FOREST GENETIC RESOURCES

International Symposium on Forest Genetic Resources

Conservation and Sustainable Utilization towards Climate Change Mitigation and Adaptation

5–8 October 2009

Kuala Lumpur, Malaysia

Extended Abstracts

Editors

Sim H.C., Hong L.T. & Jalonen R.

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From the Symposium held in Kuala Lumpur, Malaysia
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Jointly organized by
Asia Pacific Association of Forestry Research Institutions (APAFRI)
Bioversity International (Bioversity)
Forest Research Institute Malaysia (FRIM)
International Tropical Timber Organization (ITTO)

In Association with

Food and Agriculture Organization of the United Nations (FAO)
International Union of Forest Research Organizations (IUFRO)
Secretariat of the Pacific Community (SPC)
Forest Tree Breeding Centre (FTBC) Japan

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Foreword

The International Tropical Timber Organization (ITTO) funded a three-year project titled *Strengthening National Capacity and Regional Collaboration for Sustainable Use of Forest Genetic Resources in Tropical Asia* (ITTO PD 199/03Rev. 3(F)) in years 2006-2009. The project was implemented by FRIM in collaboration with APAFRI and Bioversity International. This project has been one of the main activities of APFORGEN (Asia Pacific Forest Genetic Resources Programme), which has 14 member country organizations in Asia.

This ITTO Project has seven national partners, namely Cambodia (Department of Forestry and Wildlife), India (Indian Council for Forestry Research and Education), Indonesia (Research and Development Centre for Biotechnology and Forest Tree Improvement), Malaysia (Forest Research Institute Malaysia), Myanmar (Forest Research Institute, Yezin), Philippines (College of Forestry and Natural Resources, University of Philippines, Los Baños), and Thailand (Royal Forest Department).

Towards the end of the Project duration, it was deemed beneficial to hold a symposium to present and discuss the information and knowledge on the conservation and management of forest genetic resources (FGR C&M) which has been gathered and collated from the various activities of this project, as well as to obtain feedback on the impact of these activities of on national FGR C&M. The symposium was also extended to include presentations on climate change mitigation and adaption of FGR to these impending adverse effects.

The national coordinators of APFORGEN and the National Focal Points of the ITTO Project had over the years been requested to prepare updates to their earlier reports on FGR conservation and management in their respective countries. The present volume also captures these updates submitted by the National Focal Points of the seven ITTO Project countries during the years 2007, 2008, and 2009.

As a whole, the information presented during the symposium and subsequently compiled in this publication constitutes valuable examples of sustainable forest management, which is of imminent concern in the Asia-Pacific region. It is our wish that forest practitioners, policy makers and researchers in the region will find this publication useful for planning, implementing and evaluating conservation and management of forest genetic resources and their roles in community and livelihood sustainability, climate change mitigation and adaptation.

Editors

31st July 2010

Acknowledgement

We are indebted to ITTO for funding the Project, ITTO PD 199/03Rev. 3(F) under which the symposium was organized. Our thanks also go to the collaborating organizations: FAO, IUFRO, FTBC and SPC, in organizing this symposium.

The contributions of the National Focal Points of the ITTO Project in submitting the updated reports are gratefully acknowledged. Thanks also to the many presenters who had submitted their extended abstracts in time for this compilation.

Several colleagues in FRIM, Bioversity International and APAFRI have contributed time and efforts towards the successful compilation and publishing of this volume.

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Overview of the symposium

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The International Symposium on Forest Genetic Resources was held in Kuala Lumpur, Malaysia, from 5th to 8th October 2009. It was jointly organized by the Forest Research Institute of Malaysia (FRIM), Asia Pacific Association of Forestry Research Institutions (APAFRI), and Bioversity International. Financial support was from the International Tropical Timber Organization (ITTO). The Food and Agriculture Organization of the United Nations (FAO), the International Union of Forest Research Organizations (IUFRO), the Forest Tree Breeding Centre of the Japan Forestry and Forest Products Research Institute, and the Secretariat of the Pacific Community (SPC) also contributed to organizing the event.

The main objective of the symposium was to review the status of national efforts in conserving, managing and sustainably using forest genetic diversity (FGR) in the Asia Pacific region. It served as a platform for researchers and forest administrators to discuss and share information on conservation and sustainable use of the resources. Moreover, it was an important meeting opportunity for the 14 member countries of the Asia Pacific Forest Genetic Resources Programme (APFORGEN), namely Bangladesh, Cambodia, China, India, Indonesia, Lao PDR, Malaysia, Myanmar, Nepal, Pakistan, the Philippines, Sri Lanka, Thailand, and Vietnam.

Conservation and sustainable use of forest genetic resources for climate change mitigation and adaptation was a subtopic of the symposium. The programme was divided into five thematic sessions:

- Status of Asia-Pacific FGR
- FGR and biodiversity
- FGR erosion, impacts of climate change, and biotic and abiotic disturbances
- Community involvement in FGR conservation and management
- FGR conservation and management: Regional and national status, policies and strategies

A total of 40 papers were presented, including keynote presentations from the ITTO, the FAO and Bioversity. The detailed programme is presented in Appendix I. The symposium brought together in total 63 forestry researchers, academicians, and forest administrators from 19 countries across the Asia Pacific region, including the member countries of APFORGEN as well as participants from Japan, the Pacific Islands and Australia.

The symposium was one of the activities of the project *Strengthening National Capacity and Regional Collaboration for Sustainable Use of Forest Genetic Resources in Tropical Asia* (ITTO-project). The project was implemented in the years 2006-2009 and funded by the ITTO. Countries participating in the project were Cambodia, India, Indonesia, Malaysia, Myanmar, the Philippines and Thailand.

Presentations

Keynote presentations

Dr Ma Hwan Ok, Projects Manager at the Reforestation and Forest Management Division of the ITTO, gave a presentation on the ITTO and its activities. During its history, the ITTO has provided in total over US$300 million to 400 projects related to sustainable forest management, policy implementation, capacity building and training. In total 150 projects were being implemented throughout the tropics in 2009. Future thematic areas for funding include Forest Law Enforcement, Governance and Trade (FLEGT), and Reducing Emissions from Deforestation and Forest Degradation (REDD). Together with the IUCN, the ITTO had published guidelines on *Conservation and sustainable use of biodiversity in tropical production forests* (ITTO and IUCN 2009).

Dr Oudara Souvannavong, Senior Forestry Officer at the FAO Forestry Department presented the State of the World's Forest Genetic Resources process (SOW-FGR). He emphasized that the process itself would be as important as its outcomes, and it should be considered an opportunity for capacity-building, development of networks and cooperation to define priorities. The first country reports will establish a baseline and enable analysis of trends in the future, so their diligent preparation warrants the efforts.

In her presentation about climate change, Dr Judy Loo, Senior Scientist on Forest Genetics at Bioversity International, projected severe disruption in forest ecosystems in the coming decades before the ecosystems could attain a new equilibrium with the environment. Tools for assessing vulnerability of tree species should be developed. This, however, requires research also on the related mechanisms such as migration, adaptability and plasticity, which remained little understood. Assisted migration and small-scale breeding programmes can help sustain the livelihoods of forest-dependent communities.

Country status reports

Country status reports with regard to conservation and management of FGR were presented by the partner countries of the ITTO Project, as well as China, Fiji, Japan, Papua New Guinea and Viet Nam. Some presentations specifically listed challenges to conservation and sustainable use of FGR, including the following:

- Knowledge gaps in research
    - Lack of information on the distribution, biology and protection status of species. (Myanmar)
    - Fragmented research efforts. (The Philippines)
    - Limited knowledge on genetic conservation, tree domestication and improvement for enhanced resource use. (Indonesia)
- Lack of regulatory framework and strategic planning
    - Lack of specific regulations for conservation and management .(Indonesia)
    - Lack of national strategies for conservation and sustainable use. (Fiji)
    - Climate change adaptation not incorporated in national development policies or programmes. (Philippines)
    - Conflicting and overlapping roles and mandates of institutions .(The Philippines)
    - No prioritization of species. (Fiji, Indonesia, Philippines)
- Land tenure and land use planning
    - Conflicts on the use rights of local people, open access. (Philippines)
    - Customary tenure allowing unsustainable practices. (Fiji, Papua New Guinea)

    - Lack of comprehensive and coordinated land-use policies, plans and instruments. (Myanmar, Philippines)
    - Lack of participation and awareness among landowners. (Fiji)
- Lack of resources
    - Human resources and capabilities (Indonesia, Thailand); especially in the field. (Myanmar)
    - Insufficient allocations of funding. (Indonesia, Myanmar)
    - Lack of facilities for conservation and research. (Indonesia)

Countries also listed recent initiatives for improving conservation and sustainable use of forest genetic resources. These included the following:

- Development of legal and policy framework
    - A National Strategy for Plant Conservation published in 2009. (Malaysia)
    - Formulation of Malaysian strategy on FGR conservation, to address the fact that majority of the existing policies do not pay special attention to FGR. (Malaysia)
    - Development of a national FGR conservation strategy and prioritization of species are underway. (Thailand)
    - A regional strategy and action plan on FGR conservation and management have been developed. The action plan is available from http://www.spc.int/lrd. (the Pacific Islands)
    - A National Policy on Forest Genetic Resources being drafted. Future policies would emphasize rehabilitation of degraded forests and lands, conservation of the remaining natural forests, and environmental management of plantation forests. (Indonesia)
    - An act being formulated which would directly regulate use, management, and conservation of genetic resources, including those of forest species. (Indonesia)
- Institutional arrangements
    - Creation of National Bureau of Forest Genetic Resources. (India)
    - A National Platform for forest genetic resources (China)
    - A national APFORGEN task force and a website established to support the activities of the network and conservation of forest genetic resources. (Indonesia)
    - Tropical Forest Biodiversity Centre established at the Forest Research Institute Malaysia .(Malaysia)
    - Annual FGR workshops for stakeholders held since 2008 for networking, disseminating information and discussing the future directions of resource use. (Indonesia)
- Research and conservation activities
    - Evaluation and conservation of genetic resources of important tree species through the All India Coordinated Projects. (India)
    - An ITTO-funded project for improving conservation of biodiversity in natural forests was being implemented. The objective was to formulate tools for integrating biodiversity considerations into forest management decisions. (Malaysia)
    - Developing concept and guidelines for conservation of FGR at village level. (Indonesia)
    - Chinese Academy of Forestry (CAF), Forest Research Institute Malaysia (FRIM) and Korea Forest Research Institute (KFRI) would organize a technical session on conservation and sustainable use of forest genetic resources at the IUFRO world congress in Seoul, Korea, in August 2010. (China)

- Information management
    - Database on priority species for genetic resources and tree improvement established. (Indonesia)
    - Database of the flora of Peninsular Malaysia created. (Malaysia)
    - A National database for forest genetic resources exists.(China)

Highlights from other presentations

Dr Wickneswari Ratnam listed weaknesses of genetic diversity studies in the Asia-Pacific region, which included the following areas: (i) critical levels of genetic diversity and adaptive potential of forest trees are not well understood, (ii) relationships between ecological or demographic factors and genetic processes are not known, (iii) choice of species for studies, (iv) geographic distribution of samples is imbalanced, and (v) the role of pollen and seed dispersal to gene flow is not understood, although it is crucial for fragmented forest areas.

Dr Lee Soon Leong and Dr Kevin Ng Kit Siong from FRIM presented their research on assessing genetic diversity of dipterocarps in Peninsular Malaysia. Their group has identified life-history traits and minimum population sizes for several species. Their simulation studies suggested that outcrossing species are more susceptible to impacts of logging, and removal of trees in clumps rather than at random leads to higher losses of diversity.

Dr Anura Sathurusinghe presented community forestry in Sri Lanka. Home gardens harbour more than 400 important timber species and supply over 40% of saw log and 27% of fuel wood demand of the country. Local people select and maintain seed trees in their gardens, supply germplasm to the state forest department, and maintain biological corridors. Capacity-building among the local communities e.g. in tree management and seed tree selection, and improved coordination and monitoring of activities would be needed.

C. Nugroho presented the Indonesian initiative of village-level conservation of forest tree diversity. Each community was encouraged to conserve at least one species on their land. Pilot projects demonstrated that the approach could bring continuous benefits to the communities. Secure land tenure, intensive technical assistance; leadership and support from local governments would be needed. A manual on the approach has been prepared for the communities (in Indonesian).

Cenon Padolina presented conservation strategies and initiatives of the Pacific Islands. Climate change, food security and availability of good quality germplasm were among the priorities for management of forest genetic resources. The Centre for Pacific Crops and Trees (CePaCT) had recently expanded its activities to trees and forests because of their livelihood importance, and was re-opened in September 2009 with this new name. A regional centre for tree seeds would be established under CePaCT.

Planning of future work

One morning session in the symposium was reserved for discussions and planning of future work of the APFORGEN network. The objectives were to identify thematic areas for the future and to agree on follow-up activities. As a basis for discussions, Mr Hong Lay Thong (Bioversity) presented the past activities and action plans of the APFORGEN network, and Dr Sim Heok-Choh (APAFRI) presented the ITTO-project on national capacity building.

After the presentations, the participants were divided into four sub-regional groups of South Asia, Southeast Asia, East Asia, and the Pacific. Each group was asked to identify concrete action needs and areas of common interest based on the following questions:

- What are the major limitations to conservation and sustainable management of FGR in your country?
- How could you overcome these limitations with the help of regional collaboration?
- What experiences and good practices you have developed which could be beneficial to others?

After one hour of group discussions, the participants gathered together to share and develop further the topics identified in the groups. The following issues stimulated the most discussions:

- Prioritization of species
  - Develop guidelines and approaches for prioritization (e.g. whom to involve, what kind of information needed for decision-making).
  - National and local priorities may be different.
  - Sub-regional priorities could be identified as a basis for joint efforts.
- Assessing and conserving diversity of priority species
  - Develop guidelines for conducting diversity assessment.
  - Establish sub-regional working groups to assess and conserve common priority species.
  - Develop sub-regional action plans for priority species.
  - Share research facilities and germplasm.
- Climate change (specific questions not agreed on in the session)
- Capacity building
  - Conservation technologies.
  - Providing financial support for participating in trainings.
  - E-trainings.
- Efficient national coordination
  - Provide model approaches for establishing national FGR groups to address the key issues and avoid gaps and overlaps in roles and responsibilities (e.g. whom to involve, what specific issues to discuss, working methods).

In addition, the following topics were brought up repeatedly in the presentations of the group discussions:

- How to encourage community involvement and benefit from it?
- Guidelines for developing comprehensive national FGR policies and action plans.
- How to enhance sharing of information?
  - Improved sharing of information on regional, national and sub-national levels.
  - What standards should be used or developed for documentation?
  - Standards should be international, not only regional.
  - State of the World's FGR process provides a framework.
- Development of sub-regional activities (action plans, sub-regional priority species).

The group discussions had successfully identified several action needs, and there was active discussion around the suggested topics. The outcomes of the planning session were incorporated in the recommendations of the symposium.

State of the World's Forest Genetic Resources

The symposium was followed by a one-day workshop on the State of the World's Forest Genetic Resources. The workshop was organized by Dr. Oudara Souvannavong from the FAO. The objectives were to discuss the thematic studies of the SOW-FGR process, the draft guidelines for the country reports, and gaps in knowledge and accessibility of information.

The thematic studies were discussed in detail, and revisions to the titles and descriptions of many studies were suggested. Several participants volunteered to coordinate the thematic studies or participate in their preparation. The studies which evoked most interest among the participants were those on genetic diversity in tropical natural forests; adaptation to biotic and abiotic factors, including climate change; food security, poverty reduction and livelihood improvement; and the effects of management practices on forest genetic diversity. In addition there was some interest towards the studies on indicators and on the use of native species.

It was concluded that the thematic studies should lead to identification of knowledge gaps and, thereby, provide a good basis for future collaborative research in the region around these topics.

Conclusions

The symposium was successful in bringing together researchers and forest administrators in the region. There were good discussions after the presentations, and general enthusiasm about regional collaboration on conservation and sustainable use of forest genetic resources.

Some of the current member countries have well-developed capacities in managing and conserving their resources and conducting research for assessing genetic diversity. Differences among countries in institutional, human and financial resources and capacities are, however, large. This in principle provides good opportunities for sharing experiences within the region, but at the same time the heterogeneity of countries may make it difficult to plan network activities which would be meaningful and motivating simultaneously for most member countries.

The planning session for future activities managed to identify some common areas of interest for future work. Much more work is, however, required for identifying concrete action needs and project ideas which would be suitable for proposal development. Thematic areas other than those identified in the planning session may also be considered for project development. Wide participation of, and within, member countries must naturally be encouraged in the planning process. Especially the most active and experienced country national coordinators should be motivated to take initiative in the process.

Most of the activities suggested in the planning session were of the type guidelines and model approaches to support countries in developing and implementing efficient conservation and management strategies. Thematic issues would likely have to be discussed on a general level and focus in providing frameworks for activities, rather than proposing single or few applications and approaches to address country-specific problems. An alternative would be to develop and strengthen the sub-regional working groups which could select their own thematic priority areas and working methods.

The process of project development should build on the experiences of the history of the network and especially results of the ITTO-project, where countries defined national priorities for the conservation and management of their forest genetic diversity. The results of the evaluation of the ITTO-project would be most useful in this regard – how useful were the national prioritization networks, what were the issues brought up, and what is the "what now" or "where to" situation in different countries? Sharing experiences of the project between project participants and the other countries in the region would also be important, and possible ways for doing this should be discussed.

The activities of the ITTO-project were oriented towards capacity building and coordination at the country level. In the future, an option could be to concentrate on more research-oriented activities, while still including capacity-building or policy support activities. This may help in identifying thematic areas which would be relevant for many countries in the region, and in securing funding for the network activities. Grass-root level activities involving local people and livelihood aspects could also be an alternative approach to improving conservation and sustainable use of forest genetic diversity. The strong official recognition of the APFORGEN network among the member countries is definitely an asset and helps to leverage visibility to genetic diversity and facilitate project implementation within the countries.

It was suggested that a survey could be conducted to find out the national coordinators' perception about the benefits of APFORGEN and the ITTO-project, their participation in the network activities, the constraints to benefits or participation and possible ways of overcoming these. Such a survey would provide a good basis for planning future activities. Following this recommendation, a survey was designed after the symposium and conducted among the national coordinators in February 2010.

The symposium also recommended that APFORGEN could be broadened to countries in the Pacific and other interested countries in the region, such as Australia and Japan. Pacific Islands were excluded from APFORGEN at the time of its establishment because they then had their own FGR network (the South Pacific Regional Initiative for Forest Genetic Resources, SPRIG, 1996-2006). As the project-based activities of SPRIG have since then ended, the Pacific countries would be highly interested in joining APFORGEN, as expressed by the Secretariat of the Pacific Community. If developed countries in the region were to participate in APFORGEN, they could possibly contribute financially to the network to support its activities and thus assist in conservation and management of forest genetic diversity in the region.

References

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Sustainable Forest Management and Conservation of Forest Genetic Resources

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Sustainable forest management (SFM) provides an effective framework for simultaneously enhancing the economic, social and environmental values of forests in a sustainable way. It can provide a framework for the production of timber from permanent forest estates. At the same time it can help protect biodiversity and render environmental services. SFM has recently been promoted also as an effective framework for forest-based climate mitigation and adaptation since forests are playing an important role in reducing carbon emissions and sequestrating carbon.

The ITTO Criteria and Indicators (C&I) for sustainable management of natural tropical forests encompass 7 thematic areas: (1) enabling conditions for SFM; (2) forest resource security; (3) forest ecosystem health and condition; (4) flow of forest produce; (5) biological diversity; (6) soil and water and (7) economic, social and cultural aspects. These C&I offer a comprehensive tool for ITTO member countries to monitor their forest resources and report on progress towards SFM on a regular and ongoing basis. In particular, the fifth criterion relates to the conservation and maintenance of biological diversity, including ecosystem, species and genetic diversity. For genetic diversity, special attention is given to the existence and implementation of a strategy for *in situ* and/or *ex situ* conservation of the genetic variation within commercial, endangered, rare and threatened species of forest flora and fauna.

The progress of achieving SFM in the tropics has been slow. A study on the status of tropical forest management which was conducted by ITTO in 2005 indicated that although there was greater government commitment to SFM, as demonstrated by improved legislation, administrative arrangements and consultative processes, there were very limited successful stories in achieving SFM in the tropics. According to FAO estimates, in the period 2000-2005, an average of 13 million ha of forest was deforested each year. Deforestation was especially serious in many developing counties in the tropics. Forest and land degradation are also serious problems in many developing countries. In 2000, the total area of degraded forests and forest land in 17 countries in tropical Asia was estimated to be about 270 million ha, of which degraded primary forest and secondary forest covered about 145 million ha according to ITTO report (2002). Deforestation and forest degradation have a major impact to FGR, decreasing the genetic diversity of forest. Causes of deforestation include the expansion of agriculture due to low economic viability of SFM compared to other possible ways of using the land. Illegal logging and associated illegal trade of timber are significant problems in forest degradation.

Tropical forests are predicted to experience extreme weather events which will impact on forest health and biodiversity. In the context of climate change, measures for climate change mitigation and adaptation should be promoted against unplanned deforestation and unsustainable management practices. Forest policy review to increase the conservation of biodiversity in timber production forests is urgently needed, as these forests have a huge potential for contributions to poverty alleviation. Various implementation practices such as the expansion of plantations mixed with indigenous species are encouraged since monoculture plantations are degrading biodiversity. The successful identification of more effective adaptive policy promoting conservation of forest genetic resources is an essential step in the conservation process which will contribute to the adaptive capacity of forests.

