).

Depending on the initial design of the conservation stand, it might have to be thinned one or several times before it attains rotation age. The aim of thinning is to obtain healthy trees with good crown development to ensure sufficient flowering and fruiting. In seed production stands and in plantations, selective thinning favours superior individuals. For conservation stands, systematic thinning has been advocated to maintain original gene frequencies. Systematic thinning is relevant in the cases where there are few progenies per mother tree and in consequence there is a chance of loosing entire families due to thinning. Here it might be a good idea to keep track of families within the conservation population. In any case, following a rigid programme of systematic thinning may be problematic as poorly adapted or unhealthy trees remain in the stand while superior phenotypes potentially valuable for local breeding programmes may be lost.

While it is unlikely that *ex situ* conservation stands maintain over time the exact gene frequencies of the population at the time of sampling, it is important to note that decisions related to the management can influence the level of deviation from the original material sampled. If the conservation stand is to serve rehabilitation and reintroductions into the original habitat, it might be wise to maintain the original gene frequencies as far as possible. If the conservation stand serves as a genetic resource population for breeding programmes it may be desirable to enhance heritable tributes related to production.

Pure or mixed conservation stands?

So far, conservation of forest trees *ex situ* has mainly been restricted to pioneer species, for which seed are readily available, stored and which are easy to propagate and grow. The design of *ex situ* stands has followed plantation practices implying monocultures and even-aged stand structure. Plantation forestry is the management of intentionally unstable systems and requires timely interventions to prevent the collapse of the system (Palmer 1991). Plantation design is feasible provided that resources are available for intensive management and regeneration. Using this design, the conservation officer will, after relatively few years, have to initiate thinning and start considering how to make the generation turnover, i.e. collect seed and establish a new stand. If this is not combined with utilization of the trees, it is a costly procedure (Kjær *et al.* 2001).

Furthermore, the plantation design may not be suitable for many tropical forest tree species of subsequent succession stages (Box 1). Species of late succession usually occur in mixed and uneven-aged stands and are often shade-tolerant. For the conservation of these species to succeed *ex situ*, issues such as nurse crops, mixtures of trees, reproductive ecology including maintenance of pollinators and the collecting and handling of recalcitrant seed need to be addressed.

Box 1.

Experiments with mixing several succession phase species in *ex situ* plantings

The São Paolo Forest Institute has been conserving native Brazilian forest trees *ex situ* in its breeding programme since 1979. Initially, all species were established in pure stands. However, starting in 1990, with the discovery of the importance of respecting succession stages for better adaptation and growth for the majority of native forest species, experiments were set up in mixed plantings, combining several succession phase species such as pioneers, initial secondary, late secondary and climax species. One such example is the experiment with *Guazuma ulmifolia* (pioneer), *Genipa americana* (secondary), combined with *Peltophorum dubium* (initial secondary), *Myracrodruon urundeuva* (late secondary), and *Esenbeckia leiocarpa* (climax).

Conservation is in the form of plantations in experimental designs, which allows for the study of silvicultural behaviour, heritability of traits, population structure and monitoring of genetic variability. Another advantage is the possibility of transforming the experiments into seed orchards, which permits the recombination of material and perpetuation of populations by using their seeds for reforesting altered and degraded areas. The use of low intensity selection within the *ex situ* field banks will allow the production of bred seeds with high genetic variability.

Source: Sebenn *et al*. *Ex situ* conservation of tree species at the São Paulo Forest institute, Brazil. In print.

Thus, if conservation of trees *ex situ* is to play a role in the conservation of the numerous threatened tropical tree species, and not just for a few pioneer species, it may be necessary to think of larger areas with a mixture of species. This will favour natural regeneration and long-term stability of established *ex situ* populations.

International cooperation and donor concern regarding *ex situ* conservation

The most threatened tree species are found in developing countries where funds for conservation programmes are limited. Conservation of FGR *ex situ* might in some instances be the only option but it is also a long-term activity with a large initial investment and continuing cost. Donor agencies have increasingly incorporated environmental considerations in international development activities but support is generally provided for protection of plants *in situ* because of the urgent need to protect ecosystems in face of imminent change. Furthermore, *ex situ* conservation presents few immediately tangible benefits except for employment.