The State of the World's Forest Genetic Resources

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Genetic variation, at the levels of species, populations, individuals and genes is an important part of biological diversity, since it is the basis of evolution and adaptation of species to changes in the environment, including climate change. Variation is also essential for selection and breeding to meet present and future human needs.

Conserving forest genetic resources is therefore vital, as they are a unique and irreplaceable resource for the future. In 1967, the FAO Conference recognized that forest genetic diversity was increasingly being lost, and requested the establishment of the Panel of Experts on Forest Gene Resources to help plan and coordinate the Organization's efforts to manage genetic resources of forest trees. FAO's activities on forest genetic resources are an integral part of the FAO Forestry Programme and contribute to other programme components, such as national forest programmes, sustainable forest management, tree breeding and plantation development, protected area management, and global forest resources assessment.

At its Eleventh Session in June 2007, the FAO Commission on Genetic Resources for Food and Agriculture (CGRFA) acknowledged the urgency to conserve and sustainably utilize forest genetic resources to support food security, poverty alleviation and environmental sustainability, and approved the inclusion of forest genetic resources in its Multi-Year Programme of Work. A *State of the World's Forest Genetic Resources* (SOW-FGR) Report should be prepared and presented to the Fourteenth Session of the Commission in 2013. The CBD Conference of the Parties welcomed the plan of FAO to develop the SOW-FGR.

As a follow-up to the recommendations of the CGRFA, FAO has built awareness about the plan to prepare the SOW-FGR with its main international and regional technical partners on forest genetic resources, and gathered inputs from these partners to support the preparation of the analysis of key issues for preparation of the SOW-FGR. Regional consultations were held back-to-back with other workshops or events to optimize the resources available. These consultations were organized in collaboration with international partners, in particular Bioversity International and the World Agroforestry Centre (ICRAF), regional networks and national partners. For Asia-Pacific, the first regional workshop on the SOW-FGR was organized in October 2008, in Kuala Lumpur, Malaysia, in collaboration with APAFRI, Bioversity International, APFORGEN and FRIM. Inputs from the regional consultations were integrated in the first draft of the FAO proposal for the SOW-FGR.

At its Fifteenth Session (December 2008), the Panel of Experts on Forest Gene Resources reviewed the first draft of the proposal for the possible structure and contents of the SOW-FGR Report, its preparatory process and tentative list of thematic studies.

At its Nineteenth session (March 2009), the FAO's Committee on Forestry (COFO) discussed and supported the preparation of the SOW-FGR, urging member countries to collaborate with FAO and partner organizations in producing the Report.

This presentation presented the proposed structure and content of the SOW-FGR Report, and its preparatory process.

Why Forest Genetic Resources Matter in Changing Climates

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The IUFRO Expert Panel on Adaptation of Forests to Climate Change was tasked with developing a state of the art report on impacts of climate change on forests and options for adaptation (Seppälä *et al.* 2009). The Panel concluded that climate change has already affected forest ecosystems and will have stronger effects in the future. Unmitigated climate change will exceed adaptive capacity of many forest trees in this century, and dry tropical and subtropical forests are expected to be most negatively affected by climate change.

The Intergovernmental Panel on Climate Change (IPCC) has published similar conclusions. It noted that effects are expected to be more severe in tropical than temperate areas because of aggravating factors such as the greater proportion of endemic species in the tropics and higher rates of deforestation and fragmentation for forest habitat. The fact that many tropical species are insect-pollinated also increases vulnerability to climate change. The panel concluded that 20% to 30% of species may be at risk of extinction (Parry *et al.* 2007).

The importance of understanding and managing genetic resources increases as climates change. Clearly climate change will have large impacts on forests and on their genetic resources. Impacts will not be the same in all areas, but regardless of whether the climate area will become more extreme, threatening survival of current biota, or will be moderated so that growth conditions become more favourable, the potential for species to adapt will be important.

On a global scale, there will be “winners” and “losers” in terms of growing conditions. Higher latitudes are predicted to receive higher rainfall, and warmer temperatures are likely to become more favourable for growing trees. But the species and provenances that currently inhabit those areas will likely not be suited to their current location under the new climate within a few decades, and the species or provenances that will be adapted will require considerable time to reach those areas, resulting in an interim period of instability. Many areas near the equator will likely have altered rainfall, and hotter summers which may lead to forest decline.

Because trees have such long life cycles, forests are particularly vulnerable to long-term change, but their reaction will be delayed. Forests will be subject to more frequent, extreme storms, wind damage and fire and insect disturbances, and greater stress due to drought. Climate change will result in a rapid shift in adaptation zones for tree species. Seedlings will likely be affected much more seriously than mature trees so the early observable impact of climate change is likely to be regeneration failure for many species. As trees reach the end of their lifespan, many of them will not be replaced by regeneration of the same species, so stands will gradually die out. Many tree species will not be able to migrate as rapidly, as adaptation zones are expected to shift and much of the genetic variability within the species will be vulnerable to loss.

Responses of tree species to climate change

There are three possible outcomes for populations of tree species as climate changes. They may migrate to areas with more suitable climate via seed and pollen, they may be capable of adapting to new conditions at their current location, or populations may disappear, to be replaced by other species (Aitken *et al.* 2008). In addition to the ability of a species to disperse its genes or to adapt to substantial environmental changes, the resilience of populations also depends on phenotypic plasticity, a characteristic that is observed at the individual level and determines the ability of an individual to function over a range of environmental conditions.

The ability of a tree species to disperse its genes effectively (migrate) depends on factors such as seed weight, mode of dispersal, age at which trees begin producing seed, specificity of habitat requirements, and availability of habitat within maximum dispersal range. Most current estimates of migration rates are based on historical data. It is clear that unusual long distance dispersal events have been significant in historical migrations, but even with these unpredictable events, historical migration rates were much slower than will likely be required under conditions in the near future.

The ability of a population to adapt in place depends on amount of genetic variation in adaptively important traits, size of the selection pool (population size, fecundity), and quality and quantity of gene flow (mainly pollen), where quality refers to the primary direction of gene flow relative to climatic conditions. There are examples of rapid evolution when selection pressure is high.

Phenotypic plasticity is difficult to quantify and it requires information that is often not available. Genetic field tests planted over a range of environments provide a measure of genotype × environment interaction. Low interaction implies phenotypic plasticity. Within species, the level of heterozygosity at enzyme loci has been shown to be related to plasticity in some cases (Kremer 2007). The degree to which trees are able to acclimatize over the course of a lifecycle is a measure of plasticity. Epigenetic responses are known to influence plasticity but are not well understood.

Research needed and examples of approaches

For most tree species, research is needed at the basic level of understanding the status of genetic resources and potential impacts of climate change. The small numbers of species for which provenance trials have been established, assessed and analyzed provide a basis for understanding likely impacts, to the extent that these species may be considered models. The response of different provenances to changing climate can be inferred from their current performance across a range of environments, using regression analysis to estimate the sensitivity of the provenances to climatic conditions. When predicted climate scenarios are modeled, the information can be used to predict where provenances will approach their optimum fitness. In the absence of provenance information, assessments can be made on the basis of expert opinion, using information on the frequency of occurrence, population sizes and distribution, and visual evidence of decline.

A genetic gap analysis is a spatial data-based approach to identifying conservation needs by defining the climatic niche or envelope of species and modeling the "movement" of the appropriate climatic conditions under different climatic scenarios in relation to the current distribution of species (or population; Hamann *et al.* 2006). Using GIS, the likelihood of adequate *in situ* protection in the future can be assessed by superimposing a layer with current protection areas (Hamann and Wang 2005).

A second area requiring research is predicting the vulnerability of genetic resources to climate change, taking into account ability to move, ability to adapt in place and plasticity simultaneously. The relationship between genetic variability and adaptive potential also requires research efforts to continue to link genes to specific responses. Great advances are being made in genomics and proteomics. In addition, field tests are still needed, although they are expensive and difficult to maintain in today's short-term research climate. The need to find and use sources of adaptation within wild populations – for example, genotypes with resistance or tolerance to climatic extremes or insect or disease attacks related to climate change – is a high priority.

In situ conservation of forest genetic resources in the face of climate change requires collaboration with local people, and hands-on management. Models for using traditional knowledge, co-education (useful exchange of information between those with technical and local knowledge) and involving local people in planning and management must be developed. It is necessary to consider short and long-term benefits for people living in the area while experimenting with management approaches such as participatory breeding, assisted migration and boosted pollination. A key question is how to maintain large viable diverse populations of native tree species in landscapes that must also meet the needs of human populations.

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Current Status of Forest Genetic Resources in China And National Strategies and Policies

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Forest genetic resources (FGR) are important biological resources that form the basis for achieving economic, ecological and social benefits of forests. They have direct impacts on key areas such as economic security, resource and ecological security, and significant implications to national economic development, social advancement, ecological improvement and environmental protection as well as mitigation of climate change.

FGR are needed for national economic development. FGR contain species diversity and genetic diversity of forest trees, enabling production of diverse forest products such as timber, pulp, fruits, oil and medicines. Without the diversity contained in FGR, improvement of the quality and quantity of the products would become impossible. FGR are also required for ecological improvement and environmental protection. The species and genetic diversity existing in FGR provide the basis for ecosystem diversity, which provides various ecological services, such as soil erosion control, air purification and climate regulation. More importantly, forest has both functions of carbon sequestration and carbon storage, making it an important tool for mitigating climate change. Expanded forest area, and reduced deforestation and forest degradation will help to mitigate and adapt to climate change. FGR are indispensible for social development and livelihood improvement. Diversified forests provide places for recreation, improvement of environment, beautify and greening urban and rural areas. Moreover, FGR are closely related to religion and culture.

This paper tries to provide an overall picture of FGR in China from the point view of strategies and policies as well as research activities.

Current status of FGR in China

China is one of the biodiversity-rich countries with diverse forest genetic resources, there are about 9100 species of woody plants, including more than 3000 species of arbor trees and approximately 6000 species of shrubs and vines.

However, the continual population expansion and rapid socioeconomic development have resulted in irrational uses of forest resources, coupled with climate change and environmental degradation, leading to reduction of effective forestland. FGR of natural forests are being lost rapidly. In total 17% of the species are endangered, and about 90% of the species have populations being threatened. FGR of some endemic, rare and valuable tree species have suffered from various extents of destruction or loss. FGR of breeding materials used in breeding programmes were subjected to severe loss during the last 20 years. For instance, more than 100 000 selected plus trees of various species were registered in 1989, but only 20 000 to 30 000 trees remain at present. Less than half of the many provenance trials, progeny and clonal tests and pilot plantations of improved plant materials established in the 1980s to 1990s are maintained in good condition. Due to human disturbances and environmental deterioration, many wild species are threatened and some of them have even gone extinct.

Therefore, FGR conservation should be integrated into the national development strategies and plans as an important component, and studies in FGR need to be intensified in order to achieve the ultimate goal of effective conservation and sustainable utilization of FGR of all tree species.

Major FGR research programmes in China

In recent years, increasing importance has been given to forest genetic resources. A number of research programmes are being undertaken at national, provincial and local levels. Most notably, the National Forest Genetic Resources Platform (NFGRP), a major national programme on FGR, was started in early 2000s. Its aims are to promote sharing of FGR and associated information through networking and coordination of all FGR conservation organizations and activities. The NFGRP consists of several subsystems of technical standards, institutions, legislation and policy, network of conservation sites and facilities, evaluation and monitoring, personnel and financing. This programme is currently funded on a project basis, but would be funded as an infrastructure of the forestry sector in the near future. Current activities of the NFGRP include development of technical standards, documentation, development of mechanisms for access and benefit sharing and information system, networking of conservation sites and facilities, capacity building, policy improvement and financing mechanisms. The NFGRP will act as a major infrastructure of the forestry sector to conserve and utilize FGR. A key objective of the NFGRP is to promote the utilization of FGR through an effective mechanism of FGR sharing.

Another key national programme is the Exploration of FGR Values and Rational Utilization. The programme has been funded by the central government under the Eighth Five-year Plan, and its main objective is to develop genetically improved seeds and planting materials of selected tree species of commercial value through traditional breeding and modern biotechnology. This programme is basically aimed to make use of FGR while not causing loss of genetic diversity. Along with these major national research programmes, some smaller programmes have also been carried out at provincial and local levels with funding from provincial and local governments, and in some cases, from private enterprises.

In parallel with these FGR research programmes is the production system of improved seeds and plant stocks. The system consists of forest farms and nurseries throughout the country which are working on collection and production of improved genetic resources and their application in afforestation programmes. Genetic improvement and operation application of FGR are the foci of the system.

Strategies and policies

Policies relating to FGR conservation and utilization are currently being reviewed, and in the future more attention will be paid to provisioning more incentives for sharing FGR. Currently, there is no official national strategy or action plan available. Given the increasing national and international concerns with FGR conservation, management and utilization, large number of species to be conserved and limited available financial sources, a long-term national strategy and action plan are sought. They will identify priorities of species for conservation and particular approaches to be employed for different species.

In developing such a national strategy and action plan, attention should be given to the following strategic goals:

(1) An FGR conservation plan for intermediate and long-term should be developed and integrated into national development plans for infrastructure, science and finance.

(2) The national FGR platform for conservation and utilization, including technical standards, institutions, evaluation and monitoring, and financing subsystems, needs to be operational, sequenced and prioritized for conservation activities. These activities would cover all cultivated species, and rare and endangered species identified as national priority species for protection.
(3) The present legislations and policies relating to FGR conservation and utilization should be harmonized to promote the long-term and effective FGR conservation.
(4) Development of an evaluation and monitoring system to safeguard FGR conservation.

Priorities for FGR conservation

Considering the above strategic goals, future emphasis of FGR conservation will be placed on improving the national FGR platform in order to make it fully operational and effective. Priorities are identified in the following areas: (1) Further improvement of the nation-wide network of conservation sites including both *in situ* and *ex situ*, institutions, financing mechanisms and corresponding policies and legislations as major components of the National FGR Platform; (2) Establishment of a national center for conservation of forest gene resources, including facilities for long-term seed storage and *in vitro* preservation, which will provide a useful tool for conserving rare and endangered species and further secure the conserved populations and collections *in situ* and *ex situ*; (3) Technologies for propagation of endemic, rare and endangered species in order to expand the populations and make use of them; (4) Collection and preservation of genetically improved materials derived from cultivation and breeding programmes in order to conserve the superior genes and genotypes; (5) Collection, assessment and conservation of native tree species which account for more than half of the total FGR in China. Great potential could be explored from the FGR of these native species.

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Forest Genetic Resources Conservation and Management in Cambodia

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Situated in the sub-tropical region, Cambodia has rich forests for its socio-economic development. The study conducted before 1970s showed that the total forest area was 13 227000 ha or approximately 73% of the total land area. During the civil war of nearly three decades, the Cambodian forests were destroyed from time to time.

The inventories conducted in 1992/93 and 1996/97 showed that the forests had declined to 10 859 695 ha (59.8% of the land area) and 10 638 209 ha (58.6%), respectively. Another inventory in 2002 showed that the forests had increased to 11 104 293 ha (61.2%) The latest inventory conducted in 2005/06 showed the forests have again declined to 10 730 781 ha (59.1%). Of the total forest areas, evergreen forest occupies 38%, deciduous 40% and mixed forest 14%. The rest are flooded and other forests, which occupy 8%.

Cambodian forests have been, and continue to be, under heavy pressure from a range of forces through encroachment, land conversion, logging and indirect human activities. The rapid and ongoing degradation of the natural forest has led to the erosion of the gene pools of several species and populations. The potential for tree improvement, as well as sources for good seeds from desired mother trees, is therefore dwindling.

Natural conservation of Forest Genetic Resources in Cambodia

Forest gene resource conservation and management (FGR C&M) is a relatively new concept within Cambodia. The establishment of the Tree Seed Sector within the Forestry Administration (FA) has been supported by DANIDA to support the Cambodia Tree Seed Project, which focused on capacity building activities in order to upgrade skills to enable the implementation of FGR C&M.

Ongoing FGR C&M activities include seed source establishment and management, the establishment and maintenance of demonstrations, provenance trials and seed orchards, and piloting community participation in the management of seed sources. A National Gene Conservation Strategy Action Plan and Gene Ecological-Zoning Model have been developed and adopted. A range of extension activities continue to be conducted to raise awareness of the importance of using seeds of good genetic and physiological characteristic.

A new system of protected areas was established by the Royal Decree on "Creation and Designation of Protected Area" in 1993 under the jurisdiction of Ministry of Environment. This Royal Decree includes 23 protected areas, covering approximately 3.3 million ha, divided into 4 categories: 7 National Parks, 10 Wildlife Sanctuaries, 3 Protected Landscapes, and 3 Multiple Use Areas. In addition to that, the Ministry of Agriculture, Forestry and Fisheries, also manages 9 Protected Forests, covering 1.4 million ha, which are significant for genetic resources, wildlife and watershed conservation.

The Cambodia Tree Seed Project has established 11 sites of seed sources with 23 species in natural forests. In addition to the objectives of seed collection, the seed sources are considered as protected sites for conserving genetic resources of the priority species.

Research and activities of conservation, utilization and management of forest genetic resources

Although forests are considered as a main source of income for the government and local communities, the budget allocation for research is almost nil. There is some coordinated forest research, which has been conducted by the Cambodia Tree Seed Project, but basic data are not readily available. The FA has insufficient research facilities and few staff trained in research techniques. Official records on the management of forest genetic resources are very few.

Tree improvement in Cambodia is commencing, and only very few activities have been carried out by the Cambodia Tree Seed Project since 2002. In total 19 seed production areas located in 10 provinces were established by 2006. There are 22 species conserved: *Azadirachta indica, Sindora cochinchinensis, Tarrietia javanica, Shorea hypochra, Shorea guiso, Dipterocarpus costatus, Anisoptera glabra, Pinus merkusii, Fagraea fragrans, Scaphium macropodum, Dalbergia cochinchinensis, Dalbergia bariensis, Pterocarpus macrocarpus, Toona sureni, Xylia xylocarpa, Afzelia xylocarpa, Hopea ferrea, Dipterocarpus alatus, Hakdinia cordifolia, Shorea roxburghiana, Cratoxylum formusum* and *Gluta laccifera* In total 2949 mother trees have been marked in a total area of 745 ha.

Forest Genetic Resources Conservation and Management in India

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India is bestowed with very rich and diverse flora and fauna. India accounts for approximately 2.5% of the world's land surface area and 1.8% of the world's forest area. The geographical features and land forms of the country are as varied as its extent ranging from the towering Himalayas, the extensive river plains such as Ganga and Deccan in the north, centre and south; the coastal plains or ghats to the east and west and the numerous islands. Increased use of forest resources and shrinking forest areas threaten the sustainability of forest genetic resources and highlighted the importance of conservation and sustainable management of these resources. Several species have become extinct, and some others are already threatened and may become extinct if appropriate measures for their conservation are not taken. Proper utilization of biodiversity can contribute substantially to the economic progress of the nation. Areas of rich and diverse biological resources need to be identified and conserved. As a priority, areas with rare and endemic species with very limited distribution need to be conserved before they are lost.

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

Indian forests have been under severe pressure to meet the growing demand for alternative land uses, fuel, fodder, grazing, timber, pulp wood and non-timber forest products by an ever-growing human and livestock populations and industrial development and infrastructural needs. These resources are also facing multiple threats related to habitat loss, forest fires, climate change and the invasion of exotic species. Thus, appropriate approaches for management of forests for biodiversity conservation have to be determined, followed and reflected in the management or working plans. There is an urgent need to conserve and use genetic resources as a safeguard for the future.

Methodology

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

Based on the recommendations of international negotiations, concerned with biodiversity and conservation, India has taken initiatives to protect its biological resources. These initiatives are for the protection of the flora and fauna of the country. Within the framework of the legislation, there are national parks and wildlife sanctuaries, wetland reserves and a network of biosphere reserves. Various acts and legislations were enacted for the conservation of forest genetic recourse in India. The Indian Forest Act of 1927 provided enabling provisions to make rules and regulations, which makes it quite distinct from other acts of that time. The Indian Forest Act was enacted to control indiscriminate diversion of forestland. The Biological Diversity Act (BDA 2002) of India is a broad policy statement identifying the strategies and actions that need to be taken with regard to access to genetic resources, their conservation, sustainable use, and fair and equitable sharing of benefits, as per the provisions of the Convention on Biological Diversity (CBD). The Seed Bill is to provide for regulating the quality of seeds for sale, import and export and to facilitate production and supply of seeds of quality, and for matters connected therewith or incidental thereto.

Results and discussion

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

India is one of the eight centres of origin of cultivated plants (Vavilov 1951) and one of the 12 mega gene centres of the world, possessing 11.9% of world flora. About 33% of the country's recorded flora is endemic to the region and is concentrated mainly in the northeast, the Western Ghats, the northwest Himalayas, and the Andaman and Nicobar Islands. In an identification of biodiversity hotspots carried out in the 1980s, 2 hotspots out of total 18 worldwide are in India, in the Western Ghats and the Eastern Himalayas (Myers 1988). The forests of India have been grouped into 5 major categories and 16 groups according to biophysical criteria. Among the most important groups are the subtropical dry deciduous, tropical moist deciduous, tropical thorn and tropical wet evergreen forests. Other categories include subtropical pine, tropical semi-evergreen forests and other smaller categories. Temperate and alpine areas cover about 10% of the forest area in the Himalayan region.

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

Exploration of forest-based plant products for new pharmaceuticals and the demand for medicinal plants are increasing in both developing and developed countries, especially among the youth (Farnsworth and Soejarto 1991). India is ranked second, after China, among the exporting countries of medicinal plant products. The expanding trade in medicinal plants has serious implications on the survival of several plant species, many of which are under the threat of becoming extinct. Today this rich biodiversity of medicinal plants is facing a serious threat because of the rapid loss of natural habitats and overexploitation of plants in the wild. India is very rich in bamboo diversity. There are 124 indigenous and exotic species under 23 genera, which are found naturally, under cultivation, or both (Naithani 1993). Both *in situ* and *ex situ* conservation measures are being adopted to preserve the genetic resources of bamboos. *In situ* conservation measures include establishment of preservation plots in every state. The local people also protect these species in sacred groves.

4 sites have been identified as Biosphere Reserves in the country for the conservation of all forms of life *in situ*. There are 97 existing national parks in India, which cover a total area of 38 199 sq. km or 1.16% of the geographical area of the country. The number of existing wildlife sanctuaries is 508, and they cover an area of 118 237 km^2, which is 3.60 % of the geographical area of the country. In addition to the national parks and wildlife sanctuaries, India has 7 conservation reserves and 2 community reserves. Currently, these protected areas together form a network of 156 548 km^2, approximately 4.76% of the country's total land area. The best natural stands or plantations that are near full stocking are used for the development of seed production areas. Seed stands can be categorized as *in situ* conservation areas, which refer to the conservation of species or provenances as parts of a viable existing ecosystem. The seed stands are selected for a particular area with regard to its ecological and environmental conditions to fulfill the seed demand of particular species.

With a view to improve the productivity and profitability of planting forest species and to offer an attractive land use option, many state forest departments have established seed production areas (SPA), clonal seed orchards (CSO), seedling seed orchards (SSO), vegetative multiplication gardens (VMG) and modern nurseries in consultation with ICFRE for the production of quality planting material. The importance of production forestry has been realized and strategic activities for tree improvement are in progress in the ICFRE institutes. In this approach, the emphasis is on a species-oriented tree improvement programme in collaboration with the state forest departments. During the last fifteen years, ICFRE has developed comprehensive strategies for tree improvement programmes for species like teak, neem, acacias, pines, eucalypts, bamboos, poplars, *Dalbergia* spp., *Casuarina* spp., *Cedrus deodara*, *Jatropha* spp., *Albizia* spp. and *Gmelina* spp. The approach involves the development of seed production areas, clonal and seedling seed orchards to select germplasm for progenitors and clonal accessions of high value. Several hundred trees have been identified as candidate plus trees, which are propagated vegetatively and established as a germplasm bank.

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Current Status and Recent Progress on the Conservation and Management of Forest Genetic Resources in Indonesia

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Forest genetic resources are important in Indonesia not only for conserving the genetic diversity, but also for providing genetic materials for tree improvement to increase wood production. The tropical rain forests in Indonesia have suffered from increasing disturbance and have been largely destroyed. Reforestation has been carried out by establishing plantation forests, using mainly fast growing species. The objective of plantation forestry is not only forest rehabilitation but also to substitute for wood extraction from natural forest. This development encourages tree improvement efforts for increasing wood production.

Forest genetic resources are important in Indonesia, as shown by the designation of conservation forests. These forests account for approximately 17% of the country's total forest area. Together with protection forests they occupy a protected area of 54 million ha, or roughly 45% of the total forest area. Considering the inherent characteristics of conservation forests, the government has taken various measures to secure them by law. Several legal instruments have been put into effect, and various planning frameworks have been developed through national initiatives and cooperation with international partners. Some legislation in Indonesia related to forestry and biodiversity has been enacted, although most of the legislation does not directly concern genetic resources. Currently Indonesia is in the process of formulating an act which will directly regulate utilization, management, and conservation of genetic resources, including forest genetic resources. This report describes the national strategy, implementation of national policy and management practices, organization and institutions and challenges.

National strategies for the conservation of genetic resources

Indonesia has established the Indonesian Biodiversity Strategy and Action Plan (IBSAP) 2003-2020. Eight points of policy direction for its implementation were determined by the Indonesia National Development Planning Board. These eight points were expected to be followed up by the relevant ministries and other government institutions, organizations and other stakeholders. However, as each ministry and organization has also set up its priority policy and actions, progress in the implementation of the strategy would vary.

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

Conservation and management practices of forest genetic resources

The IBSAP has been used as a guide in the conservation of natural resources, including forest genetic resources. Examples of the conservation efforts include *in situ* conservation in terrestrial parks and protected areas, *in situ* conservation outside the networks of protected areas, coastal and marine conservation, and *ex situ* conservation. Indonesia has a system of protected areas which includes *in situ* conservation.

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

Ex situ conservation in Indonesia is practiced for two purposes: conservation practices and tree improvement. Some institutions have established *ex situ* conservation areas. Research Institutes under FORDA have 15 Arborea and Centre for Plant Conservation has established 17 Botanical Gardens. The Centre for Biotechnology and Tree Improvement (CBFTI) has developed *ex situ* conservation for tree improvement of *Santalum album*, *Eusideroxylon zwageri, Araucaria cunninghamiii*, *Alstonia* spp., *Intsia* spp. and *Arthocarpus altilis.* *Ex situ* conservation for *Shorea leprosula* and *Lopophetalum multinervium* was established by the Gadjah Mada University in collaboration with several states and private-owned companies. The state-owned forestry enterprise Perhutani established *ex situ* conservation areas for teak in 1999 by collecting plus trees from different origins throughout Indonesia.

Indonesia does not have a national list of priority species for the conservation of forest genetic resources or tree improvement. As there is a large variation among regions in terms of biodiversity, species characteristics, social and cultural values, each region has its own priority species to promote. As a result there is no formal document listing priority species at the national level. The existing list of priority species was compiled from various institutions.

Institutions and organizations

Indonesia has established a National APFORGEN Secretariat to carry out activities related to forest genetic resources programme because Indonesia is a member of the Asia Pacific Forest Genetic Resources Programme (APFORGEN). The Centre for Plantation Forest Research and Development (CPFRD) is the National Coordinator for APFORGEN based on the terms of reference of the National Coordinators as stated in the joint letter of assignment from Bioversity International and APAFRI. Apart from the APFORGEN secretariat programme, CPFRD carried out a series of Annual National Workshops from 2004 to 2007 to identify stakeholders, increasing awareness and formulation of the concept of FGR C&M (Forest Genetic Resources Conservation and Management). Results from the Workshop in 2004 also contributed to the APFORGEN Action Plan 2005-2007. The Secretariat also issues publications such as leaflets, flyers, workshop proceedings and the tri monthly Newsletter on APFORGEN activities at the national level.

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

Meetings of National Partners of APFORGEN were held once a year. The first meeting was held in Bogor in June 2008 and the second on 30 September 2009. In total 38 institutions related to forest genetic resources (FGR) in Indonesia were invited to the meeting. Participants represented governmental organizations, enterprises and companies, non-governmental organizations and universities. The objectives of the meeting were to (1) disseminate information on the work and practices of APFORGEN, (2) develop networking across the institutions involved, (3) consolidate the management programme of forest genetic resources across the institutions, and (4) agree on follow-up actions.

Recent activities related to the implementation of national policy

Conservation activities and tree improvement are needed to save the genetic resources and ecosystems, to preserve the productivity of forests and to increase the usage value of their genetic resources. Because of the wide variety of forest genetic resources species, prioritization of species is necessary. This would be based on determining the existing benefits, values, future potential values and the status of conservation of species. For this reason, the CPFRD has compiled a database on 60 priority species for genetic resources and tree improvement, including the taxonomy, distribution, ecological characteristics, reproductive biology, usefulness, genetic variation and status of conservation.

The concept on FGR conservation at village level has been developed as a basis for conservation activities. It takes into account the availability of farm land, crop species and the potential to directly benefit local communities. Villages, which number over 70 000 in Indonesia, are adopted as conservation units. If each village could conserve one species, Indonesia would be able to conserve at least 4000 species, assuming that not all villages would be involved in this activity. Some institutions have initiated efforts related to the conservation of genetic resources in forest plantations at village level.

The CPFRD also has established demonstration plots on FGR conservation and management in order to conserve endangered species, and to demonstrate to local communities how to realize activities for FGR conservation at village level which they are expected to.

Challenges and conclusions

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

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

- Mobilization of alternative funding is still difficult. The first and third challenges require more national efforts, while the remaining two require collaborative activities at regional and international levels.

Some conclusions could be listed as follows:

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

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The Progress of Forest Tree Genetic Resources Conservation in the Last Four Decades in Japan

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Japan, a country of archipelago, consists of four main islands located at the east end of the Eurasian continent. It stretches from 24° to 46° N. Most of the forests are formed by warm temperate zone species, but there are also sub-tropical and/or sub-frigid forests. Owing to this unique geographical characteristic, forest tree species are abundant with 1327 indigenous tree species (FAO 2005), which is the third largest number in the warm temperate zone.

There are 25 million ha of forests out of 37 million ha of land, which is a relatively high proportion of forest areas. As a result of the long history of intensive use of forest land, there are more than 10 million ha of man-made forests, and pure natural forest is limited when the secondary forests are excluded. The age distribution of plantation forests in Japan resembles normal distribution due to the current decline of reforestation areas. The annual reforestation area, which once exceeding 300 000 ha, has dropped sharply in recent years to around 20 000 to 30 000 ha. Reforestation is conducted with conifer species such as *Cryptomeria*, cypress and larch. Seed transfer zones, which were determined for major conifer plantation species to avoid failure of reforestation, were delineated by empirical results of reforestation, and they seem to be feasible in practice.

Forest tree breeding programme and genetic resource conservation

Similar to many other countries, forest genetic resource conservation was initiated to preserve genetic materials that were selected for forest tree breeding programmes. About 9000 plus trees were selected in the 1950s for improving wood productivity, and most of them were vegetatively propagated to establish CSO and preserved at clone banks. These are the core genetic resources managed by the Gene Bank Project.

In addition to the plus trees, “gene preservation stands” (forest tree superior genes conservation stand) were established in the middle of the 1960s, with the aim of preserving potential genes for future breeding for major plantation species. They comprise 670 stands of 4141 ha and 32 species, (Table 1). Most of them were originally seed stands showing excellent growth and form. They were classified into three types; *in situ* conservation stands, seed stands supposed to be harvested, and *ex situ* seed stands that were established with seeds from the second type. Majority of the preservation forests were for conifers which were target species of tree improvement, while 16 broadleaved species were also included.

Genetic resources maintained at clonal archives are sometimes useful for specific breeding objectives. In the case of pollinosis caused by the pollen from *Cryptomeria*, cedar trees producing less or no pollen were successfully identified in the clonal archives of plus trees, and then used for reforestation to alleviate the pollinosis problem. In the case of pine wilt disease, however, resistant pines to the disease had to be selected from heavily infested stands, because the tolerance of plus trees was far below the target level (Toda and Kurinobu 2002).

Table 1. Gene preservation stands established in 1960s.

Species	Gene preservation forest, ha (sites)			
	In situ	Seed stand	*Ex situ* seed stand	Total
Conifer	227 (25)	2534 (238)	901 (362)	3662 (613)
Broadleaved	393 (29)	35 (12)	51 (16)	479 (57)

Forest genetic resource conservation to support biodiversity

With the increase in social concern on biodiversity, the Forestry Agency reorganized the system of protection forests into seven categories in 1983. Among these, two types of forest reserves are specifically for genetic resource conservation. The first one, Bio-genetic resource Reserve (in total 36 000 ha at12 locations), is a representative plant community in each region. All organisms in the community are conserved and almost no operations are permitted in the Reserve. The second type is Forest tree genetic resources conservation stand (9000 ha at 329 sites). Stands dominated by one or a few of the target species were chosen to conserve genetic diversity within the species. These stands are expected to cover 106 species of a wide variety, including major forestry species as well as endangered species. Operations are allowed only to maintain genetic diversity or regeneration of the target species.

An investigation to evaluate the status of conservation was made by comparing species distribution and the location of the conservation stands (Hoshi *et al.* 1994). Many of the target species, such as *Cryptomeria* and *Fagus crenata*, were found to be adequately conserved with this network of protection forests, while for some of the species the conservation status seemed insufficient because of the small number of sites (e.g. Pine species) or the population size per site (e.g. *Zelkoba serrata*) within the protected areas network. Since geographic variation is essential for conserving genetic diversity of widely distributed species, studies using DNA markers are under way for several species. These findings would be utilized to formulate conservation strategies in the future.

Gene Bank Project for forest genetic resource

The Forest tree gene bank project, a part of the national gene bank project under the Ministry of Agriculture, Forestry and Fishery (MAFF), was started in 1985 and it has been conducted hitherto by the Forest Tree Breeding Center (FTBC). This project consists of collection, preservation and dissemination of materials for research purposes, and therefore a database system needs to be developed for effectively maintaining records.

Although the majority of the materials of the gene bank are the breeding stock selected by the previous breeding programmes, endangered species and natural monuments have also been included as targets for collection. The total current stock of the resource is 33 000 lots, of which 23 000 are vegetative plants and 10 000 are germplasm samples with facility preservation. The number would increase by new explorations scheduled for the middle-term of the programme, when the target for collection has been shifting from the ordinary plantation species to those that are threatened with extinction.

Summary and Prospect

Forest genetic resource conservation in Japan was initiated to preserve breeding materials. It has since then expanded to cover forestry species in general, including endangered species as a result of the establishment of *in situ* conservation forests as well as the gene bank project for *ex situ* conservation. The current status of conservation *in situ* and *ex situ* has to be evaluated by taking into consideration species distribution as well as geographic variation. The results derived should then be utilized to formulate conservation strategies where priority species for conservation will be determined. They will hopefully also be utilized to investigate effective adaptation measures to global warming.

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Status of Philippines Forest Genetic Resources Conservation and Management Practices

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The Philippines is considered one of the 18 megabiodiversity countries, which in total contain two-thirds of the Earth's biodiversity and about 70-80% of the world's plant and animal species. The country is considered fifth in the number of plant species and contains 5% of the world's flora. Species endemism is very high, covering at least 25 genera of plants and 49% of terrestrial wildlife. Paradoxically, it is also considered a biodiversity hot-spot with 24 and 28 critically endangered and endangered fauna, respectively, while 99 and 187 flora are considered critically endangered and endangered, respectively. Some critically endangered Dipterocarps are *Hopea acuminata, Shorea astylosa and Vatica pachyphylla* (4th National Report to the Convention on Biological Diversity, 2009). Threats to FGR include habitat fragmentation (due to unsustainable harvesting), anthropogenic pressures (from agricultural encroachment, excessive population growth, fires and grazing), introduction of invasive alien species, mining, thrust on developing *Jathropa* estates, and conflicting and overlapping roles and mandates of the stakeholders and managers of forest and other natural resources.

Forest resources and types

The Philippines have twelve forest formations spanning different elevations, soils, localities, soil moisture and climates. These include Tropical lowland evergreen rain forest, Tropical lower montane rain forest, Tropical upper montane rain forest, Tropical subalpine forest, Forest over limestone, Forest over ultramafic rocks, Beach forest, Mangrove forest, Peat swamp forest, Freshwater swamp forest, Tropical semi-evergreen rain forest and Tropical moist deciduous forest. These forest formations attest to the great diversity of Philippine forests and, therefore, the richness of the forest genetic resources contained in them.

Major policies on FGR

National policies relevant to FGR conservation have been enacted. The major policies include Republic Act (RA) 7586 which provides the law for the establishment and management of protected areas in the Philippines. Executive Order No. 247 or the Bioprospecting Law prescribes guidelines for and establishing of a regulatory framework for the prospecting of biological and genetic resources. This was streamlined by the Joint DENR-DA-PCSD-NCIP Administrative Order No. 1 Series of 2005. Republic Act 9147, or the Wildlife Resources Conservation and Protection Act, provides for the conservation and protection of wildlife resources and their habitats, appropriating funds and for other purposes. Executive Order No. 578 is the policy of the state on biological diversity.

Conservation strategies

In situ and *ex situ* conservation strategies are practiced in various parts of the country. *In situ* conservation started in 1932 through the institution of the National Parks System. To date, a total of 60 national parks and 8 game refuges and bird sanctuaries were established under this system. These parks, refuges and sanctuaries became the core component of the National Integrated Protected Areas System (NIPAS) which was established in 1992 through RA 7586. For e*x situ* conservation there are field genebanks and plantations for timber trees. Also, botanical gardens and parks are used. The Philippines has 9 botanical gardens with a total of 16 000 taxa. Similarly, seed banks, clone banks and *in vitro* genebanks are maintained. 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. Scientists at the National Museum in Manila have started a Plant Rescue Operation which was inspired by the Mt Pinatubo eruption. Likewise, clonal propagation and tree improvement and provenance trials are continuing activities where FGR are conserved through continuous and productive use.

Success stories on FGR conservation

Two contrasting stories were presented: an Indigenous Community managing ancestral forests, and a corporate firm managing watershed reservation for geothermal energy production.

For the Indigenous Community it is the Ikalahans of Imugan, Sta. Fe, Nueva Vizcaya, Philippines that was chosen for this presentation. They are an indigenous tribe in the mossy rain forest of Northern Luzon practicing sustainable hunting, gathering and swidden agriculture techniques. Approximately 15 000 ha of forest was tenured to them in 1974. Their indigenous and innovative practices have contributed to the conservation of the FGR in this vast forest land. This includes the wild fruit production and processing for the following species: *Psidium guajava, Saurauia bontocensis, Embelia philippinensis, Passiflora edulis, Sandoricum koetjape, Zingiber, Oficinale imugani, Hibiscus sandariffa* and *Malvaviscus arboreus*. There is a harvest limit of 15%, while 85% is for wildlife and allows for continuous natural regeneration. Not all lands are used for cash crops. A portion of their land is used for food and housing, scattered organic vegetable farms, raising orchids from wild genetic stock and mushroom production. For additional income, they are engaged in furniture production with wood coming from the systematic culling of the natural forest. In terms of wildlife protection, 3000 ha are designated as biodiversity sanctuaries. Hunting is strictly regulated in production forests and strictly prohibited in sanctuaries. Through the help of other institutions, the Ikalahans are working for the institutionalization of payments for environmental services (PES). Ikalahan ancestral domain provides half of the water of a major dam, Magat Dam. They are also gathering data for the carbon sequestration potential of their 10 000 ha of forests.

The Energy Development Corporation (formerly the Philippine National Oil Company) is engaged in geothermal energy production in the country. In six of their geothermal production fields where communities and forest are intermeshed together they have worked in partnership with local communities in the protection and forest rehabilitation work. Organization, training, and empowering the local communities within and around the Geothermal Production Fields are parts of the Community/Social Forestry Program of the company. The EDC is also actively engaged in introducing and assisting communities to develop livelihood programmes.

In one site they have helped to develop a federation of People's Organizations (POs) to establish and manage a now-prospering forest resort.

Constraints to FGR conservation

Several constraints were identified as hindering FGR conservation in the country, namely open access forests; sustainability of initiatives; conflicting land tenurial instruments; conflicting and overlapping roles and mandates of government agencies and tenured occupants inside the protected areas, and in forests outside protected areas; no national list of priority species for conservation; very limited and fragmented genetic studies; and the fact that climate change adaptation policies are not incorporated in national development policies or programs.

Recommendations

To address these constraints, the following recommendations are proposed: strengthening of community-based forest management programmes; cultivation of corporate-community partnerships; sustainable livelihood programmes to address poverty issues; scaling-up or expanding success stories; tenure security and responsibility; collaborative programmes between government agencies, academic and research institutions, NGOs, POs and private groups in addressing production and protection goals in forest rehabilitation or restoration programmes; and streamlining of climate change adaptation programmes in national and local development policies.

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Forest Genetic Resources Conservation and Management in Vietnam

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Vietnam has 14.3 million ha of natural forests in 1943, covering 43% of the country's land area. However, the forest area has fallen rapidly to 9.18 million ha or 27.2% of the total land area in 1990. For the period 1980-1990, Vietnam lost an average of 100 000 ha of forest per year. Since 1995, the forest area has increased as a result of forest rehabilitation and plantation programmes. By the end of 2008, the forest area in Vietnam was 13 118 770 ha (38.7% forest cover), of which 10 348 590 ha were natural forests and 2 770 180 ha were plantation forests.

Owing to global warming, Vietnam will suffer annual losses of US$ 17 billion, with 17 million people being directly affected and 12.2% of the most fertile land lost. Vietnam is also establishing and implementing a number of programmes to protect forests and increase both the quantity and quality of forests throughout the country. Several large programmes have been implemented including the greening of bare land programme (Programme 327, 1993-1997), the Five Million Hectare Reforestation Program (1998-2010), the National Action Plan for Biodiversity (1995, 2007) and the National Action Plan to combat desertification 2006-2010 and Vision 2020, and also the Programme towards climate change mitigation and adaptation.

Vietnam has established 128 special use forest areas covering more than 2 million ha and accounting for 11.7% of the total forest area or 6.7% of the total land area. There are 30 national parks, 60 nature reserves and 38 landscape protection areas in the special use forest system. To protect the environment and biodiversity, the Government of Vietnam has promulgated many related legal documents, including the Law on Environment Protection (2005), the Law on Forest Protection and Development (1991, 2004) and the Biodiversity Law (2008). Forest rehabilitation has also been implemented in the nature conservation system in areas where forest was destroyed before the forest became a reserve. Many native species are used for planting in conservation programmes.