In order to overcome the problems with funding, *ex situ* genetic conservation programmes may be successfully carried out by multiple organizations working cooperatively. Examples include the provenance studies carried out by IUFRO in the past and the current efforts of the Central America and Mexico Coniferous Resources Cooperative (CAMCORE). CAMCORE is a cooperative working to establish *ex situ* genetic resource populations of tropical species of which many are threatened. Presently, 24 organizations are members of the cooperative. *Ex situ* populations have been established for 22 conifer and 13 hardwood species (CAMCORE 2000).

Ex situ conservation is also attended to by international agencies like IUFRO, IPGRI and FAO that have been instrumental in drawing global attention to the need for collection and conservation of FGR. *Ex situ* programmes coordinated through multilateral organisations usually have a reasonable time horizon for funding because of the commitment from member governments. However, secure long-term funding is rarely available because donors continuously reassess priorities and redirect limited funds. Therefore, international centres cannot carry the conservation responsibility alone (Plucknett *et al*. 1987). In addition, many forest trees are outside the mandate of international organizations and are responsibilities of national programmes, many in the developing world.

Discussion – the role of ex situ *conservation stands*

Ex situ conservation of tropical forest trees is hampered by the very large number of taxa that require protection, the large area needed for the cultivation of trees, and the lack of adequate methods for long-term storage of seeds of many species. Moreover, once in cultivation, continual propagation by seed would be limited in many species because pollinators may not be abundant or even present at the new site. On the positive side, the long life cycles of many tropical trees should ensure survival of the original material for many years (Bawa and Ashton 1991).

The most important function of *ex situ* conservation stands is to provide material for planting and breeding programmes. *Ex situ* stands of experimental design may be transformed into seed orchards, which achieve two objectives simultaneously, conservation of genetic resources and seed production. An example of this is the *ex situ* stands of dipterocarps in Indonesia (Table 1) and Brazilian species at São Paolo (Box 1). On the other hand, if interest in maintaining *ex situ* stands is tied to intimately with seed sales this may endanger the maintenance and regeneration of the stands once demand is low as was the case with the *ex situ* stands of tropical pines (Theilade *et al.* 2001).

Often we assume that the traits of interest to tree breeders will remain constant. We do not foresee breeding programmes losing interest in improving rate of growth, but history shows that new traits are often desired. Examples of traits added to breeding programmes include wood density, pulping characteristics and disease and insect resistance. Therefore, an important function of genetic resource populations, whether *in situ* or *ex situ*, is to maintain variation so new desired traits could be identified and be incorporated into breeding populations in the future. In Europe, genetic conservation programmes have been proposed the use of both *in situ* and *ex situ* populations in different multiple populations (Eriksson 2001). Use of multiple populations conserve genetic variation better than a single population of the same size would (Namkoong 1984).

Ex situ conservation is extremely important when an organization is breeding exotics and the species is in jeopardy within its native range. One example is the collections and plantings made by Australia and New Zealand of *Pinus radiata.* The natural distribution of *P. radiata* is limited to five relatively small populations in California. Collections of these populations are planted in large blocks in Australia and New Zealand with management plans in place.[1]

Besides providing material for planting and breeding programmes, the accessibility of plants in cultivation presents research opportunities not possible with remote and dispersed wild populations as well as opportunities for education and for increasing public awareness that would not otherwise exist. *Ex situ* stands generate knowledge on biology and silviculture. This role is vital if we are to have knowledge about plant populations on the edge of extinction that provides a sufficient basis for their management *in situ*.

So far, *ex situ* stands have mainly served to provide material for plantations and breeding programmes but material conserved *ex situ* is of great relevance to the rehabilitation of *in situ* sites too. The United Nations Environment Programme (UNEP) has requested support to establish centres for *ex situ* conservation, particularly to conserve samples for restoration of ecosystems (UNEP 1990). There is no doubt that the role of *ex situ* stands in providing material for rehabilitation of altered and impoverished forest areas will increase in the decades to come. For example, huge tracts of National Parks and other protected areas have been degraded from forest to grassland or shrubs. These areas are obvious candidates for rehabilitation efforts, which could draw on planting material from *ex situ* plantings.