Table 1. National Nature Conservation System (Vietnamese Government 2003).

Category	Number
1. National Park	30
2. Nature Conservation Reserve	60
2a. Nature Reserve	49
2b. Species/habitat reserves	11
3. Landscape reserve	3
Total	128

Vietnam's forest flora is abundant and diverse. Owing to many forest plants being considered threatened, the Government announced Decision No 32/2006/ND-CP in 2006 on endangered, precious and rare forest plant management. The Decision has divided species into two groups: Group 1 includes forest plants which are prohibited for logging due to specific scientific, environmental or economic values in areas where the population occurs in low numbers and is rare or is considered high risk to become endangered or extinct; and Group 2 contains forest plants which are valuable and for which there is a need to utilize but populations are rare or at risk of becoming endangered or extinct.

Table 2. Main tree species for planting by ecological region (MARD 2005).

No	Species	Forest ecological regions								
		1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	*Acacia auriculiformis*	+	+	+	+	+	+	+	+	+
2	*A.crassicarpa*					+	+		+	
3	*A. mangium*	+	+	+	+	+	+	+	+	+
4	*A.mangium* x *A.auriculiformis*	+	+	+		+	+	+	+	
5	*Aquilaria crassna*	+				+	+	+	+	+
6	*Bambusa oldhami* f.		+		+					+
7	*Bombax malabarica*				+					
8	*Calamus tetradactylus*				+					
9	*Canarium album*	+	+	+						
10	*Casuarina equisetifolia*				+	+	+			
11	*Cedrela odorata*				+				+	
12	*Ceiba pentandra*	+					+		+	
13	*Chukrasia tabularis*	+			+	+				
14	*Cinnamomum cassia*		+			+	+			
15	*Cunninghamia lanceolata*		+	+						
16	*Dendrocalamus barbatus*	+	+			+				
17	*Dipterocarpus alatus*						+	+	+	
18	*Eucalyptus camaldulensis*						+		+	+
19	*E. tereticornis*				+	+	+			+
20	*E. urophylla*	+	+	+	+	+		+		
21	*E.urophylla* x *E.camaldulensis*	+	+	+	+	+				
22	*Hopea odorata*						+	+	+	
23	*Ilex kaushue*			+						
24	*Illicium verum*			+						
25	*Khaya senegalensis*				+			+	+	+
26	*Litsea glutinosa*							+		
27	*Lithocarpus fissus*			+		+				
28	*Manglietia conifera*		+	+						
29	*Melaleuca cajuputi*									+
30	*Melaleuca leucadendra*									+
31	*Melia azedarch*	+	+		+		+	+	+	
32	*Michelia mediocris*							+		
33	*Neolamarckia cadamba*								+	+
34	*Phyllostachys edulis*			+						
35	*Pinus caribaea*					+	+	+	+	
36	*Pinus kesiya*							+		
37	*Pinus massoniana*			+						
38	*Pinus merkusii*					+				
39	*Rhizophora apiculata*									+
40	*Sophora japonica*				+					
41	*Styrax tonkinensis*		+							
42	*Tarrietia javanica*					+				
43	*Tectona grandis*	+						+	+	
44	*Toona sinensis*			+						
45	*Toona surenii*								+	
46	*Vernicia montana*	+								
	Species by region	13	13	15	14	16	14	14	16	10

Note: (1) North-western region, (2) Central part of North Vietnam, (3) North-eastern region, (4) Red river delta, (5) North of Central Vietnam, (6) South of Central Vietnam, (7) Western Highland, (8) South-eastern Vietnam and (9) South-western Vietnam.

In 2005, the Ministry of Agriculture and Rural Development issued a list of 46 tree species for planting in nine forest ecological regions (Table 2). The list includes mainly native tree species such as dipterocarps, *Manglietia conifera, Styrax tonkinensis, Cinnamomum cassia, Illicium verum, Aquilaria crassna, Chukrasia tabularis, Pinus merkusii, P. massoniana, P. kesiya* as well as exotic tree species such as *Acacia auriculiformis, A. mangium, Acacia* hybrids, *Eucalyptus camaldulensis, E. urophylla,* Eucalypt hybrids, *Pinus caribaea* and *Leucaena leucocephala*.

It can be seen that the number of tree species to supply materials is large. Attention to mangrove forest restoration was also given. Protection forest, special use forest and mixed tree species planting with native tree species occupy a large percentage (Table 3) of such activities.

Table 3. Plantation forest areas according to tree species in 2007.

No	Plantation tree species group	Plantation area (ha)	Percentage (%)
I.	Mixed tree species group	491 158	21.1
II.	Pure plantation tree species group		
1	Acacia species group	584 911	25.2
2	Pine species group	327 212	14.1
3	Mangrove forest species group	220 267	9.5
4	Native tree species group	190 191	8.2
5	Eucalyptus species group	172 584	7.4
6	Bamboo and rattan species group	109 228	4.7
7	Other tree species group	227 977	9.8
	Total	**2 323 528**	**100**

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Exploring Genomics and Transcriptomics Approaches in Conservation of Tropical Forest Species

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In many countries in tropical Asia and the Pacific, both the rapid loss and degradation of forests and associated genetic resources are posing a serious problem. The majority of timber species harvested are indigenous species from natural stands. Several steps have been taken to alleviate the above problem, including reforestation programmes and designating forest reserves and national parks in which felling is limited or prohibited. Some efforts have been made by national and international research organizations, individually and collectively, in basic studies of genetic conservation such as reproductive biology, genetic variation of important tree species, ecology of tropical rainforests and the development of management systems for natural forests.

The timber species, especially members of the Dipterocarpaceae and Leguminosae, are particularly important for timber production. The decrease and degradation of their genetic resources will make it difficult to secure the breeding populations and planting stocks for sustained production of valuable timber. Maintenance of genetic diversity in forest tree populations which are undergoing population changes due to natural or human-induced events is seen to be instrumental for adaptability and continued evolution (Muller-Starck *et al*. 1992; Bush and Smouse 1992). Whilst usage of molecular markers provides a better understanding of the genetic structure and mating systems of populations, there exists a knowledge gap between these genetic markers and the expression of adaptive traits among individuals, families and populations.

Genetic diversity of tropical forest species

Traditionally, genetic variation of tree species has been understood through assessment of survival and growth performance parameters in common garden-type trials such as species, provenance and progeny tests. Notwithstanding the long term benefits of such activities in terms of availability of plant materials for continuous assessments and evaluation of genotype × environment interactions, these exercises can be time-consuming, labour intensive and costly. Molecular markers offer quick detection of genetic variation and characterization of genotypes. They can be effectively used in early selection for traits such as hybridity. However, for other quantitative traits such as disease resistance and wood quality, associations need to be demonstrated with data from well-designed and replicated field trials.

A number of provenance trials and comprehensive studies on genetic structure of natural populations of commercial tropical timber species have been conducted in the past two decades. The large scale provenance trials include *Acacia mangium* (Harwood and William 1992), *A. auriculiformis* (Kamis Awang 1995) and *Tectona grandis* (Wyatt-Smith 1961). Results from these studies have been used to some extent for the production of genetically improved planting materials for plantation establishment in Indonesia, India, Malaysia, Thailand and Vietnam. In the last decade or so, molecular markers have been employed to understand the genetic structure of natural populations of various important timber species.

A survey of genetic diversity studies in Asia reveals three major shortcomings – species choice, geographic distribution of samples, and pollen and seed dispersal. Recently the issue of species choice has begun to be addressed with broad-based studies in which a diversity of species was selected, as opposed to only economically valuable species. Greater cooperation and funding are required to address the second shortcoming, whilst the third shortcoming has been addressed for some tropical species, e.g. *Acacia auriculiformis* (Wickneswari and Norwati 1993), *Dryobalanops aromatica* (Lee *et al.* 2001) and *Shorea leprosula* (Lee *et al.* 2000).

Genomics and transcriptomics of tropical forest species

The beginning of the 21st century has seen the rapid race in sequencing entire genomes of plants, animals and microorganisms. *Arabidopsis* was the first plant genome to be completely sequenced (in 2000). This was soon followed by the rice genome in 2002. The complete sequence of plant genome has profound implications on plant biology, exploitation of plant products and conservation. Sequencing the entire plant genome is one of the approaches in forest genomics to study genetic diversity for conservation. This method is fairly efficient for mass gene discovery, and it also enables the understanding of structural genomics (gene location and distribution, and gene organization) and functional genomics or transcriptomics (protein structure, function pathway and gene expression).

An alternative to entire genome sequencing for gene discovery is EST (Expressed Sequence Tag) analysis. EST sequences are usually screened for genes through BLAST (Basic Local Alignment Search Tool) analysis against public gene-orEST databases. The comprehensive genomic database of *Arabidopsis*, rice and several forest tree species (*Pinus*, *Eucalyptus* and *Populus*) are good sources for gene identification and comparative genomics in tropical forest tree species. The information on the genomics of tropical forest tree species is meagre compared to temperate forest tree species. However, the recent years have seen some efforts being put into forest genomics of tropical tree species (*Acacia* and *Shorea*). In our laboratory, for instance, 6000 ESTs of *Acacia* hybrid (*Acacia mangium x A. auriculiformis*) have been generated from the inner bark tissue (Choong *et al.* 2005). The Blast results revealed substantial number of genes involved in xylem and cambium formation in the EST database of the *Acacia* hybrid. These genes might serve as good candidates for developing molecular markers in adaptive genetic diversity studies for wood and fibre formation traits, or to a lesser extent, pathogen resistance trait.

ESTs provide good sources for genetic variation study through the development of ESTPs (Expressed Sequence Tag Polymorphisms) and EST-SSRs (Expressed Sequence Tag-Simple Sequence Repeats). EST-SSRs are more superior than genomic SSRs as they can detect adaptive genetic diversity. EST databases of many plant species are available in GenBank, and they can be readily exploited for cost-effective, rapid and efficient strategy of developing EST-SSRs.

Another application of ESTs is to develop DNA microarrays. Adaptive response to different environmental stresses and treatments can be studied for many genes simultaneously in DNA microarrays. It is important to understand the expression patterns of a group of genes and their interactions. DNA microarray studies are now underway for most of the studied forest species, in order to characterize global patterns of gene expression during xylem and fibre differentiations, and in response to different biotic and abiotic stresses.

With the current availability of second generation sequencing platforms like Solexa and 454 and advanced bioinformatic tools, transcriptomes and genomes can be rapidly and cheaply sequenced, assembled and analyzed. These new sequencing platforms and analytical tools can be exploited for the discovery of genome-wide

SNPs for association studies on traits related to adaptation, and for understanding regulation of genes involved in adaptation through sequencing of microRNAs.

Conclusions

DNA-based systems for gene expression analysis and microRNA analysis for understanding gene regulation in different tissues and the responses to biotic and abiotic stresses can provide a direct link between genotype and phenotype. Identification of quantitative trait loci (QTLs) related to adaptive traits will enable rapid assessment of ecosystem integrity for sustainable management of ecosystems.

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Genetic Variation in Populations of narra (*Pterocarpus indicus* Willd.) from Five Selected Provinces in the Philippines Using Isozyme Analysis

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Knowledge on forest tree genetic resources will support the selection and prioritization of species that can be used for extensive reforestation programmes. Narra (*Pterocarpus indicus* Willd.), being the national tree of the Philippines, is an important part of the country's history, culture and economy. The inclusion of *P. indicus* in the priority list of species for the reforestation programme of the government does not yet ensure that the genetic base of the species is conserved. This is because of the uncertainty of the genetic background of seed sources of the species. This research was conducted to assess the genetic diversity of designated seed production areas (SPA) of *P. indicus*.

Methodology

A total of 173 leaf samples of narra, *Pterocarpus indicus* were randomly taken from seed production areas (SPAs) in Ilocos Sur, Cebu, Iloilo, Marinduque, and Quezon. Each sample was analyzed using 12% starch gel in a Mupid-2-Mini-Gel Electrophoresis apparatus with Tris-Histidine buffer pH 8.0 at 5–10 ºC. The voltage was set at 50V for 3–4 hrs. Five enzymes were used in the investigation, namely acid phosphatase (ACPH), alkaline phosphatase (ALPH), esterase (EST), nicotinamide adenine dinucleotide (NADH-DH) and malic enzyme (ME). Banding patterns that were observed for the fifteen isozyme loci were identified based on the computed relative mobility (Rf) of each band.

Genotypic and gene frequencies of the fifteen isozyme loci were computed. Three indices were used to determine the variability within the population. These were the proportion of polymorphic loci (P) calculated based on Ayala and Kiger (1984), the average heterozygosity (H) computed using the formula adapted from Nei (1975) ,and the average number of alleles per locus (A).

Each locus was first tested for polymorphism at 95% criterion of polymorphism. This implied that the frequency (q) of the most common allele must have a value equal to or within the range of 0.05-0.95 ($0.05<q<0.95$). Failure to meet this assumption means that the locus was monomorphic.

Genetic variation between populations was determined by calculating genetic identity (I_N) and genetic distance (D) based on Nei (1972) wherein genetic identity made use of gene frequencies of randomly mating diploid populations labeled as x and y. The standard genetic distance between populations, D_s was calculated as the negative logarithm of the genetic identity. The probability of genotypic similarity (I) was likewise computed.

Results and discussion

The extent of genetic variation within and among the populations of *P. indicus* from the five selected provinces (Ilocos Sur, Cebu, Iloilo, Marinduque and Quezon) was measured by observing enzyme polymorphism using starch gel electrophoresis. Individuals of *P. indicus* were sampled using their leaves as source of homogenates. Fifteen presumptive loci (*ACPH-1, ACPH-2, ACPH-3, ACPH-4, ALPH-1, ALPH-2, ALPH-3, EST-1, EST-2, EST-3, NADH-DH-1, NADH-DH-2, NADH-DH-3, ME-1, and ME-2*) encoding for acid phosphatase (ACPH), alkaline phosphatase (ALPH), esterase (EST), malic enzyme (ME), and nicotinamide adenine dinucleotide (NADH-DH) were detected. Each locus was controlled by two alleles, slow (S) and fast (F). Four zones of enzyme activity were detected in acid phosphatase (ACPH-1, ACPH-2, ACPH-3, and ACPH-4) with Rf values of 0.08-0.21, 0.22-0.38, 0.4-0.55, and 0.62-0.69, respectively. On the other hand, alkaline phosphatase had three loci (ALPH-1, ALPH-2, and ALPH-3) with Rf values of 0.16-0.34, 0.35-0.44, 0.47-0.60, respectively. Esterase also had three presumptive loci (EST-1, EST-2, and EST-3), with Rf values of 0.13-0.21, 0.23-0.42, and 0.45-0.53. NADH-DH, which was observed only in the Cebu, and Marinduque populations had three presumptive loci (NADH-DH-1, NADH-DH-2, and NADH-DH-3) with Rf values of 0.21-0.25, 0.27-0.39, and 0.44-0.54. Meanwhile, malic enzyme, which was observed only in the Cebu population, had two presumptive loci (ME-1 and ME-2) with Rf values of 0.11-0.19 and 0.32-0.45.

Genetic variation within a population of *P. indicus* estimated using the following parameters: proportion of polymorphic loci (P), average number of alleles per locus (A), and average heterozygozity (H) showed that the Quezon population had the lowest P (0.167), followed by Iloilo (0.375). Ilocos Sur and Marinduque had the same P (0.500) while Cebu had the highest value of P (0.583). These data suggested that polymorphism was lowest in Quezon while Cebu had the highest level of polymorphism. However, the results for the average number of alleles did not follow the same trend as the polymorphism data. Again, the Quezon population had the lowest A value (1.167) followed by the Iloilo population (1.375), however, Ilocos Sur had the highest A value (1.625) this time followed by Cebu (1.583), then Marinduque. The presence of more alleles indicated a higher genetic variability in Ilocos Sur. These results were further verified by the average heterozygozity results. Although Ilocos Sur (0.229), Cebu (0.290), and Marinduque (0.343) had the higher H values compared with Iloilo (0.189) and Quezon (0.100), this time Marinduque had the highest H, while, Quezon still had the lowest. These confirmed that the Quezon population of *P. indicus* was the least diverse.

Genetic variations among populations of *P. indicus* were measured using the following parameters: genetic identity (I_N), genetic distance (D) and genotypic similarity (I). These parameters were based on the gene and genotype frequencies. The highest genetic identity was observed between the Ilocos Sur and Iloilo populations of *P. indicus* (0.675), followed by Ilocos Sur and Marinduque (0.643). The lowest value for genetic identity was recorded for Iloilo and Quezon (0.219). Consequently, the genetic distance was highest between Iloilo and Quezon (1.517), followed by Cebu and Iloilo (1.472). The lowest value was recorded for Ilocos Sur and Iloilo (0.393). Both genetic identity and genetic distance measured how much two populations were related to each other. The genetic identity and genetic distance data suggested that the Ilocos Sur and Iloilo populations were the most genetically related populations while Iloilo and Quezon were the most distant ones.

These data on interpopulation variations were supported by the dendrogram produced using the NTSYS pc version 2.0. The dendrogram was expected to have five major clusters wherein each cluster was composed of individuals from one sampled population. At 0.14 index of similarity coefficient, there were two major clusters formed. The first major cluster diverged at approximately 0.18 index of similarity coefficient. At 0.55 index of similarity coefficient, there were twenty-eight (28) clusters formed. Clusters one to four (1- 4) comprised of samples from Ilocos Sur. The fifth to tenth clusters were composed of individuals from Marinduque. Individuals from Cebu were included in clusters eleven (11) to thirteen (13). Clusters fourteen (14) to twenty-one (21) were composed of individuals from Iloilo while clusters 22 to 28 include individuals from Quezon. Thus, it could be noticed that although there were no five definite clusters formed, the five populations were still relatively distinct from each other at 0.55 index of similarity coefficient. This dendrogram confirms the results based on the Genetic Identity which suggests that Quezon is distantly related from the other populations.

Based on the measures of intrapopulation variations in narra, Quezon had the least diverse population of all, suggesting that Quezon was probably not a good source for seed production. Good areas for seed production were those where there was high genetic diversity such as Cebu, Ilocos Sur or Marinduque. Populations with higher diversity are more likely to survive adverse environmental conditions. Also, based on measures of interpopulation variations, Quezon was one of the distantly related populations, suggesting that individuals from the Quezon population were not good representatives of the narra population in the Philippines in terms of genetic make-up. Based on the results, the enzyme ME was detected only in the Cebu population, suggesting that it could be a genetic marker for the said population. NADH-DH on the other hand was observed only in the Cebu and Marinduque populations.

It could be recommended that seed collection should be concentrated on areas where there was high genetic diversity such as Cebu. The population in Cebu could serve as good source of high quality seed for plantation development. These preliminary results should be further confirmed through DNA analysis or with further investigation through isozymes.

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Genetic Variation in the Threatened Conifer *Fokienia hodginsii* in Vietnam Using ISSR Markers: Implications for Conservation

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Fokienia hodginsii (Cupressaceae) is a widely distributed conifer in Vietnam. It occurs in montane evergreen forests on granite or limestone-derived soils in north and central Vietnam, extending to southeastern China and Laos (Luu and Thomas 2004). *Fokienia hodginsii* prefers the high humidity ranging from 81% in December to 86% in September (Van *et al.* 2000) and high precipitation of up to 1268 mm to 3000 mm and mean annual temperature from 15.4 °C to 23.6 °C. *Fokienia hodginsii* is over-exploited by local people and forestry enterprises. Human activities have heavily degraded or completely destroyed its habitats. Thus, this species is recorded in many patches of secondary forests, including protected areas. These include the vegetation on bare limestone faces on steeps and ridges of mountains, where forests have been degraded. The vegetation of the remaining habitats of *F. hodginsii* includes little-disturbed forests and secondary forests. The nature of terrain in the habitats is very complex. They are located on mountain slopes exceeding 20-30° and sometimes on steep slopes up to 60-70°.

The studies conducted on population genetics of various conifers showed low levels of genetic differentiation among populations (Ledig *et al.* 2001; Epperson and Chung 2001; Shea and Furnier 2002; Lee *et al.* 2002). In *Abies sibirica,* Larionova *et al.* (2007) found a low level of genetic variation and genetic differentiation among populations in Middle Siberia. In another species, *Abies* sp., Aquirre-Planter *et al.* (2000) demonstrated a low genetic variation within populations and high genetic differentiation among populations from southern Mexico and Guatemala, in comparison to most coniferous species reported.

At present there is very little information on the ecological parameters of *F. hodginsii*, and there is lack of data especially on the genetic variability of this species. It is therefore difficult to develop conservation strategies for *F. hodginsii.* The objective of this study was to investigate the genetic variation of *F. hodginsii* using ISSR markers, and to provide technical assistance to the Protection Forestry Department on issues related to the conservation of this conifer in Vietnam.

Materials and methods

Plant materials

The research was carried out in eight sites, two each in Lao Cai and Ha Giang, and one each in Son La, Hoa Binh, Thanh Hoa and Nghe An (Figure 1). Samples from 322 individuals were collected from 8 known populations for DNA analysis. At Ta Van (HLS) and Bat Mot (TTH), the original vegetations have been lightly disturbed. The original vegetation at Tay Son (NA) has been greatly degraded by human activities such as over-exploitation for fuelwood collection and development of a light-demanding species. These altered the spatial distribution and age-class structure of trees in these sites. Small populations (<50 individuals per population) of *F. hodginsii* were found on bare limestone faces on ridges and steeps of mountains at all study areas.

DNA extraction and DNA amplification for ISSR

Genomic DNA was extracted from young leaves using the modified CTAB method by Xavier and Karine (2000). Polymerase chain reaction was carried out in 25 µl solution consisting of 2.5 µl reaction buffer, 2.5 µl $MgCl_2$, 2 µl dNTP, 0.1 µl of primer, 1.25 units Tag DNA polymerase and 1.5 µl of template DNA. The reaction mixture was subjected to amplification in the Gene Amp PCR System 2400, under the following thermal cycler: an initial denaturing step at 94 °C for 4 min, followed by 35 cycles consisting of 1 min at 94 °C, 30 seconds annealing temperature for each primer and 1 min extension at 72 °C, and 10 min at 72 °C for a final cycle to complete the extension of any remaining products before storing the samples at 4 °C until analyzed. The amplification study sites of the *F. hodginsii* products were separated by electrophoresis on 7.5% polyacrylamide gels in 1 x TAE buffer, and then stained by ethidium bromide for 10 min. The banding patterns were visualized under UV light and photographed using a MEGA 8.4 Panasonic camera. 1kb ladder was used as DNA standard (Invitrogen).

Data analysis

ISSR bands were scored as presence (1) or absence (0). The binary data were analysed by PopGene v.1.31 (Yeh *et al.* 1999) to estimate genetic diversity parameters within and among populations.

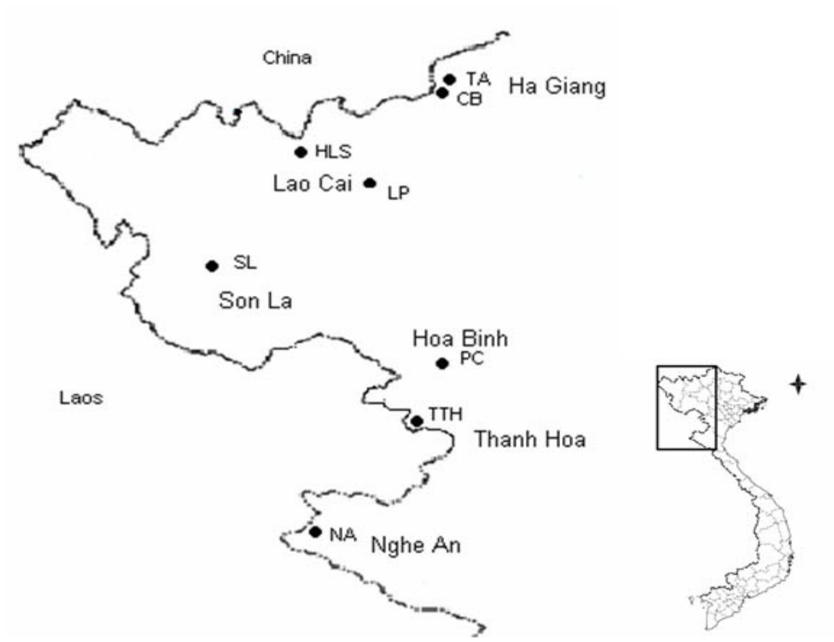

Figure 1. Map showing the studying sites of *Fokienia Hodginsii*. Study sites: LS: Ta Van, LP: Liem Phu, CB: Cao Bo, TA: Thai An, SL: Co Ma, PC: Pa Co, TTH: Bat Mot, NA: Tay Son.

Results and discussion

The eight ISSR primers produced a total of 170 bands across all 200 individuals of the eight *F. hodginsii* populations. At the population level, the proportion of polymorphic loci (P) averaged 33.82%, the Nei's (1973) gene diversity (H) averaged 0.0701, and the Shannon's index (I) averaged 0.1145. At species level, these values were P = 98.82%, H = 0.0926 and I = 0.1765. The total genetic diversity (Ht) among all the populations of *F.*

hodginsii was found to be 0.097, whereas the genetic diversity within populations (Hs) averaged 0.0701. The coefficient of genetic differentiation (Gst) was found to be 0.2771. Gene flow (Nm) calculated among all the populations of *F. hodginsii* was high (1.3046). All identities obtained in the comparisons of the eight *F. hodginsii* populations exceeded 0.9. Genetic identity averaged 0.9677. The mean genetic distance between populations was 0.0336.

The clustering of *F. hodginsii* populations using the UPGMA dendrogram based on pairwise genetic distances showed that two groups separated clearly at population level. One group included three populations CB, NA and TTH. Moreover, the CB population was separated clearly from NA and TTH, with lower proportion of polymorphic loci (28.24%), genetic diversity (0.0669) and Shannon's index (0.1053). The second group included the five remaining populations. The populations PC and SL were separated from the other three populations HLS, LP and TA, with higher genetic diversity and Shannon's index.

Fokienia hodginsii has lower values of genetic diversities both at population and species levels than other coniferous species. High values of genetic variability were reported for populations of many conifers such as *Pinus pinceana* (P = 56.5%, H = 0.174, Ledig *et al.* 2001), and *Pinus brutia* (P = 68%, H = 0.271; Korol *et al.* 2002). Low genetic variabilities have also been found in some conifers with restricted occurrences: *Abies sibirica* (P = 20% H = 0.0642; Larionova *et al* 2007), *A. flinckii* (P = 30.2%, H = 0.113), *A. guatemalensis* (P = 20%, H = 0.069), *A. hickeli* (P = 28.2%, H = 0.1), and *A. religiosa* (P = 31.8%, H = 0.108; all Aguirre-Planter *et al.,* 2000), *A. lasiocarpa* (P = 43.4% H = 0.124; Shea,1990), and *Picea breweriana* (P = 44.2% H = 0.129; Ledig *et al.* 2005). In other studies, high levels of genetic variability within and among conifers were also obtained for *Picea sitchensis* (Hs = 0.147 and Ht = 0.159; Yeh and El-Kassaby 1979), and *Pinus longaeva* (Hs = 0.465, Ht = 0.484; Hiebert and Hamrick 1983).

Our results confirmed the suggestion that the genetic structure of natural populations of *F. hodginsii* is strongly affected by small population sizes. The number of observed individuals was small and varied considerably, being about 50 individuals at Cao Bo (CB) and 150 at Thai An (TA) secondary forests, and below 100 at Bat Mot (TTH) and Den Thang (HLS), the little-disturbed forests inside National Parks of Xuan Lien and Hoang Lien Son, respectively. Such small populations are the prone to the occurrence of inbreeding and the effect of genetic drift (Ellstrand and Elam 1993). The current distribution of *F. hodginsii* has been strongly influenced by fragmented habitats. The species occupies forests at 1300-1900 m elevation. Forests have been greatly fragmented by human activities and formed small forest patches. A few natural populations of *F. hodginsii* remain in such small patches. Forests were destroyed and converted to other landscape unsuitable for *F. hodginsii* survival. In addition, the low level of genetic variability in this species might be caused by founder effects associated with altered climatic conditions. The logging activity and the associated creation of gaps cause changes in the original vegetation structure. There was variation in the spatial distribution, age class structure of trees and the invasion of exotic species. Distribution of *F. hodginsii* is characterized by terrain and climate. Therefore, the species has been exposed to geographic isolation.

The limited genetic variability within populations also indicated considerable levels of differentiation among populations. Estimates of the Gst value for *F. hodginsii* populations showed high amounts of genetic differentiation (Gst = 0.2771). This value was clearly higher than those reported in other coniferous species, such as *Pseudotsuga menziesii* (Gst = 0.026; Yeh and O'Malley 1980), *Pinus longaeva* (Gst = 0.038; Hiebert and Hamrick 1983), *Pinus sibirica* (Gst = 0.041; Goncharenko *et al.* 1993), and *Pinus flexilis* (Gst = 0.101; Jorgensen *et al.* 2002). A higher Gst value has, however, been detected for *Picea asperata* (Gst = 0.34; Xue *et al.* 2005). The results confirm the assumption that genetic drift increased genetic differentiation among populations (Ellstrand and Elam 1993). The high differentiation could be a consequence of limited gene flow (Nm = 1.3046). Fragmented habitat experience gene flow barriers and decreased migration among populations for *F. hodginsii*. Founder effects might contribute to the high level of genetic differentiation among the populations.

In conclusion, *F. hodginsii* had a low level of genetic variability and high level of genetic population differentiation. These characteristics are results of human interference. Habitats of *F. hodginsii* have been degraded and fragmented, and only a few natural populations survive. From a conservation point of view, effective management strategies for *F. hodginsii* should include both *in situ* and *ex situ* activities. Establishment of seed orchards from all the populations should secure genetic sources of this species. Monitoring of the genetic variability in planted populations is important for ensuring that high level of genetic diversity is maintained.

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Molecular Database for Classifying *Shorea* Species (Dipterocarpaceae) and Searching the Origin of Timber in Some *Shorea* Species

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Tropical forests have been declining due to over-exploitation and illegal logging activities, and large quantities of unlawfully extracted timber and other wood products have been exported, mainly to developed countries. Therefore, if we developed DNA databases to identify the species and origin of populations, and DNA extraction methods for imported woody products, it would be very useful for checking the legality of wood products. In this study, we aimed to (i) construct a cpDNA sequence database for the genus *Shorea*, which is the largest genus of the family Dipterocarpaceae and widely distributed within Southeast Asia, and (ii) develop methods for extracting and analyzing DNA from veneers and plywood made from dipterocarp species

Materials and methods

In total, 200 individuals were sampled, representing 84 *Shorea* species, which covered ca. 70 % of the major commercial timber species in Indonesia and Malaysia. Total DNA was extracted by using the modified CTAB method or using the DNeasy Plant Mini Kit (Qiagen). Four non-coding regions of the chloroplast genome were selected for polymerase chain reaction (PCR) amplification based on the high degrees of polymorphism found in the preliminary studies.

The veneer samples were cut into smaller pieces with a pair of pruning scissors, and ca. 1 g samples of the pieces were powdered with a disruptor. DNA was extracted, using the DNeasy Plant Mini Kit and a QIAshredder Maxi Spin Column from the DNeasy Plant Maxi Kit (Qiagen), and DNA concentration was determined using a fluorescence spectrophotometer with λDNA as a standard. Four chloroplast DNA regions were amplified by PCR.

Results and discussion

The sequences obtained were aligned from each of the samples for the following regions: trnL intron (506 bp), trnL-trnF (441bp), trnH-trnK (1780 bp), and psbC-trnS (1559 bp). The total sequence length was 4286 bp, including some gaps. The phylogenetic tree suggested that each group based on wood colour is monophyletic, except for *S. roxburghii*, implying that it should be able to find nucleotide substitutions capable of distinguishing each of the four groups. In this study, we examined multiple samples for each species collected from individuals in various regions, including Peninsular Malaysia, Sabah, Sarawak and Indonesia. The sequences found in some individuals were not identical to those found in some of their conspecifics, indicating that it may be possible to identify the geographic regions from which individuals of some species originated.

Two unique nucleotide sites were found in *S. albida* that were not present in any of the other *Shorea* species examined, the 11th and 1225th sites of the trnH-psbA-trnK sequence obtained, at which G and C, respectively, were present in *S. albida*, but A and G were presented in all of the other *Shorea* species. *Shorea albida*, which taxonomically belongs to Red Meranti (section Rubella, Ashton 1982), was clearly discriminated by cpDNA sequence data. In Japan *S. albida* wood is subjected to different tax rates than other members of Red Meranti. The nucleotide variations should, therefore, be useful for discriminating *S. albida* from the other Red Meranti species to detect illegal trading.

The methods were developed for extracting and analyzing DNA from wood products, such as veneers and plywood made from dipterocarps, to identify the species they originated from. A chloroplast DNA database for classifying *Shorea* species, which are both ecologically and commercially important canopy tree species in the forests of Southeast Asia, was also developed. The candidate species of veneer samples using their sequences and anatomical data were determined. The DNA database were also developed for searching the origin of timbers in *S. leprosula* and *S. parvifolia* using cpDNA polymorphism and multi-locus genotypes of EST-SSR markers. The use of the methods for analyzing DNA from dipterocarp wood products and the database may have strong deterrent effects on international trade of illegitimate dipterocarp products. Consequently, it may be highly beneficial for the conservation of tropical forests in Southeast Asia.

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Impact of Climate Change on Forest Resources: Perspective Bangladesh

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Climate change is real, and Bangladesh may be the worst victim of the future climate change situation. The country is especially vulnerable not only because of huge numbers of climate refugees as a result of sea level rise, but also because of depletion of a number of forest species and invasion of undesired species due to elevated temperature. This study focused on two species: indigenous *Swintonia floribunda*, which is now in the red data book as endangered species, to find out the affect of elevated temperatures, and *Acacia auriculiformis*, introduced exotic species which is now spreading as an undesired species in reforested areas where elevated temperatures may expedite the regeneration. Reforestation was done with native species at the the Chittagong University campus in 2008. However, gregarious *Acacia* trees were found in that reforested area in the following year. Specialized treatments are still followed to raise the seedlings of *Acacia* in plantations. This observation led to identification of the need to investigate whether *Acacia* will be a threat for the reforested area in future as a result of changing climate of Bangladesh?

Methodology

Germination, survival and initial growth performance of *Swintonia floribunda* were measured in different elevated temperatures using a standard method. However, for the study of *Acacia* species, the following methodology was used.

Sampling procedure for regeneration status for Acacia

For regeneration, nine sample plots, three each from low, mid and high hill slopes in the area were selected. Each plot measured 2 × 2 m in size. Seedlings were identified, counted and recorded in the data recording sheet.

Analysis of data to measure quantitative structure of the regeneration

After collection of field data to measure quantitative characteristics, data were compiled and processed with the help of computer. Using the formulas by Moore and Chapman (1986), Shukla and Chandel (1980), and Dallmeier *et al.* (1992), tree density (individuals ha^{-1}), Relative density (RD %), Frequency, Relative frequency (RF %), Abundance, Relative abundance (RA %) and Importance Value Index (IVI) were calculated for each species.

Analysis of data to measure different diversity indices

As measures of diversity, Simpson Index (Simpson, 1949), Diversity Index (Odum, 1971), Shannon-Wiener Index (Michael, 1990), Species Richness Index (Margalef, 1958) and Species Evenness Index (Pielou, 1966) were calculated.

Results and Discussion

Swintonia floribunda

Germination, survival and initial growth performance of *Swintonia floribunda* were measured in different elevated temperatures: ambient temperature (T_0: 32.8 ºC), and ET-1(T_0 +1.4 ºC), ET-2(T_0 +2.4 ºC), ET-3(T_0 +2.8 ºC), ET-4(T_0 +3.4 ºC) and ET-5(T_0 +4 ºC) The result revealed that elevated temperature had significant impact on the germination percentage and germination value for both species (Fig. 1). However, ET-4 and ET-5 showed a negative impact on growth of the seedlings of *Swintonia floribunda.* The planting season in Bangladesh is June to early August, with average temperature (last 20 years) of 32.8 ºC. Recently, temperature is increasing with an alarming rate, and already exceeds the average by 2.8 ºC. This may reduce the indigenous forest resource, indicating a need for further research to develop higher temperature resistant genetic repository for this species.

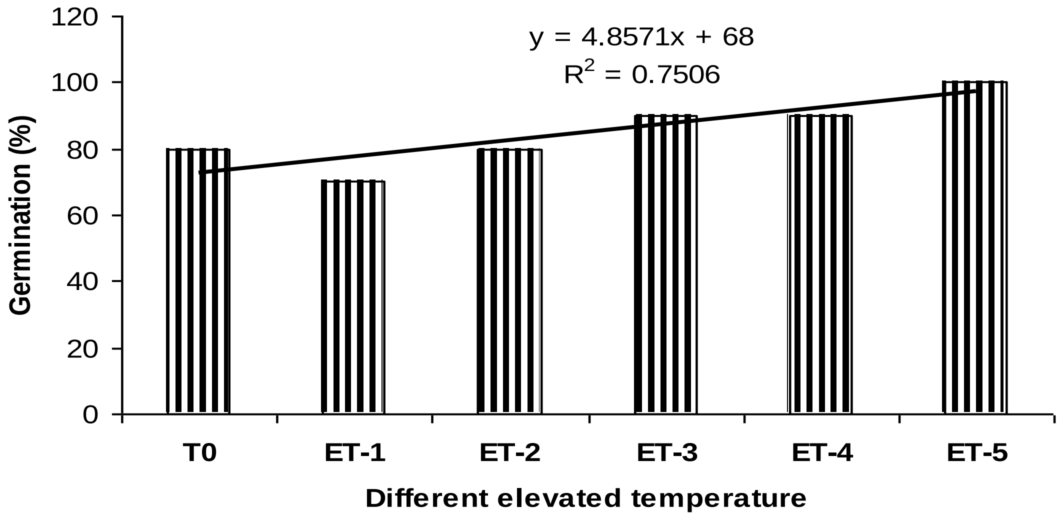

Figure 1. Germination percentage under existing and five different elevated temperatures. See text for explanations.

Temperature has a significant effect on growth performances of *Swintonia floribunda* seedlings. Similar experiments showed the presently ecologically viable and economically important species *Artocarpus chaplasha, Michelia champa, Gmelina arborea, Albizia* spp. and *Lagerstroemia speciosa* may shift their native location in future. A a result of changing climate, the natural forest of Bangladesh may lose its native, economically valuable species. Climate and land use change may produce a new vegetation assemblage, which may lead to potentially long-term changes in forest species composition and community structure in Bangladesh.

- The survival capacity of seedlings is increasing with increasing temperature, but only up to a certain limit.
- The species may be extinct in near future (when temperatures increase high) because it cannot tolerate higher temperatures.
- ET-3(T0 +2.80 ºC) may be a suitable temperature for the existence of *Swintonia floribunda* species.
- Therefore, temperature is one of important factor in changing climate, but it might not be the sole responsible criterion for making the species endangered
- However, the stated species repository is severely depleting

Acacia species

After studying the field data of newly reforested and old plantations of *Acacia*, the results revealed that temperature may be a key factor to ease germination. As aresult, the study areas may change from limiting zone to acclimatized zone for these species. This study suggests that climate and land-use change may produce a new vegetation assemblage that may lead to potentially long-term changes in species composition and community structure in Bangladesh.

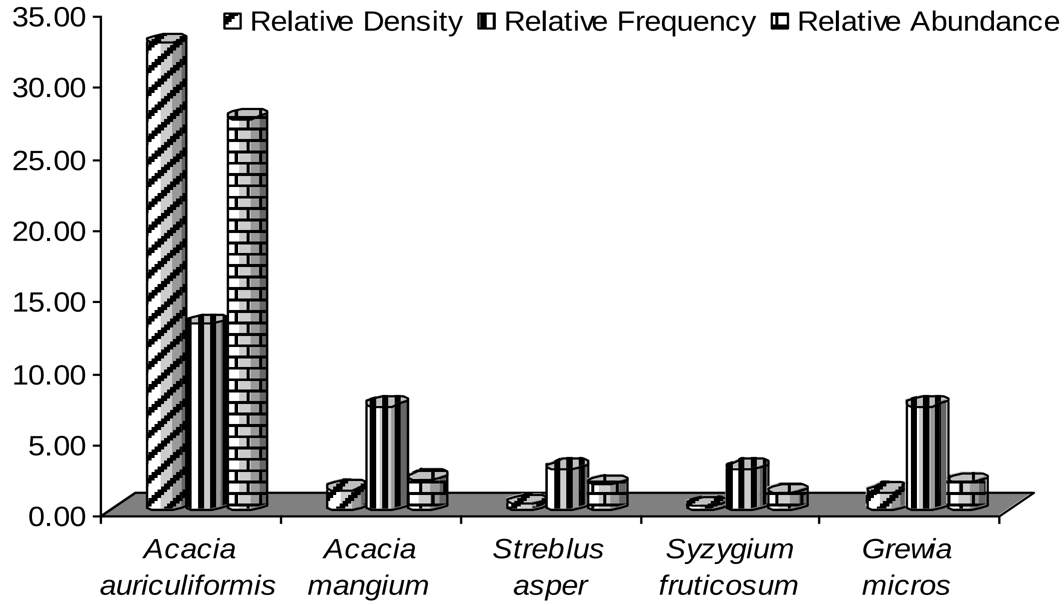

Figure 2. Relative density, Relative frequency and Relative abundance of dominant five species that regenerated (*Acacia* is a undesirable species).

The results illustrated that *Acacia* species became empowered to alter the composition of the reforested areas, and its acclimatization helped the species to become a threat as an undesirable species in the reforested areas of Bangladesh (Fig. 2). This may be due to not-well-thought-out government policies, weak enforcement of existing safeguards, and lack of public awareness that alien invasive species are taking over natural habitats and rapidly changing the native characteristics of the ecosystem, or changing climate. Here, soil surface temperature is a key factor which affects establishment and growth of naturally occurring *Acacia* species and its eventual invasion.

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Optimum Population Sizes for Effective Conservation and Management of Tropical Plant Species

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To conserve forest genetic resources, conservation programmes must be guided by the biological attributes of the species. We cannot conserve effectively what we do not understand. Tropical forests are rich in plant species diversity, and for the majority of these species, obtaining adequate knowledge for setting up conservation strategies is impossible. It is suggested that for the conservation of tree species, the species can be grouped according to their life history traits. The information generated for a species can then be adapted for other species that have similar type of life history traits. Accordingly, we have recently completed a series of ecological genetic investigations of four dipterocarps (*Shorea lumutensis*, *Neobalanocarpus heimii, Hopea bilitonensis* and *H. subalata*) with different life history traits to set conservation strategies. This extended abstracts was extracted from Lee *et al*. (2006) and Lee (2007, 2008, 2009).