We firmly believe that it is preferable to conserve both species and ecosystems *in situ*. However, it is obvious that this will not be an option for many species or provenances where habitat destruction is total. *In situ* and *ex situ* techniques for conservation come most closely together in re-introductions and recreation of habitats for rare and endangered species (Prance 1997). As more habitats are lost and some tree species are conserved only *ex situ*, it will be necessary to restore suitable habitats. We recommend that future *ex situ* conservation efforts on tropical trees should focus more on creating habitats to move the species back into *in situ*-like situations. By mimicking *in situ* conditions it may be possible to facilitate natural regeneration. Such strategy will broaden the range of species that can be considered for *ex situ* conservation in living stands, and may very well be a regular component in large-scale reforestation and rehabilitation programmes already undertaken in many countries today.

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[1] Note from the editors: It must, however, be noted that this applies only when the exotic species in its place of origin is rare and highly threatened. For other species that are used in tree improvement programmes, it would be better to promote exchange of material from the original source, rather than attempting to conserve it in *ex situ* stands. In most cases, the genetic diversity in introduced species would be far less than what could be found in its place of origin.

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Annex I

Reports of the sub-regional working groups

The Southeast Asia Working Group Report

Member countries of working group:
Cambodia, Indonesia, Lao PDR, Malaysia, Philippines, Thailand and Vietnam.

Common areas of interest
Common areas of interest identified are listed in the table below. All of these are of national priority and need funding support.

Recommendations	CAM	INS	LAO	MAL	PHI	THAI	VIE	total
Increase collaboration on evaluating FGR.	X	X	X	X		X	X	6
Establishment of *ex situ* conservation stand	X		X	X	X	X	X	6
Strengthening of national programmes on FGR.	X		X		X	X	X	5
Improve silvicultural methods for FGR conservation and management.	X			X	X	X	X	5
Increase education and training on FGR conservation and management.	X		X		X	X	X	5
Increase exchange of genetic materials.	X	X		X		X	X	5
Enhance research on demography, genetics and reproductive biology.	X	X	X	X		X		5
Generate financial support for FGR work and regional collaboration.		X	X	X		X	X	5
Increase assessments on the distribution of forest species.		X	X	X		X	X	5
Enhance domestication of rare, endangered and valuable species.			X	X	X	X	X	5

Regional capacity building needs:
- Short and long term training on conservation methods, molecular population genetics, eco-geographical survey, planning of FGR programme, etc.
- Upgrading of equipments and facilities
- Scientist exchange/scientific collaboration/study visits
- Planning of FGR programme

APFORGEN priority species

52 priority species were identified as shown in the table below.

Species	CAM	INS	LAO	MAL	PHI	THAI	VIE	Total
	DFW	CFBTI	NAFRI	FRIM	UPLB	RFD	FSIV	
Rattan	X	X	X	X	X	X	X	7
Pinus merkusii	X	X	X		X	X	X	6
Bamboo	X	X	X		X	X	X	6
Hopea odorata	X		X	X		X	X	5
Pinus kesiya	X		X		X	X	X	5
Tectona grandis		X	X	X		X	X	5
Acacia crassicarpa		X	X		X	X	X	5
Afzelia xylocarpa	X		X			X	X	4
Aquilaria crassna	X		X			X	X	4
Chukrasia tabularis			X	X		X	X	4
Dalbergia cochinchinensis	X		X			X	X	4
Dipterocarpus alatus	X		X			X	X	4
Fagraea fragrans	X		X	X		X		4
Hopea ferrea	X		X			X	X	4
Pterocarpus macrocarpus	X		X			X	X	4
Shorea roxburghii / *S. cochinchinensis*	X			X		X	X	4
Tarrietia javanica	X	X	X				X	4
Xylia xylocarpa/dolabriformis	X		X			X	X	4
Gmelina arborea		X	X	X	X			4
Acacia mangium		X	X			X	X	4
Acacia auriculiformis		X		X	X		X	4
Eucalyptus spp.		X	X			X	X	4
Alstonia scholaris		X	X			X		3
Anisoptera costata	X		X				X	3
Casuarina equisetifolia					X	X	X	3
Melaleuca cajuputi		X		X			X	3
Pterocarpus indicus			X	X	X			3
Rhizophora spp.					X	X	X	3
Albizia lebbeck	X		X					2
Artocarpus heterophyllus		X			X			2
Azadirachta excelsa				X		X		2
Azadirachta indica			X			X		2
Dalbergia bariensis\ oliveri	X						X	2
Dipterocarpus grandiflorus			X		X			2
D. tuberculatus			X			X		2
Eusideroxylon zwageri		X		X				2
Gonystylus bancanus		X		X				2
Intsia palembanica				X		X		2
Metroxylon sagu				X	X			2
Parashorea stellata			X			X		2
Parkia speciosa			X	X				2
Shorea leprosula		X		X				2
S. macrophylla		X		X				2
S. ovalis		X		X				2
S. parvifolia		X		X				2
Toona sureni			X				X	2
Cunninghamia lanceolata			X				X	2
Diospyros mun			X				X	2
Dysoxylum loureiri	X		X					2
Erythrophleum fordii			X				X	2
Fokienia hodginsii			X				X	2
Toona ciliata			X			X		2