Shorea lumutensis is a rare, locally abundant and predominantly outcrossing dipterocarp. Population surveys showed the species was present in five populations. The species showed high levels of genetic diversity and has 94.2% of its total genetic diversity residing within the population. The optimum population size to maintain 95% of genetic diversity was estimated as 270 individuals (in the range of 200–310) and the mean breeding unit size was estimated as 52 individuals. Therefore, for *S. lumutensis*, conserving an area no less than 100 ha with at least of 300 individuals exceeding 10 cm dbh (including 60 reproductive trees >30 cm dbh) in each population will be sufficient to maintain maximum levels of genetic diversity. This would help to withstand loss of genetic variability due to drift and should be enough to contain the minimum number of reproductive individuals to prevent inbreeding.

For *ex situ* conservation, as the species is an outcrossed one and the majority of the genetic diversity was partitioned within population, a minimum of 10 unrelated mother trees per population should be used to establish a field gene bank. As the species exhibited significant spatial genetic structure up to the scale of about 20 m, the selected mother trees should be more than 20 m apart.

Neobalanocarpus heimii is a widespread endemic, semi-gregarious and predominantly outcrossing dipterocarp. The species showed high levels of genetic diversity and has 84.2% of its total genetic diversity residing within the population. As the cluster analysis partitioned the populations into four genetic clusters, corresponding to four geographical regions in Peninsular Malaysia, these four regions should be considered independently for the selections of *in situ* conservation areas. Since the species has 15.8% of the total genetic diversity residing among populations and displays mix-mating system, five strategically placed populations in each of the four regions should capture majority of their total genetic diversity and likely be sufficient to prevent the species from becoming an endangered species. The minimum population size needed to maintain 95% of genetic diversity was estimated as 185 individuals (in the range of 145–220). In terms of breeding unit parameters, the mean breeding unit size and area for *N. heimii* was reported as 62 individuals and 86.3 ha, respectively. Therefore, for *N. heimii*, conserving an area no less than 200 ha with at least 200 individuals exceeding 10 cm dbh (including 65 reproductive trees >30 cm dbh) in each population will be sufficient to maintain maximum levels of genetic diversity to withstand loss of genetic variability due to drift, and should be enough to contain the minimum number of reproductive individuals to prevent inbreeding.

For *ex situ* conservation, similar to the selections of *in situ* conservation areas, the four regions should be considered independently for the selections of mother trees for seed collections. As the species is outcrossed and 84.2% of its genetic diversity was partitioned within population, a minimum of 25 mother trees per region should be used to establish a field gene bank. Using 40 progenies per mother tree and combining the progenies from four regions would provide a stand of 4000 individuals. If the individuals are line-planted at a spacing of 5 × 5 m, a minimum of 10 ha is required.

Hopea bilitonensis is a rare, locally abundant and predominantly selfing dipterocarp. The species showed moderate levels of genetic diversity and has 88.4% of its total genetic diversity residing within the population. Population survey showed that the species, although rare (found in two small populations) and restricted to the limestone hills of Kinta (Perak), is locally common in its niche. Genetic studies showed that there is no indication of major biological bottlenecks, but from an ecological and conservation point of view, the populations are seriously threatened. As the species exhibits high selfing rate, the minimum population size required to maintain 95% of its genetic diversity was only 70 individual. If the number of 70 is to be considered and limited to two *in situ* conservation areas, the total number of individual to be conserved is only 140. However, since the species is known from only two localities within the Tempurung massif, for added safety, much larger population or area should constitute units of in situ conservation. For *ex situ* conservation, since the species exhibits high selfing rate, in order to capture the maximum levels of genetic diversity, at least 50 unrelated mother trees should be considered for germplasm collections.

Hopea subalata is an extremely rare dipterocarp with an apomictic mode of reproduction. Population survey showed that the species is only found in Kanching Forest Reserve, in two compartments which are separated by a distance of approximately 1 km. The species shows low levels of genetic diversity and has only 52% of its total genetic diversity residing within the population. The population survey further showed the presence of only 74 reproductive trees of *H. subalata* in the two compartments and there were no regenerating stands surrounding some of these reproductively mature individuals. Thus, from an ecological and genetic point of view, both populations are seriously threatened, and extinction of the species is not unlikely if nothing is done to conserve it. As only 52% of total genetic diversity resided within the population, more than five populations are required in order to capture 99% of their total genetic diversity.. However, as the species comprises only two populations, establishment of *in situ* conservation areas are limited to two.

In term of *ex situ* conservation, since the species reproduces largely apomictically, in order to capture the maximum levels of genetic diversity, seed collections should consider all the reproductive trees in the two compartments. This germplasm should then be distributed and established at the State Forestry Department and the network of Botanic Gardens in Malaysia. Even if the habitat remains untouched, the two populations face some risk of decline through exposure to the vagaries of natural temporal and spatial variations, such as environmental and demographic variations. Hence, monitoring of population size should also be conducted at appropriate intervals to detect any drastic reduction, so that timely management prescriptions can be provided to ensure the health of the populations. At five-year intervals, the populations should be enumerated to determine size distribution, mortality, recruitment, population growth and other demographic variables for the species. The information generated helps to understand the mechanisms that influence population behavior and can be used to predict population trends. In addition, genetic assessment should also be conducted to determine population bottlenecks and inbreeding depression. Although monitoring is an expensive process in terms of time and resources, it is the only way to ensure that *H. subalata* is conserved effectively.

The ecological genetics studies of various tropical tree species according to life history traits allowed the prediction of optimum population sizes for effective conservation and sustainable utilisation of tropical plant species, and serve as models for other studies related to conservation of tropical plant species. It is hoped that all this effort will provide some scientific foundation for the conservation and management of Malaysian forest resources. While we are enjoying our forests now for timber, medicines, rattans, bamboos, recreation, water, clean air and so on, it is our responsibility also to preserve them for the benefits of our future generations.

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Outcrossing Tree Species is More Susceptible to the Negative Impact of Logging

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Abstract

The impact of selective logging on genetic diversity of two tropical tree species with contrasting breeding systems was examined using direct comparison and simulation methods. *Shorea leprosula* is a diploid and predominantly outcrossed species, whereas *S. ovalis* ssp. *sericea* is an autotetraploid species with apomictic mode of reproduction. Direct comparison of adjacent natural and logged-over stands showed reduction of genetic diversity of *S. leprosula*, but not of *S. ovalis* ssp. *sericea*. These results clearly demonstrated that a single logging event would cause the genetic erosion of *S. leprosula*. However, the apomictic mechanisms and the effects of tetrasomic inheritance of *S. ovalis* ssp. *sericea* might be a way of maintaining the level of genetic diversity. These results clearly implied that outcrossing species might be more susceptible to the negative impact of logging on genetic diversity than apomictic species. Simulation studies were conducted using three approaches: (1) simulated removal of individuals based on diameter size classes, (2) simulated removal of individuals at random, and (3) simulated removal of individuals in clump. The simulation study based on the first approach showed that the loss of genetic diversity was higher for the Malayan Uniform System (MUS) compared with the Selective Management System (SMS). This might suggest that SMS is more orientated towards the conservation of genetic diversity. In addition, the simulation study showed that to conserve 100% of the total number of alleles, the tolerable cutting limits of *S. leprosula* in the 50-ha plot of Pasoh Forest Reserve should be >85 cm diameter at breast height (dbh). Comparison of simulation studies based on the second and third approaches showed that the loss of genetic diversity was more rigorous if logging activities were anticipated through extraction of trees in clump rather than by extracting trees at random.

Introduction

Management of tropical rain forest for sustainable yield depends on understanding the effects of timber extraction practices on the continued reproduction of trees. Whether the effective population size in logged forest remains sufficiently large to maintain genetic diversity and reproductive output is a fundamental question for sustainable forest management. In Peninsular Malaysia, several different systems have been introduced for the management of production forests (Appanah and Weinland, 1993). Two of the most popular guidelines are the Malayan Uniform System (MUS) and the Selective Management System (SMS) (Wyatt-Smith, 1963; Thang, 1987). The MUS is the standard management system for lowland dipterocarp forests, whereas the SMS is the principal management system for hill dipterocarp forests. In brief, the MUS practice is based on a cutting cycle of 55 years and consists of removing all mature crops not less than 45 cm diameter at breast height (dbh). For the SMS practice, selective felling is based on a 30-year cutting cycle and is carried out where the cutting limit should not be less than 50 cm dbh for dipterocarp species and not less than 45 cm dbh for non-dipterocarp species. However, both harvesting guidelines are based solely on generalized cutting limits, without the consideration of maintaining the levels of genetic diversity.

The aims of this study were to examine the impact of logging on the genetic diversity of *Shorea leprosula* and *S. ovalis* ssp. *sericea* using direct comparison and simulation methods. To date, however, no study has been conducted to compare the susceptibility of apomictic and outcrossing species to the effect of logging on genetic diversity. The study utilized the demographic structure data of a 50-ha permanent demographic plot. With the availability of the demographic structure data, we were able to relate and compare the demographic patterns and the levels of genetic diversity at various size classes of both studied species. Given that the genetic erosion of apomictic species cannot be compensated through pollen flow, the direct comparison of the adjacent logged-over and natural stands within a continuous forest allowed us to postulate that an apomictic species (*S. ovalis* ssp. *sericea*) is more susceptible to the negative impact of selective logging on genetic diversity than an outcrossing species (*S. leprosula*). This study also presumed the task of determining the immediate impact of the two harvesting guidelines (MUS and SMS) on genetic diversity based on a large and well-mapped ecological plot using a simulation method. This approach also has the potential to enhance the harvesting guidelines by determining the optimum cutting limits for optimal maintenance of the levels of genetic diversity. Simulation of logging activities provides an important advantage because it is non-destructive, as one does not have to cut down an entire logging set-up just to find out how severe is the impact of the logging operation. Simulation studies were also carried out to compare the impact of extracting trees at random and extracting trees in clumps on genetic diversity. Our previous study showed significant levels of spatial aggregation and spatial genetic structure for *S. leprosula* (Ng et al., 2004). It is expected that loss of genetic diversity will be more rigorous if logging activities are anticipated through the extraction of trees in clumpws rather than at random.

Materials and methods

Study sites

This study was conducted at Pasoh Forest Reserve (Negeri Sembilan, 2°59′N, 102°19′E) Peninsular Malaysia (Fig. 1). The Pasoh Forest Reserve covers an area of 6000 ha, of which 2450 ha is managed by the Forest Research Institute Malaysia (FRIM) as a research station. In 1985, a 50-ha permanent demographic plot was established within the core primary lowland forest by FRIM, in collaboration with the National Science Foundation of the United States, and Smithsonian Tropical Research Institute. All woody plants within the plot, with diameter at breast height (dbh) 1 cm and above, were enumerated and identified to species.

For the direct comparison study, two adjacent study sites were selected within the Pasoh Forest Reserve: (i) a natural stand, i.e. the 50-ha demographic plot, and (ii) a logged-over stand, namely Compartment 21, an area of 113.31 ha within the buffer zone (see Fig. 1). The logged-over stand was harvested in 1955 following the MUS, in which all commercial timber trees above 45 cm dbh were logged using bullock-carts and tractors. The relative disturbance levels for the logged-over stand (Compartment 21) in comparison with the natural stand (50-ha demographic plot) has been described in Lee et al. (2002).

Sample collection and DNA extraction

A total of 429 and 394 samples (leaf or inner bark tissues) of *S. leprosula* were collected from the natural and logged-over stands, respectively (Table 1). For *S. ovalis* ssp.

sericea, 170 samples were collected from the natural stand and 159 individuals from the logged-over stand (Table 1). The collected samples were further classified according to dbh into one of three size classes: large (dbh >30 cm), medium (dbh 11–15 cm) and small (dbh 1–5 cm). Genomic DNA was extracted using the procedure of Murray and Thompson (1980) with modifications, and further purified using the High Pure PCR Template Preparation Kit (Roche Diagnostics).

Microsatellites and statistical analyses

Details of the microsatellites and statistical analyses were described in Ng et al. (2009).

Simulation analysis

Spatial coordinate and microsatellite genotypic data of all *S. leprosula* individuals of at least 30 cm dbh within the 50-ha demographic plot were used for the simulation studies. A computer program named CUTTING SIMULATION 1+2 was written to assist the simulation analyses. To determine the immediate impact of the two forest management systems (MUS and SMS) on genetic diversity, simulated-removal of individuals based on diameter size classes was conducted. The removal of individuals was based on the following diameter classes: >100, >95, >90, >85, >80, >75, >70, >65, >60, >55, >50, >45, >40 and >35 cm. For example, >100 cm represents the removal of trees above 100 cm dbh. The prescriptions of the MUS (removing all mature crops >45 cm dbh) and SMS (removal of dipterocarps ≥50 cm dbh) were also tested. The percentages of genetic diversity maintained were then plotted against the removal of trees at various diameter classes to determine the effects of individual removal based on diameter size classes on genetic diversity.

To compare the impact of extracting trees at random and in clump on genetic diversity, two types of simulation analyses were carried out, namely simulated removal of individuals at random and simulated removal of individuals in clump. Detail description can be found in Ng et al. (2009).

Table 1. The number of samples of *Shorea leprosula* and *S. ovalis* ssp. *sericea* collected from the natural stand (NS) and logged-over stand (LS) in Pasoh Forest Reserve. The individuals were classified according to diameter at breast height (dbh) into size classes: large (dbh > 30 cm), medium (dbh 11-15 cm) and small (dbh 1-5 cm)

Size class	*S. leprosula*		*S. ovalis* ssp. *sericea*	
	NS	LS	NS	LS
Large	154	138	58	52
Medium	132	121	55	53
Small	143	135	57	54

Results and discussion

The highest allelic measures (A_a, A_e and R_s) of *S. leprosula* in the natural stand were found in the large trees, followed by the medium- and small-sized trees (Table 2). On the other hand, for *S. ovalis* ssp. *sericea*, all the three size classes showed relatively similar A_a values in the natural stand (Table 2). Direct comparison of adjacent natural and logged-over stands showed a substantial loss of genetic diversity of *S. leprosula* in three size classes (Table 2). The reductions of A_a and A_e ranged from 7.2% (medium-sized trees) to 15.7% (large-sized trees), and from 10.2% (small-sized trees) to 21.2% (large-sized trees), respectively. Similarly, R_s also showed the highest reduction in large-sized trees (23.1%). The mean observed (H_o) and expected heterozygosities (H_e), however, showed slight reductions in all the three size classes. In contrast, for *S. ovalis* ssp. *sericea*, the levels of genetic diversity were found to be comparable or even higher in the logged-over stand than the natural stand in the three size classes (Table 2). A_a showed no increase in large-sized trees, whereas H_o and H_e showed an increase in all the three size classes.

Direct comparison of adjacent natural and logged-over stands for the large-sized trees of *S. leprosula* indicates a loss of 14 (25.5%) of rare alleles (allele frequencies <0.05) in the logged-over stand, with an average frequency of lost alleles being 0.009. In contrast, only one common allele (2.7%; allele frequencies >0.05), was lost, with a frequency of 0.056 (Table 3). However, no loss of common and rare alleles was observed in the logged-over stand for *S. ovalis* ssp. *sericea*. The classification of common and rare alleles was based on Marshall and Brown (1975).

The direct comparisons of adjacent logged-over and natural stands within a continuous lowland dipterocarp forest showed a substantial loss of genetic diversity in outcrossing species (*S. leprosula*), but not in apomictic species (*S. ovalis* ssp. *sericea*). This indicates that outcrossing timber species are more susceptible to negative impacts of logging than apomictic species. The loss of genetic diversity in logged-over stand still prevailed even after 51 years of regeneration. This might indicate that the population dynamic processes (i.e. gene flow) were unable to restore the loss of genetic diversity. Although *S. leprosula* is an outcrossing species (Chan, 1981; Lee *et al.*, 2000), other studies have shown that seed and pollen dispersal of *S. leprosula* in lowland dipterocarp forests are rather limited (Chan, 1980; Chan and Appanah, 1980; Appanah and Chan, 1981). In addition, the population dynamic processes can be influenced by many abiotic and biotic factors, which are environmentally sensitive and can easily be affected by fluctuations of environmental conditions due to logging. Hence, instead of relying on population dynamic processes to restore the loss of genetic diversity, logging activities should be designed in such a way that the current levels of genetic diversity can be maintained even after logging.

Immediate effects of logging on genetic diversity based on simulation approaches

The immediate effects of logging on genetic diversity based on simulated removal of individuals at various size classes are shown in Fig. 1. In general, the simulation studies showed a clear reduction of the total number of alleles (A_t) but not of the observed (H_o) and expected heterozygosity (H_e). Simulation, according to the prescriptions of the MUS (removal of all mature crops not less than 45 cm dbh) and the SMS (cutting limit for dipterocarp species not less than 50 cm dbh), showed that the reduction of A_t was greater for the MUS (10.4%) than for the SMS (9.7%). In addition, to maintain 100% of A_t, the tolerable cutting limit was defined as minimum 85 cm dbh.

The simulation study showed that in order to conserved 100% of the total number of alleles, the tolerable cutting limit for *S. leprosula* was over 85 cm dbh. This further suggests that in order to maintain the current levels of genetic diversity, logging activities should only target trees exceeding 85 cm dbh. It is important, however, to keep in mind that this estimate might be species- and even population-specific. The simulation study also showed that the loss of genetic diversity for *S. leprosula* was higher for the MUS than for the SMS, which might suggest that the SMS is more orientated towards the conservation of genetic diversity. Hence, based on this simulation study, it is recommended that the current prescribed cutting limits, especially for the SMS, can be refined to ensure optimal maintenance of genetic diversity.

Table 2. Comparison of the levels of genetic diversity between the natural stand (NS) and logged-over stand (LS) in three size classes (large, medium and small) of *S. leprosula* and *S. ovalis* ssp. *sericea* (Ng et al. 2009). Mean number of alleles per locus (A_a), effective number of alleles per locus (A_e), allelic richness (R_s), observed (H_o) and expected heterozygosities (H_e). The genetic diversity loss (positive value) or gain (negative value) is indicated as percentage (%). The A_e and R_s were not estimated for *S. ovalis* ssp. *sericea* due to statistical difficulties for autotetraploid species. Standard errors are in parentheses.

Species	Size Class	A_a			A_e			R_s			H_o			H_e		
		NS	LS	%	NS	LS	%	NS	LS	%	NS	LS	%	NS	LS	%
S. leprosula	Large	13.4 (2.8)	11.3 (2.4)	15.7	6.6 (1.8)	5.2 (1.2)	21.2	13.4 (2.4)	10.3 (2.1)	23.1	0.67 (0.08)	0.63 (0.08)	6.0	0.77 (0.07)	0.72 (0.07)	6.5
	Med.	11.1 (2.4)	10.3 (1.9)	7.2	6.2 (1.8)	5.5 (1.1)	11.3	10.9 (2.3)	9.9 (1.8)	9.2	0.72 (0.07)	0.70 (0.07)	2.8	0.76 (0.92)	0.74 (0.07)	2.6
	Small	11.0 (2.2)	9.9 (1.7)	10.0	5.9 (1.2)	5.3 (1.1)	10.2	10.8 (2.2)	9.8 (1.7)	9.3	0.73 (0.05)	0.70 (0.05)	4.1	0.75 (0.84)	0.74 (0.07)	1.3
S. ovalis ssp. *Sericea*	Large	9.3 (2.0)	9.3 (2.2)	0.0	-	-	-	-	-	-	0.47 (0.11)	0.68 (0.07)	-44.6	0.67 (0.10)	0.75 (0.06)	-11.9
	Med.	9.7 (2.7)	9.6 (1.6)	1.0	-	-	-	-	-	-	0.51 (0.12)	0.71 (0.08)	-39.2	0.64 (0.13)	0.69 (0.07)	-7.8
	Small	9.4 (1.6)	9.3 (2.2)	1.1	-	-	-	-	-	-	0.50 (0.13)	0.63 (0.11)	-26.0	0.63 (0.11)	0.67 (0.09)	-6.3

Table 3. The numbers of common and rare alleles and allele losses for *S. leprosula* and *S. ovalis* ssp. s*ericea* (large-sized tree) at the natural stand (NS) and the logged-over stand (LS) in Pasoh Forest Reserve. The classification of common and rare alleles was based on Marshall and Brown (1975).

Species	Stand / variable	Common alleles[a]	Rare alleles[b]	Total alleles
S. leprosula	NS	39	55	94
	LS	38	41	79
	Total number (%)	1 (2.7)	14 (25.5)	
	Mean allele frequency lost	0.056	0.009	
S. ovalis ssp. *sericea*	NS	35	30	65
	LS	35	30	65
	Total number (%)	0	0	
	Mean allele frequency lost	-	-	

[a] Allele frequency ≥0.05.
[b] Allele frequency<0.05.

The immediate effects of logging on genetic diversity based on simulated removal of individuals at random and in clump are shown in Fig. 2. The loss of A_t was more rigorous if logging activities were anticipated through extraction of trees in clump rather than at random. At a removal intensity of 50%, removal of trees in clumps resulted in approximately 3.5% higher a reduction in A_t than removal at random. To sustain 95% of A_t, the percentage of the permissible removal in clump is about 3.3% whereas for removal at random it is 26.0%.

The comparison of simulation studies showed a higher loss in total number of alleles for removal of individuals in clump than removal at random. This also means that the loss of total number of alleles will be more rigorous if logging activities are anticipated by extracting trees in clump rather than at random. Previous studies on *S. leprosula* revealed significant spatial aggregation and spatial genetic structure for this species (Ng et al., 2004, 2006). The significant levels of spatial aggregation represent the distribution of individuals that are in clumps (physical locations), whereas the significant spatial genetic structure is the genetic association of individuals within each clump that are genetically more similar (allelic relationships). Hence, the substantial loss of the total number of alleles for simulated-removal of individuals in clump might be due to the significant levels of spatial aggregation and spatial genetic structure of *S. leprosula*.

Since selective logging often results in the removal of individuals of large-sized trees which are in general reproductive trees, both the spatial aggregation and spatial genetic structure of the reproductive individuals will be altered. Removal of individuals at random for significantly spatially aggregated and spatially genetically structured species would apparently randomize the spatial distribution of individuals and the allelic relationships among reproductive trees. Therefore, when encountered with highly aggregated timber species (in which individuals within each clump are more similar genetically compared with individuals of other clumps) and if the clumps consist of many individuals, removal of trees should not be carried out in clump but rather at random, with the purpose of leaving behind a few individuals for each clump. This will

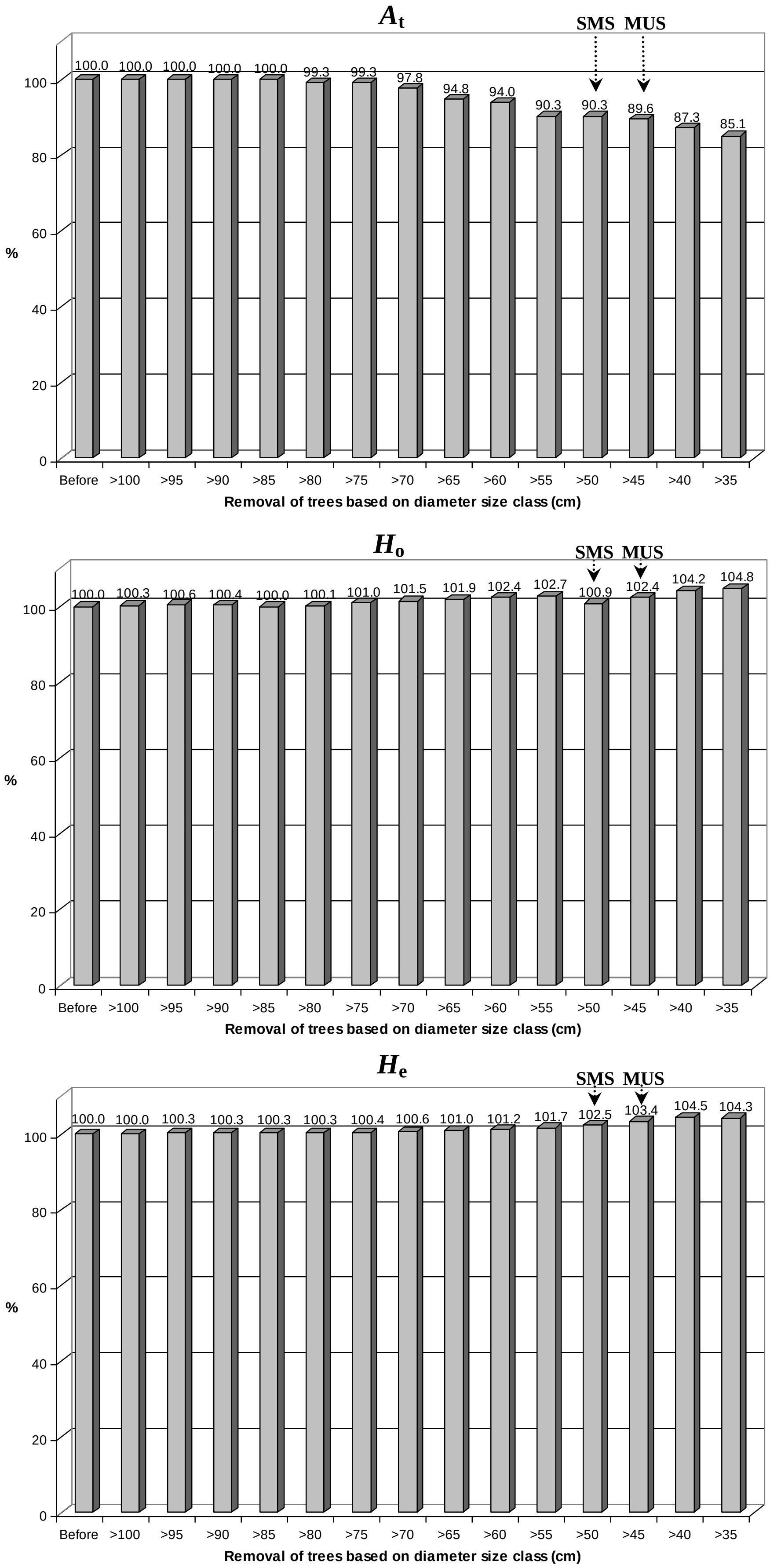

Figure 1 – For explanation, please see next page.

Fig. 1 (previous page). Immediate effects of logging on genetic diversity parameters (total number of alleles, A_t, observed H_o and expected heterozygosity, H_e) based on diameter size classes for *S. leprosula* in the 50-ha plot of Pasoh Forest Reserve. The current harvesting systems that generalize on cutting limits are indicated by arrows (MUS: ≥45 cm dbh; and SMS: ≥50 cm dbh). All analyses were conducted on trees ≥30 cm dbh. For example, >100 cm represents the removal of trees above 100 cm dbh (Ng *et al*. 2009).

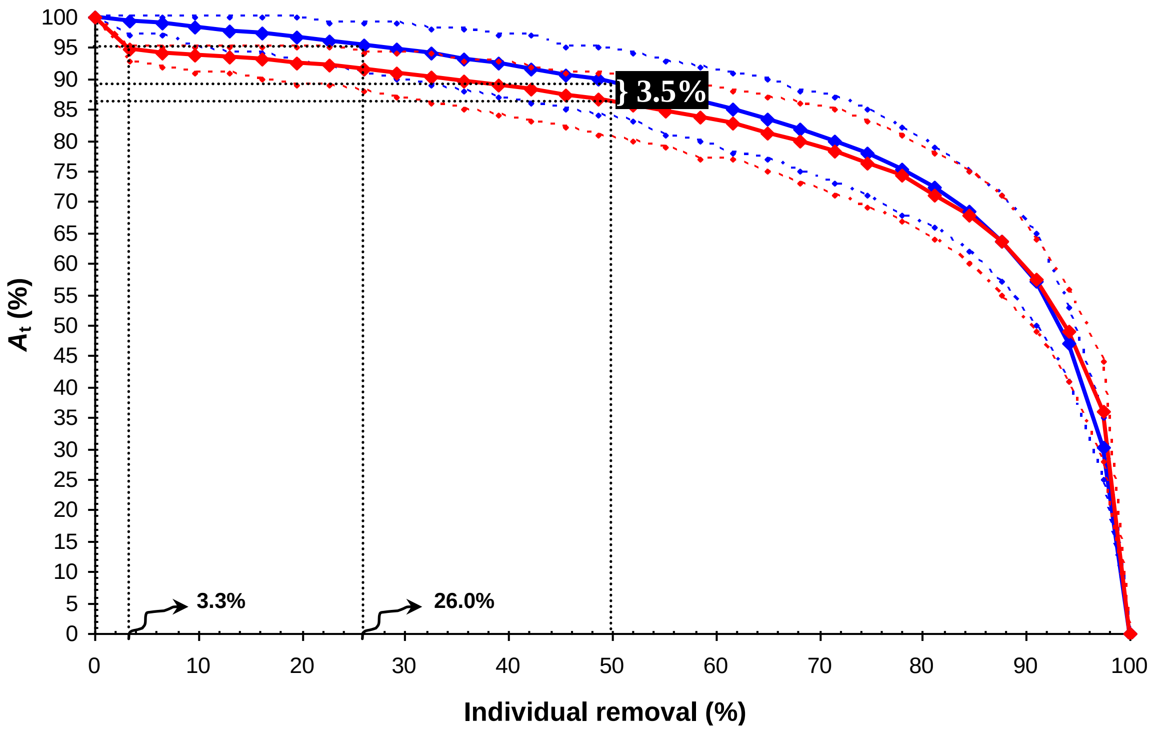

Figure 2. Immediate effects of logging on the total number of alleles (A_t) based on simulated removal of individuals at random and in clump for *S. leprosula* at the 50-ha plot of Pasoh Forest Reserve. All analyses were conducted on trees ≥ 30 cm dbh. Continuous lines: Blue and Red represent the simulated-removal at random and in clump, respectively. Dashed lines represent respective positive and negative 95% confidence intervals (Ng et al. 2009).

ensure the maintenance of stand-scale genetic diversity, and at the same time reduce the chances of mating among relatives, which can minimize the effect of inbreeding depression due to biparental mating. Nevertheless, severe reduction in the density of reproductive trees will also tend to increase selfing (Naito *et al*., 2005). In addition, logging activities have been reported to increase the proportion of seed sets by selfing (Murawski *et al*., 1994; Lee, 2000; Obayashi *et al*., 2002). Therefore, while logging activities can be designed in such a way that a few individuals are left behind for each clump, logging activities should also maintain a certain degree of density among the reproductive trees to reduce self-fertilization.

On the whole, conservation of genetic diversity in tropical tree species is a challenging and an urgent task. Reducing the impact of logging activities on genetic diversity of tree species would be important in its contribution to maintaining a resource for long-term use. Based on the present study, it is conceivable that an inventive and scientifically justifiable harvesting system can be formulated to minimize the negative impacts of logging on forest tree species. The improved system might lead to less profitable logging concessions. However, taking into consideration the huge savings in terms of environmental conservation and future resource supplies, this is only a small price to pay. Hence, the challenge to researchers is to provide an answer to policy-makers on how large areas within production forests are to be set aside for conservation purposes so that at they at the same time still allow for forest harvesting to be carried out economically.

Acknowledgement

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Impacts of Pathogen to Forest Genetic Resources: Effect of Gall Rust Disease to *Falcataria moluccana* Genetic Resources in Indonesia

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Genetic variation is the basis of evolution and the catalyst for species to adapt to changes in the environment (FAO 2009), including pest and disease attacks. Pathogens are posed to be a major threat to genetic variation of forest tree species. In the case of exotic pathogens, the balance between host and pathogen does not exist, thus it is more likely to cause epidemics that decimate populations and erode their genetic diversity (Byrne, 2000). *Falcataria moluccana* (batai, sengon) occurs naturally in Indonesia (Moluccas and Irian Jaya islands), Papua New Guinea, New Britain and the Solomon Islands ranging from 10°S to 30° N (Richter and Dallwitz 2000). The trees have been planted and established since more than fifty years in community forests and more than twenty years in plantation forests in Java Island, Indonesia (Zebala 1997). In 2004, outbreaks of gall rust disease on *F. moluccana* caused by the rust fungus *Uromycladium tepperianum* were detected in East Java, and they continue to be an epidemic throughout Java Island up to now. The disease causes severe damage to all growth stages of the plant, from seedlings in the nursery to mature trees in the field (Rahayu 2007). The objectives of this study were to demonstrate the genetic diversity and relationships among 44 genotypes of *F. moluccana* originating from 11 seed sources using random amplified polymorphic DNA (RAPD), and to distinguish the effect of gall rust disease to the seedlings from the 11 seed sources assessed.

Methodology

A Randomized Complete Block Design (RCBD) with 3 blocks, 7 replications in each block and 4 unit samples in each replication for 4 week old *F. moluccana* seedlings from 11 seed sources were set up for gall rust inoculation and a control treatment (Table 1). The genomic DNAs used in the study were extracted from seedling leaves of 44 accessions belonging to control seedlings. DNA quantification, PCR amplification and gel electrophoresis were conducted for random amplified polymorphic DNA (RAPD) technique. Symptoms exhibited by gall rust on seedling vary in different plant tissue and could appear on the shoot, leaf stalk and stem. However, the scores for gall rust disease were based on estimations made on the stem since earlier findings indicated that the stem is the most susceptible to it (Rahayu *et al*. 2006). Based on the index score for gall rust symptoms, gall rust disease severity (DS) was calculated using modified Chester's formula (1959).

Results and discussion

The genetic diversity of *F. moluccana* seedlings from the 11 seed sources assessed using RAPDs technique was small. All genetic parameters estimated in this study, including effective number of allele (1.036-1.094), number of polymorphic loci (34-55), proportion of polymorphic loci (35.05% to 56.76%), Shannon Diversity Index (0.115-0.192) and Nei's Diversity Index (0.176-0.291) showed low values. The genetic distance among the 11 *F. moluccana* seed sources were small (0.0358 to 0.1515), and simultaneously the genetic similarities among them were high, ranging from 0.859 to 0.965. All seedlings from Brumas (RO2, RO5, R2001 and 2S/75) seed sources were closely related to those from East Timor, East Flores, Moluccas and Java, but distant to Wamena (Figure 1). Fortunately, seedlings from Wamena also showed more tolerance to gall rust disease than other seed sources (Figure 2; Rahayu *et al*. 2009). There were negative and small relationship between polymorphic loci, Shannon's Diversity Index, Nei's Diversity Index and the severity of the gall rust disease at 7, 17 and 27 days after inoculation (DAI; R^2 = 4% to 27%). However, their relationship at 37 and 47 DAI were positive and relatively moderate (R^2 = 39% to 49%). Thus, correlations between genetic variation and gall rust disease severity in *F. moluccana* seedlings were inconsistent in time, and their relationship was not strong. However, *in situ* and *ex situ* gene conservation from native populations of Irian Jaya, particularly Wamena is required in order to prevent the loss of low frequency alleles that may be genes that confer protection against gall rust fungus.

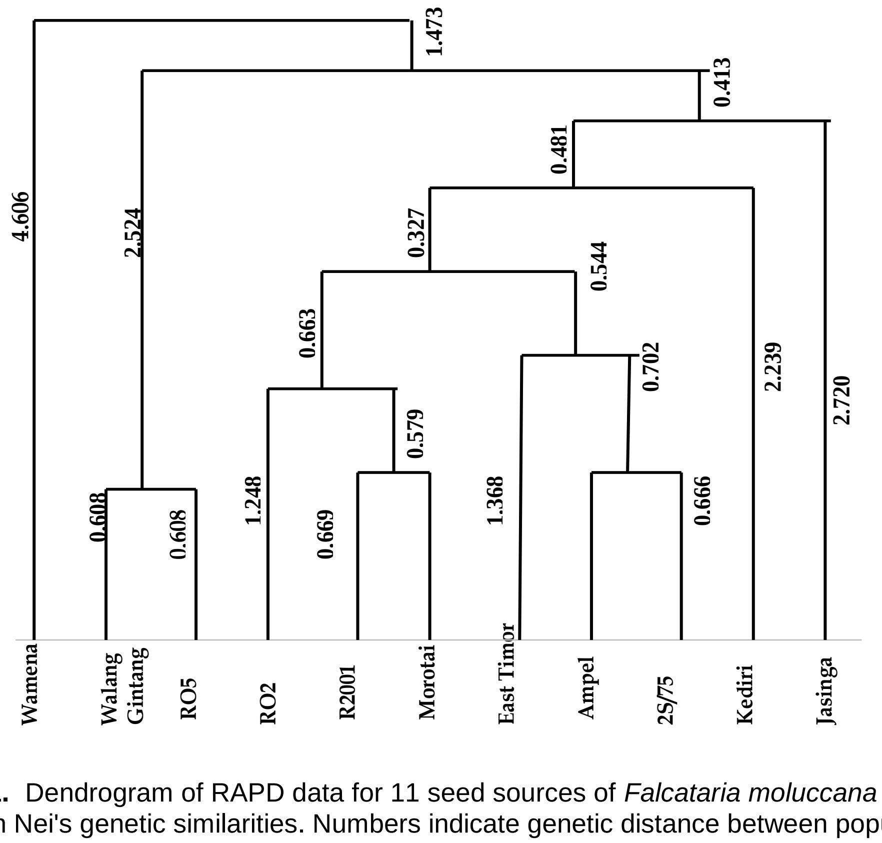

Figure 1. Dendrogram of RAPD data for 11 seed sources of *Falcataria moluccana* seedlings, based on Nei's genetic similarities. Numbers indicate genetic distance between populations.

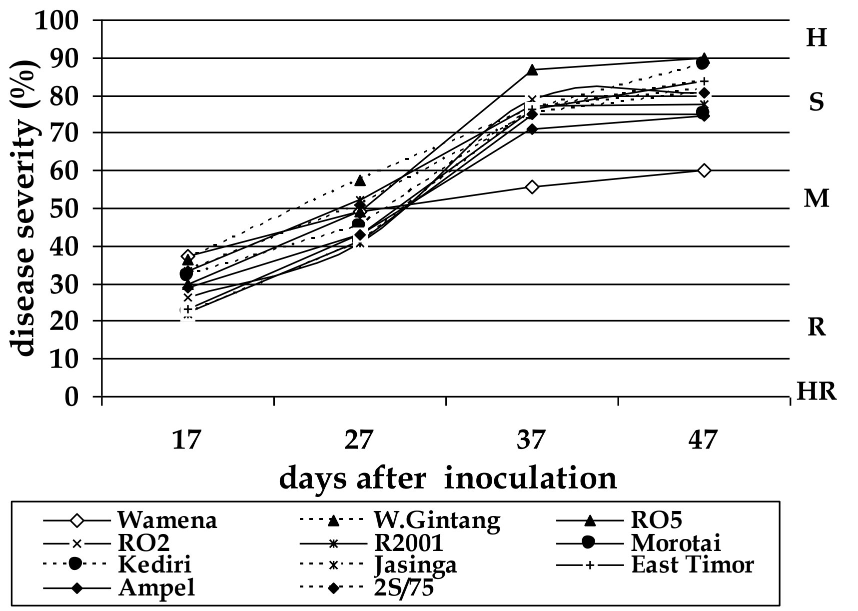

Figure 2. The progress of gall rust disease severity of *Falcataria moluccana* seedlings from 11 seed sources, inoculated with *Uromycladium tepperianum* teliospores, at 17, 27, 37 and 47 DAI, with different categories: HS = highly susceptible (90-100%), S = susceptible (70-<90%), M= moderate (30-<70%), R = resistant (10-<30%), HR = highly resistant (0-<10%)

Table 1. *Falcataria moluccana* seed sources used to evaluate their response to gall rust disease caused by *Uromycladium tepperianum*.

Seed source	Origin	Altitude (m a.s.l)	Latitude	Longitude	Seedlot number
Wamena	Papua	1500	4°01'S	138°31'E	A01 A02 A05 A09 A11 C03
Walang Gintang	East Flores	280	4°01'S	138°31'E	508 A 509 A 502 A 550 480 481 483 484 485 486
RO5	Brumas, Sabah	-	-	-	Mixed from Solomon Island and Sri Lanka
RO2	Brumas, Sabah	-	-	-	Imported from Indonesia
R2001	Brumas, Sabah	-	-	-	Mixed from the Philippines, Sri Lanka, Solomon Is & Indonesia
Morotai	North Moluccas	50	2°22'S	128°25'E	530 533 539 540 541 546 548 555 556 559
Kediri	Central of Java	200	7°49'S	112°01'E	429 430 432 438 439 440 441 443 445 446
Jasinga	West of Java	325	6°29'S	106°27'E	039 040 041A 042 047 051 051A 057 058 061 063
East Timor	Timor	900	8°43'S	125°34'E	510 511 516 517 519 524 525 527 528 529
Ampel	Central of Java	590	7°32'S	110°35'E	244 245 249 250 253 254 258 262 263 264
2S/75	Brumas, Sabah	-	-	-	Imported from Sri Lanka

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The Status of *Rafflesia* Populations in Taman Negara, Malaysia. How Well Are They Being Protected?

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The gigantic red-bloom of *Rafflesia* is one of the best attractions to promote ecotourism in Malaysia. According to Nais and Wilcock (1998), if each *Rafflesia* site could produce 2–10 blooms a year, one *Rafflesia* bloom could attract RM200–RM8000 (approximately 60-2500 USD) per annum. However, there are five factors that are driving the species to the brink of extinction: the limited distribution and rarity of *Rafflesia*, large sex imbalance, specific host plants, high bud mortality rate, and low level of pollination success and fruit set. In addition, human activities such as collection of *Rafflesia* buds for traditional medicine, slash-and-burn agriculture and logging further threaten the populations.

The distribution of *Rafflesia* is confined to western Malesia. In Peninsular Malaysia, *Rafflesia* populations have been recorded in five states orlocations, namely Kelantan, Perak, Terengganu, Pahang (Wong and Latiff 1994), and Tioman Island (Bidin *et al.* 1991). The three *Rafflesia* species which can be found in Peninsular Malaysia are *R. cantleyi*, *R. azlanii* and *R. kerrii*, of which *R. cantleyi* and *R. azlanii* are endemic to Peninsular Malaysia. The IUCN in 1997 listed the status for both *R. cantleyi* and *R. kerrii* as vulnerable, while the status of *R. azlanii* remains unknown as it was only discovered in 2003 (Latiff and Wong 2003). Recently, a fourth species of *Rafflesia* (*Rafflesia lima-lidah*) was discovered in a remote area of Kelantan (Wong and Gan 2008).