APFORGEN modus operandi

The following suggestions for APFORGEN modus operandi were made:

1. APFORGEN to provide technical guidelines and methodologies.
2. Categorize, compile and disseminate information provided by Southeast Asia members.
3. Maintain list-serve and newsletter.
4. Language barrier: APFORGEN to help in translating FGR information in English into national languages for the non-English speaking countries.
5. Update, validate and list new initiatives on priority species.
6. Support funding or provide ways and means to find funding for collaborative FGR activities.
7. Support and facilitate scientific visits and attendance to international meetings.
8. Establish linkages and coordinate to deploy expertise in various areas for APFORGEN member countries.

Information dissemination

Suggestions for contents for the APFORGEN web site:

1. Technical reports
2. List of experts
3. Updated list of priority species
4. Current research activities
5. Maps of forests in each country
6. Red list of endangered species
7. Updated events all over the world that are related to FGR (e.g. seminar, conference, symposium etc)
8. Basic information in SE-Asia with reference to the priority species listed
9. Name, address and email of all the APFORGEN members
10. Job opportunities related to FGR
11. Ways to address problems concerning FGR
12. Sharing success stories concerning FGR
13. Research profile in each country (institutions)
14. Publication, books and journals
15. Member news
16. Link to various related sites

Suggested effective communication mechanisms among APFORGEN members:

1. Email: personnel in charge to check regularly and to respond promptly or to direct to expert who will respond more authoritatively
2. Tele-conferencing (Electronic forum) for any urgent issues
3. Formal letter for correspondence

The South Asia working group report

Member countries of the working group:
Bangladesh, India, Nepal, Pakistan, and Sri Lanka

APFORGEN Action Plan
Common Areas of Interest that have on-going national activities are:

1. Ecogeographic surveys
2. Genetic studies/population genetics
3. Reproductive biology
4. Germplasm collection, storing and propagation
5. Evaluation (species and provenance trials etc)
6. Tree improvement (including domestication)
7. *In situ* conservation
8. *Ex situ* conservation
9. Taxonomy
10. Ethnobotanical studies
11. Silvicultural systems
12. Agroforestry systems
13. Forest management guidelines
14. Wood products (manufacturing/marketing)
15. Non-timber forest products
16. Seed technology
17. Forest rehabilitation/restoration

Priority areas identified include:

1. Germplasm collection, storing and propagation
2. Pest and diseases management
3. Species selection, hybridisation
4. Asexual propagation (clone and tissue culture etc)
5. Reproductive biology
6. Non-timber forest products
7. Provenance trials and evaluation
8. *In situ* conservation
9. Wood products (manufacturing/marketing)
10. Ethnobotanical studies
11. Exchange of information in forest genetic conservation
12. Forest rehabilitation/restoration
13. Conservation policies and strategies

Regional capacity building needs identified include:

1. Participation in workshops/seminar/study tour/visits
2. Exchange of training materials and resource persons
3. Short-term/Long-term training courses
4. Production of training materials
5. Preparation and exchange of extension and public awareness materials and exchange of grey literature

APFORGEN priority species

The priority species suggested for regional activities are:

a) Species that are suitable for tree improvement and multiplication:
   - *Albizia lebbeck*
   - *Albizia procera*
   - *Artocarpus heterophyllus*
   - *Azadirachta indica*
   - *Cassia siamea*
   - *Casuarina equisetifolia*
   - *Chukrasia tabularis*
   - *Hopea odorata*
   - *Lagerstroemia ovalifolia*
   - *Lagerstroemia speciosa*
   - *Pterocarpus indicus*
   - *Pterocarpus macrocarpus*
   - *Rhizophora spp.*
   - *Schima wallichii*
   - *Tectona grandis*
   - *Terminalia chebula*
   - *Acacia nilotica*
   - *Dalbergia latifolia*
   - *Dalbergia sissoo*
   - *Pterocarpus marsupium*
   - *Shorea robusta*
   - *Cedrus deodara*
   - *Pinus wallichiana* subsp. *karakorma*
   - *Adina cordifolia*
   - *Bassia latifolia*
   - *Schleichera oleosa*
   - *Albizia odoratissima*

Species with conservation priority:
- *Acer caesium*
- *Artocarpus* sp.
- *Gmelina arborea*
- *Rhododendron* sp.
- *Taxus baccata*
- *Alnus nitida*
- *Celtis eriocarpa*
- *Fraxinus xanthoxyloides*
- *Grewia asiatica*
- *Prunus padus*
- *Saussurea lappa*
- *Ziziphus nummularia*
- *Diospyros ebenum*
- *Chloroxylon swietenia*
- *Acacia catechu*
- *Bombax ceiba*

Modus operandi

The modus operandi suggested for APFORGEN could include the following elements:

1. Activities to be carried out on a sub-regional approach. Three ecological zones are suggested: Temperate, Sub-tropical and Tropical.
2. APFORGEN may work through groups on timber, fuel, fodder, etc. as well as non-timber forest products (including rattan, bamboo, fruit, seeds, medicinal plants etc).
3. APFORGEN to conduct training need analysis, assist to locate funds and training institutions for capacity building.
4. APFORGEN should be flexible in the choice of priority of species and its sub-group activities.
5. APFORGEN to facilitate visits/attending of workshops by member countries and publication of scientific outputs.

Information dissemination

Suggestions of contents for the APFORGEN web site:

1. Recent technological development
2. Conservation status of plant species, national priority species
3. Future programme
4. Regional collaboration
5. Information on donor
6. List of expertise/ specialisation
7. Bibliography database; information database

Effective communication mechanisms among APFORGEN members**:**

1. Frequent meetings
2. Website/electronic mail

Annex II

Workshop programme

APFORGEN INCEPTION WORKSHOP
15-18 July 2003
Forest Research Institute Malaysia (FRIM)
Kepong, Kuala Lumpur, Malaysia

DAY 1: 15 July 2003 (Tuesday)

09:00–10:00	Welcome address by IPGRI (*Dr P. Sajise, Regional Director, IPGRI-APO*) Welcome address by FAO (*Dr S. Appanah, FAO*) Welcome address and opening by Chairman, APAFRI (*Dato' Dr Abdul Razak Mohd. Ali*)
10:00–10:30	Coffee/tea break
Session I	**Forest genetic resources conservation and APFORGEN**
10:30–13:00	Chair: *Dr S. Appanah (FAO)*; Co-Chair: *Dr Sim H.C. (APAFRI)*
10:30–10:45	Adoption of the workshop programme
10:45–11:15	Background and purpose of the Workshop (*Hong L.T., IPGRI)*
11:15–11:45	IPGRI's activities on conservation and use of forest genetic resources (*Dr Weber Amaral/Dr Jarkko Koskela, IPGRI*)
11:45–12:15	The role of *ex situ* conservation of trees in living stands (*Dr Ida Theilade/ Dr Anders Pedersen, DFSC*)
12:15–12:45	Regional programmes on forest genetic resources: EUFORGEN experiences (*Dr Jarkko Koskela, IPGR*I)
13:00–14:00	Lunch
Session II	**Forest genetic resources in South Asia: update and capacity-building needs**
14:00–17:15	Chair: *Dr B. Krishnapillay (FRIM)*; Co-Chair: *Dr V. Ramanatha Rao (IPGRI*)
14:00–14:30	Bangladesh (*Dr Sk. Sirajul Islam*)
14:30–15:00	India (*R.P.S. Katwal*)
15:00–15:30	Nepal (*P.R. Tamrakar*)
16:00–16:15	Coffee/tea break
16:15–16:45	Pakistan (*Dr Shams-ur-Rehman*)
16:45–17:15	Sri Lanka (*J.E. Munashinghe*)
19:30–21:30	Welcome Dinner

Day 2: 16 July 2003 (Wednesday)

Session III	**Forest genetic resources in Southeast Asia: update and capacity-building needs**
8:30–13:00	Chair: *Dr Anders Pedersen (DFSC)*; Co-Chair: *Dr Shams ur Rehman (PFRI)*
8:30–9:00	Cambodia (*Sok Srun*)
9:00–9:30	Indonesia (*Dr Nur Masripatin*)
9:30–10:00	Laos *(Khamphone Mounlamai & Chanhsamone Phongoudome*)
10:00–10:30	Coffee/tea break
10:30–11:00	Malaysia (*Dr Lee S.L. & Dr B. Krishnapillay*)
11:00–11:30	Philippines *(Dr Ramon A. Razal)*
11:30–12:00	Thailand *(Vichien Sumantakul)*
13:00–14:00	Lunch

Session IV **Forest genetic resources in Southeast and East Asia: update and capacity building needs**

14:00–15:30 Chair: *R.P.S. Katwal (ICFRE);* Co-Chair: *Dr Sk. Sirajul Islam (BFRI)*

14:00–14:30 Vietnam *(Dr Nguyen Hoang Nghia)*

14:30–15:00 Revisiting the Moving workshop 2001 on Conservation, Management and Use of forest genetic resources in S.E. Asia region (*Dr Anders Pedersen, DFSC)*

15:00–15:30 Potential of using molecular markers to facilitate gene management and the *in situ* and *ex situ* conservation of tropical forest trees *(Dr S. Changtragoon*)

16:00–16:15 Coffee/tea break

16:15–17:30 Chair: *Hong L.T. (IPGRI);* Co-Chair: *Dr Sim H.C. (APAFRI)*

16:15–16:45 Development of APFORGEN website: using EUFORGEN website as a model? *(Dr Jarkko Koskela, IPGRI*)

16:45–17:30 Introduction to the working group tasks and selection of chairpersons and rapporteurs *(Dr Jarkko Koskela /Hong)*

Day 3: 17 July 2003 (Thursday)

Session VI **Working Groups – discussion and drafting of framework for FGR needs/ collaboration and APFORGEN strategies**

08:30–08:45 Chair: *Dr Jarkko Koskela / Hong L.T.*

08:45–10:00 Plenary group discussion on structure of APFORGEN (*Dr Percy Sajise, facilitator)*

10:00–10:30 Coffee/tea break

10:30–13:00 Working groups (discussion): Working groups to discuss and provide comments on APFORGEN (based on background document).

Guidelines for working groups:

- Identify common capacity-building needs (1) human resources, 2) institutional capacity, 3) policies and regulatory framework, and 4) information and knowledge.
- Develop concept notes on high-priority capacity-building needs for proposal development
- Identify national and regional donors and funding opportunities
- Draft sub-regional strategies and work plans for APFORGEN
- Set up sub-regional task forces for further proposal development
- Other issues

13:00–14:00 Lunch

14:00-16:00 Working groups discussion (continued)

16:00–16:15 Coffee/tea break

16:15-17:30 Working groups discussion (continued)

Day 4: 18 July 2003 (Friday)

Session VII **Working Groups continued**

08:30–10:00 Working groups continue discussion and to finalise their work

10:00–10:30 Coffee/tea break

Session VIII **Working Groups presentations**

10:30–13:00 Chair: *Dr B. Krishnapillay (FRIM)*

10:30–11:45 Presentation by working group and discussion – South Asia Sub-region

11:45–13:00 Presentation by working group and discussion – South East Asia Sub-region

13:00–14:00 Lunch

Session IX	**Workshop recommendations and concept notes**
14:00–16:00	Chair: *Dr V. Ramanatha Rao*
	• Concept notes – finalisation of lead persons and deadlines
	• Discussion and adoption of workshop recommendations for further action
16:00–16:15	Coffee/tea break
Session X	**Closing of Workshop**
16:15–17:00	Chair: *Dr V. Ramanatha Rao*
	Wrap-up and closing by *Dr. P. Sajise*, Regional Director, IPGRI-APO

Annex III

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Annex IV

Group photo

IPGRI

Forest genetic resources
conservation and management

Proceedings of the Asia Pacific Forest Genetic Resources Programme (APFORGEN) Inception Workshop, Kepong, Kuala Lumpur, Malaysia,15–18 July, 2003

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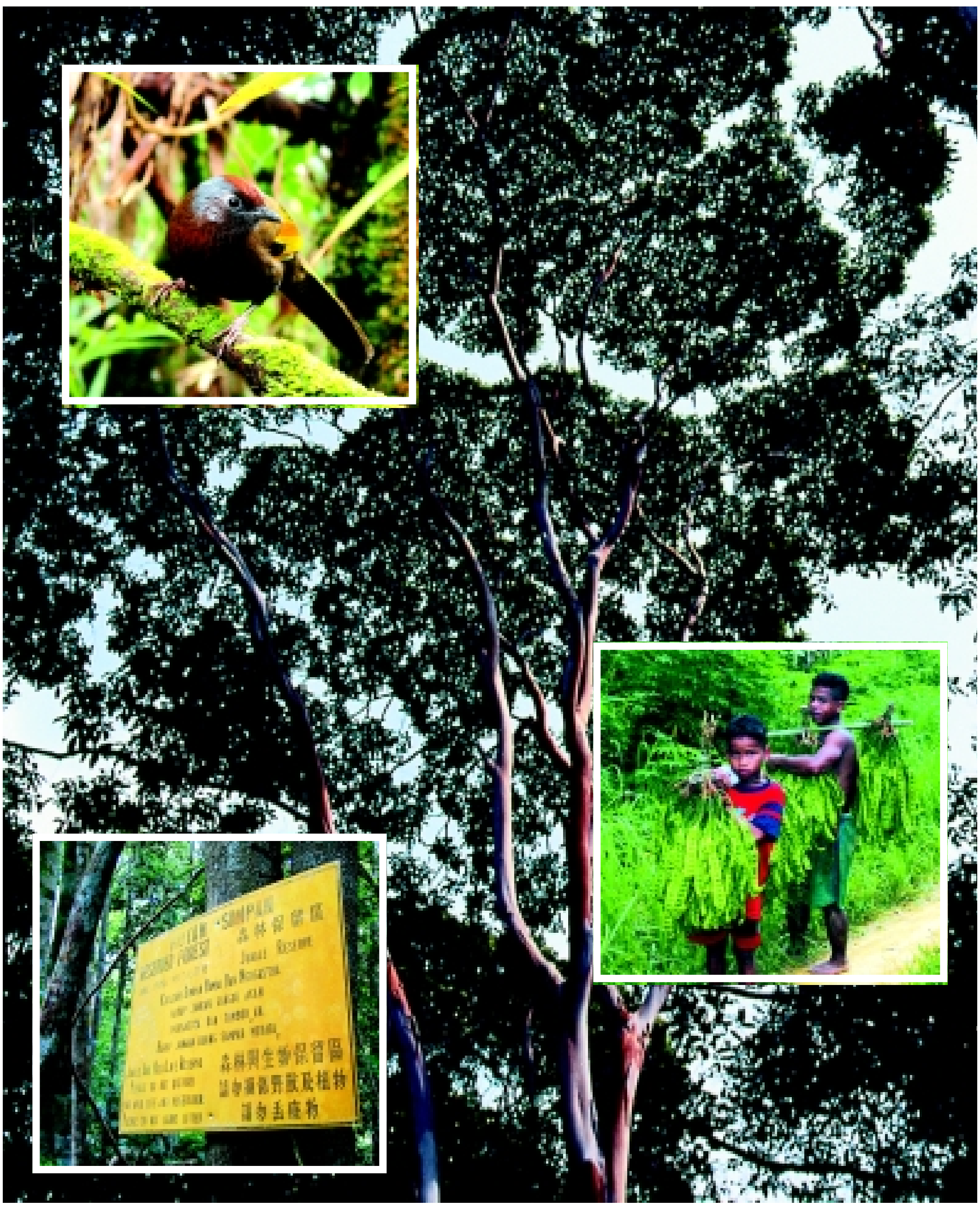

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