Methodology

Findings from previous and ongoing studies on *Rafflesia* populations carried out in Taman Negara by the *Rafflesia* Research and Monitoring Team (RRMT) of National University Malaysia (UKM) were reviewed. The study also looked at legislative provisions related to *Rafflesia* protection in Taman Negara, with an aim to identify gaps and options. Interviews and short discussion with the Superintendent of Pahang National Park and park officers were also carried out to gather information on park management, latest distributions of *Rafflesia* and its conservation status.

Results and discussion

Distribution and status of Rafflesia in Taman Negara

Seven sites of *Rafflesia* were found occurring within Taman Negara. The earliest record of *Rafflesia* in Taman Negara was noted at Sungai Peleting, a tributary of Tahan River (Latif and Mat-Salleh 2001). Besides Sg. Peleting, *Rafflesia* has also been discovered at Air Terjun Empat Tingkat and Sg. Chendana nearby the Kenyir dam.

Another site with several populations of *Rafflesia* was discovered and monitored by Mohd Ros in Sg. Tekal, near Merapoh, known locally as Juadan.

Apart from that, RRMT members also found two locations during a joint inventory with Department of Wild Life and National Park (DWNP) in 2005. Nurul Fatanah discovered two populations of *Rafflesia* at Puteh, on the route to Mt. Tahan, while Siti Munirah and Khairil discovered eight populations of *Rafflesia* at Taman Negara Kuala Koh area. The populations sighted at Kuala Koh ranged from dynamic (active with many stages of buds) to threatened and dormant (inactive). Another site of *Rafflesia* in Melantai was discovered by RRMT (Nurul Fatanah and Tan) in 2005. Based on the said discovery, Tan carried out a further study on the biology of Rafflesiaceae in Melantai in 2006.

The current status of *Rafflesia* in Taman Negara as a whole is unknown, as a thorough study was only carried out at two sites within a short period of time. The *Rafflesia* status in Melantai, Kuala Tahan, is categorized as vulnerable because of the limited number of individuals found in four of the populations. Furthermore, *Rafflesia* was only confined to Malang foothill, hosted by *Tetrastigma leucostaphyllum* vines nearby the Melantai River. In addition, the *Rafflesia* population, particularly the buds, nearby the trail towards Mt. Tahan, was exposed to further threat of being trampled. This has resulted in one of the populations becoming dormant while the other three remained active at the end of the study period.

Legislative provisions related to Rafflesia in Taman Negara

Taman Negara stretches across three States (Kelantan, Terengganu and Pahang), and both Federal and State legislative provisions apply to the area where *Rafflesia* is concerned. At the State level, Taman Negara (Kelantan) Enactment 1938, No. 14; Taman Negara (Terengganu) Enactment 1939, No. 6; and Taman Negara (Pahang) Enactment 1939, No. 2, are used in Kelantan, Terengganu and Pahang respectively. These three Enactments make provisions for the protection of the species, particularly matters pertaining to cutting, destruction, damage, removal and other activities related to clearing, breaking up, digging or cultivation in its habitat. Several differences were noted on these enactments. Enactments of both Terengganu and Pahang retain the privileges of aborigines to continue to collect or hunt for forest products. The other difference can be seen in the amount of penalty or years of imprisonment that can be imposed on offenders.

In addition, the Federal legislations, such as the Protection of Wild Life Act 1972 and International Trade in Endangered Species Act 2008, are also applicable to the protection of fauna and flora within Taman Negara. The Protection of Wild Life Act 1972 provides protection on wildlife in term of species dead or alive, wild or in captive. Meanwhile, the International Trade in Endangered Species Act 2008 makes provisions for the protection of flora and fauna listed in the Act.

It was noted that these two Acts could help to play a role in protecting *Rafflesia* populations by incorporating *Rafflesia* into the definition of wildlife in the Protection of Wild Life Act 1972, and having it listed in the Schedule of the International Trade in Endangered Species Act 2008. With the listing of *Rafflesia*, protection to these threatened species would be provided by provisions related to acquiring of licenses and permits, possession of the species, seizure of species within 24 hours without warrant from suspected vehicles, protection of female species, breeding and propagation, and other dealings related to the protected or scheduled species..

Management of Taman Negara

Management of Taman Negara is a key to protecting *Rafflesia*. According to Mr. Taufik, Superintendent of Pahang National Park, the boundary of Taman Negara is well demarcated and marked with signposts and several red rings painted on tree trunks. Frequent helicopter monitoring equipped with GPS, which focuses on the boundaries, is also carried out. GPS reading and photo shots will be taken and recorded at suspicious locations, e.g. signage of huge area of fallen trees. The enforcement officers of DWNP accompanied by army forces will then carry out further inspection on ground at the suspicious locations.

An issue of concern is the site design and planning. The existing Park design is without any buffer zone, and lacking the linkages connecting it to other protected areas. Apart from that, there are unforeseen effects from the surroundings of Taman Negara towards the protected habitats.

Recommendations

It is proposed that there should be a complementary solution adopted by both Federal and State Government, harmonizing legislative provisions that can better protect these species, as well as intensification of programmes that raise awareness amongst the government stakeholders and the public on the importance and value of conserving *Rafflesia* populations in Taman Negara.

In addition, participation from local communities to conserve *Rafflesia* sites should be further promoted. Moreover, ecotourism of *Rafflesia* is recommended but to be conveyed with comprehensive planning to ensure sustainability of *Rafflesia* sites. It is also proposed that further study be conducted in Taman Negara to better understand the species and their habitat to ensure its sustainability. In the long term, we may need to introduce a structured research and conservation programme to be adopted by States to strengthen and inform decision-making that can affect the species.

Conclusion

In conclusion, every stakeholder plays a very important role in conserving *Rafflesia*. Although *Rafflesia* is protected in the National Park, there are still measures and precautions that can be introduced such as buffers, markings and signages around *Rafflesia* populations to help protect this fragile species.

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Sacrificing Biologically Rich Forest and Forest Genetic Resources for Livelihood of Climate Change Induced Flood Victims and Peace Building

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Kailali, situated in the far west of Nepal, has the largest forest cover among the 20 Terai (lowland plain) districts. Out of 324 790 ha of land area in the district, 210 410 ha (68%) of land was covered by forest in 1991. This includes 119 170 ha of forest in the hills and 91 250 ha in the plain (DOF 2005).

Although the district does not have any protected areas, the forest area provides an important biological corridor which connects the Bardia National Park with the Shuklaphanta Wildlife Reserve. The corridor also connects the Katarniyaghat National Park of India with the hills of Nepal. The important corridor forests include Katase Dora Jhadi, the forest between Kanda and Kandra River, the Basanta Corridor or Badka Ban (Kandra to Likma River), the Rajipur Dagariya and Chaumala forest, and the Kanari forest (Survey 2009). The forest type ranges from tropical to sub-tropical vegetation. In the tropical region (up to 1000m), *Shorea robusta* dominates the forests, with common associates such as *Terminalia alata, Adina cordifolia, Anogeissus latifolia, Syzygium jumbos* and *Lagerstroemia parviflora*. *Shorea robusta* forests are replaced on the south-facing slopes by other forest types and associations, e.g. *Acacia catechu-Dalbergia sissoo* forest and other riverine forest of species such as *Bombax ceiba, Trewia nudiflora* and *Sygygium jumbos*, and deciduous hill forests dominated by the associations of *Terminalia* and *Anogeissus* spp. (Jackson 1994).

The sub tropical vegetation (1000–2000m) consists of *Pinus roxburghii*; Riverine forests with *Toona* and *Albizia* species and *Castanopsis* species are found (Jackson 1994, WTLCP 2008). Rare and valuable species such as *Pterocarpus marsupium* and *Dalbergia latifolia* are also found in the district (WTLCP 2008).

Kailali also harbours the largest number of wetlands in the country. A total of 174 wetlands are spread out in the district, occupying an area of 1010 ha (WTLCP 2008). Among these wetlands, Ghodaghodi Lake is one of the most important Ramsar sites in Nepal, and it is considered as a key biodiversity area by Critical Ecosystem Partnership Fund (CEPF; WWF 2005). A number of major rivers such as the Karnali, Mohana, Pathraiya, Kanara, Kateni, Khutia and Thuli Gand also flow through the district. These rivers along with the 174 natural wetlands provide important interspersion for wildlife and migratory birds (WTLCP 2008).

The important fauna found in Kailali are tiger (*Panthera tigris*), Asian elephant (*Elephus maximus*), sloth bear (*Melursus ursinus*), clouded leopard (*Neofelis nebulosa*), dolphin (*Platanista gangetica*) and other endangered species such as hispid hare (*Caprolagus hispidus*), smooth coated otter (*Lutrogale perspicillata*), common otter (*Lutra lutra*) and swamp deer (*Cervus duvaucelli*). It is also home to 140 species of birds including threatened vulture, adjutant stork and near-threatened Indian spotted eagle.

The district is also equally important transit point which connects six hill districts of the far west through a road network. Population growth in Kailali is 4.83%, which is the highest in Nepal. The doubling time for this population growth is just over 14 years (WWF 2000). With this tremendous population growth and rapid urbanization, the forest area of the district is rapidly decreasing.

Methodology

This research was conducted using three different methods:

- Unstructured interviews with target groups such as forest users, district forest officials, Maoist cantonment activists, squatters, flood victims, ex-bonded labours and local villagers.
- Secondary data were collected from sources such as media reports, programme reports, books and other electronic sources, and
- Field visits conducted in the districts, which included transect walks of the accessible forests, observation of the environmental impact by flood, conducting interviews with government forest department staff, and collecting data at the district forest offices, cantonment sites, flood victims, ex-bonded labours and CFUGs

Results and discussion

The plains of Kailali have faced tremendous forest resource degradation since 1991. A forest cover change survey carried out by Department of Forest through the analysis of satellite imagery (1991–2001) revealed that plains of Kailali have lost the largest area of forest amongst the 20 Terai districts of Nepal. Within this 10 years, the plains of Kailali lost 6838 ha of forest. On the other hand, the hills of Kailali observed an increase in 2364 ha of forest areas (DOF 2005). This increase may be attributed to the inaccessibility and remoteness, migration to plains and successful community forestry programme.

The forest encroachment records from Village Development Committee (VDC) and Municipality of Kailali (1991–2007) showed that 16 857 ha of forest have been encroached in 42 VDCs and 2 municipalities (WTLCP 2008). A total of 15 VDCs have deforestation between 500 and 1800 ha; 17 VDCs have deforestation between 100 and 500 ha, and 22 VDCs with less than 100 ha deforestation. Likewise, the Community Forestry Resource and Training Centre (COMFORTC) also carried out forest encroachment survey in early 2007 which revealed that 24 773 households have encroached 15 713 ha of forest (WTLCP 2008). The weak law enforcement by government due to the decade-long conflict and increasing institutional log smuggling to neighbouring India are the main causes of deforestation. Deforestation was also attributed to the encroachment from ex-bonded labour, virtual squatters and flood victims. But their share of contribution to deforestation is difficult to calculate. During the study, it was revealed that in the name of ex-bonded labour and flood victims, the so-called squatters who were well supported by some local political parties and log smugglers were seen encroaching the forest.

Dilemma in identifying ex-bonded labour and its impact on forest

In Nepal, the bonded labour system (Kamaiya system) which was prevalent in 5 Terai districts was abolished in 17 July 2000. However, until now, proper rehabilitation of the freed bonded labour has been a distant dream. One of the difficulties was to identify true bonded labour, and the total number of ex-bonded has often remained a debatable issue in Kailali. Backward Society Education (BASE), a local NGO, identified 44 944 people belonging to ex-bonded labour (BASE 1995).

The government data, which was collected more or less at the same time as BASE (in 1994/1995), however, estimated the number to be 30 463 (Karki 2001). The government survey undertaken in 2000 on ex-bonded labour also gave a similar figure which comprised 6329 households. On the other hand, Ministry of Land Reform and Management has identified 18 400 households with ex-bonded labour in four categories in five districts. Out of these, in total 12 019 Kamaiya families were given a piece of land measuring 0.1343 ha on average (GEFONT 2004).

The rehabilitation of ex-bonded labour is so frustrating that, time and again, they used to grab the land in protest. Over 200 000 Nepalese tribal freed from slavery and living in makeshift tents has grabbed more than 10 000 acres of government land in protest against the state's failure to rehabilitate them, more than four years after their release (One World South Asia 2004).

The government's process of identifying available land has been hampered in many places by an underlying conflict between the Forest Ministry and the Land Reform Ministry. Initially, Land Reform officials had indicated that they intended to make land available by reclaiming *Ailani*, or unregistered land, that is often cultivated illegally by large landowners. This would save forest land, and the approach was supported by the Forest Ministry. However, it now appeared that the government has decided to distribute forest land instead. According to DFO, in Kailali District, 310 ha of forest land have been distributed to 2662 families (MS Nepal 2001).

Dilemma in identifying squatters and flood victims and its impact on forest

Encroachment by so called squatters is going unabated in the jungles along the Basanta corridor in Kailali. In the past six months, 3000 households have occupied land in 30 places in the Basanta area alone (2007). Time and again, the government has shown courage to reclaim the encroached forest, but the so called squatters were well supported by local political parties and log smugglers.

Heavy rainfall (229 mm of rainfall within 24 hours and over 400 mm of rainfall within 48 hours) from 19 to 21 September 2008 caused severe flash floods and landslides in Kailali resulting in that 23 660 households (an estimated 153 790 people) throughout the District were flood-affected, according to the Nepal Red Cross Society (NRCS) (DDRC 2009). All the flood victims were given temporary refuge in the forest, but the government could not manage their permanent settlement. The encroachment was even worst when so called squatters also started to creep in along with the flood victim in their encroachment business.

Maoist Cantonment and its impact on forest

In 2007, the forest in Kailali has also been sacrificed for peace building. Government of Nepal has established 4 cantonment sites where 4111 Maoist combatant reside, occupying a total forest area of 208 ha (Table 1). This also affected an additional 500 ha of nearby forest.

Table 1. Maoist cantonment sites.

Cantonment	Location	Total combatant*	Forest area (ha) occupied**	Forest area (ha) affected**
Seventh div HQ	Talband, Masuriya	1500 (M 1250: F 250)	30	55
Lesnigam Smriti Brigade	Badepur	1011 (M 686: F 325)	70	140
Bahubir Youdha Smriti Brigade	Sahajpur	750 (M 600: F 150)	73.31	263
Lokesh Smriti Brigade	Chisapani	850 (M 550; F 300)	35	40
	Total	**4111 (M 3086: F 1025)**	**208**	**498**

* Alternative Energy Promotion Centre (2007)
** Survey 2009

Conclusion

The government could not identify freed bonded labour nor squatters nor flood victims and properly rehabilitate them. Due to unmanaged rehabilitation, the forest in Kailali is disappearing fast. Some organizations and some political parties are supporting the landless people, flood victims and the freed Kamaiyas. The intention could be praiseworthy, but it is inviting fake squatters to destroy more jungles and immensely benefiting the log smugglers. Some of the forest land has also been sacrificed for peace building in the country.

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Climate Change and the Potential Risk to Forest Genetic Resources

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Abstract

Climate change is linked to increasing concentrations of greenhouse gases, and is associated with increasing temperature and abnormal patterns of rainfall with increased frequency and intensity of droughts and flooding. These changes have long-term implications for the viability and sustainability of forest resources. The relationships between forests and climate change are complex and multidimensional. Contributing factors are deforestation and forest degradation which together create a globally significant source of greenhouse gas emissions.

Why are forests vulnerable to climate change? First, warming temperatures, increased variability of rainfall, and increased frequency and severity of extreme weather events combine to reduce the ability of forests to continue providing goods and services to local communities and to society at large. Second, longer and more severe droughts mean more frequent and severe forest fires, which are often catalyzed by burning events in adjacent agricultural lands. Third, damaged and fragmented forests are more susceptible to other stress factors. Because healthy forests are more resilient to climate change, sustainable forest management must be given more emphasis in adaptation strategies.

Introduction

In the last three decades, the world's climate has undergone drastic changes as a result of rapid industrial development and deforestation. A phenomenon called climate change has become common and often associated with extreme weather abnormalities. Industrial development is responsible for the accumulation of greenhouse gasses in the atmosphere. Forest influences climate change mainly by affecting the amount of carbon dioxide. Carbon dioxide is released into the atmosphere whenever there are forest fires, or when forests are felled. Forest also helps regulate moisture in the atmosphere and can reduce temperatures.

Tropical forest systems are the most species rich environments. Although they cover less than 10 percent of world's surface, they may contain 90 percent of the world's species. Over the last decade, rapid deforestation has taken its toll with some 15 million hectares of forests lost annually, mostly in the tropics. It is also clear that the structural integrity of much of the forest cover that remains has deteriorated. The facts are startling. Forests have virtually disappeared in 25 countries; 18 have lost more than 95 percent of their forests and another 11 have lost 90 percent. The highest current estimate of the world's remaining forested areas is about 3.6 billion hectares, down from the originally forested area of more than 6.0 billion hectares. Primary forests have undergone the greatest transition. About 14 million hectares of tropical forests have been lost each year since 1980 as a result of changes in land-use from forest to agriculture. Forest decline threatens the genetic diversity of the world's plants and animals (Duke University 2009).

Potential risk

Impacts on biodiversity

Biological diversity or biodiversity refers to the total variability of life on Earth. It includes variation at the species level, at other taxonomic levels, and at the genetic level. It also pertains to variation in ecological functions such as those of pollinators and seed dispersers (Fearnside 1999).

As air temperatures and CO_2 concentrations rise, and water and nutrient availability change, fundamental ecological processes will also be changed. Consequently, changes in biodiversity that have already been observed in temperate areas will likely occur. There will be, however, significant variations between species in response to climate change. Some species will surely suffer less than predicted because of their greater than expected environmental tolerance, while others will decline at unexpectedly high rates (Williams *et al*. 2003).

Impacts on forest composition

Some aspects of current climatic change, including lower rainfall, greater seasonality, larger inter-annual differences, and lower soil moisture are likely to impact seedling distribution and growth. Blundell and Peart (1998) showed that among dipterocarps, greater seasonality, characterized by more extreme climate conditions, caused heavier flowering and mass fruiting for some species, and led to reduced survival of seedlings for others. These results indicate that forest regeneration is likely to change, leading to differential canopy species composition over time.

Impacts on genetic diversity

Global climate change may have a serious impact on genetic resources in tropical forest trees. Genetic diversity plays a critical role in the survival of populations in rapidly changing environments. Furthermore, most tropical plant species are known to have unique ecological niches, and therefore changes in climate may directly affect the distribution of biomes, ecosystems, and constituent species. Climate change may also indirectly affect plant genetic resources through effects on phenology, breeding systems, interactions between plants and pollinators and seed dispersers, and it may reduce genetic diversity and reproductive output. As a consequence, population densities may be reduced leading to reduction in genetic diversity through genetic drift and inbreeding (Euforgen 2006).

Impacts on disease outbreak

Concentrations of greenhouse gases are rising and this is associated with changing climates. Although warming rates are expected to be less in Indonesia than the global average, rainfall increases (10-30% wetter in Sumatra and Kalimantan) and decreases in Java and southern islands (up to 15%) are anticipated, and these are likely to affect interactions between pathogens and trees. The effects of changes in rainfall and humidity on pathogen behaviour are more predictable than others which relate to effects on complex biotic reactions. This is partly because the distribution of hosts and their physiological and morphological behaviour are also affected. So both increased and reduced damage to forests by pathogens is expected. Susceptibility to exotic pathogens may also change.

Conservation strategy under climate change

The challenge that conservation of FGR is facing is how to develop and improve conservation programmes in a rapidly changing environment. The conventional approach of diversity-based strategy may not be sufficient to cope with rapid degradation of FGR. In fact, for some species, the diversity may already be in the brink of extinction. Lefevre (2006) suggested a process-based conservation strategy rather than just diversity-based strategy. In other words, conservation should focus on the management of the evolutionary processes that shape the diversity. Evolutionary process such as plasticity, adaptation and migration process should be given research priority.

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Forest Genetic Resurces Conservation and Management at Community and Village Level: An Alternative Approach

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Conservation and management of forest genetic resources (FGR C&M) in Indonesia was proposed to have two goals: to conserve endangered plant species and provide genetic resources for tree improvement. Research on tree improvement is relatively new because Indonesia has been depending on forest products from natural forests. However, because of the rapid degradation of natural forests, sustainable management of forest plantations is becoming very important for the efforts to substitute wood production from natural forests. As a tropical country, Indonesia has many valuable plant species which need to be conserved and managed properly in order to provide a reserve of genetic materials for tree improvement. It is also understood that government and research institutions could not carry out all conservation efforts by themselves.

Based on this background, an initiative was started to involve communities at village level to conserve and manage FGR in farm lands. There are 70 000 villages in Indonesia, and if it is assumed that 50% of them actively conserve one species, it means that 35 000 species or populations would be conserved. This initiative was discussed in a series of workshops to formulate an implementation strategy. This approach was then implemented by developing demonstration plots of FGR C&M with the involvement of community at village level.

This paper discusses how the initiative was implemented and how to encourage the communities to get involved in this programme. Experience in implementing demonstration plots of FGR C&M at village level is presented. This initiative has just begun and is not yet established, but initial experience could be shared to develop FGR C&M programmes particularly with approaches in community involvement.

Basic concept

The concept on FGR conservation at village level was developed as a basis for conservation activities. This means that villages are adopted as conservation units. It takes into account the availability of farm land, crop species and the potential to directly benefit local communities. This conservation programme should be participatively carried out and self-sufficiently implemented by village communities.

The Conservation of FGR is implemented gradually, depending on the awareness and knowledge of the community members. Usually the establishment begins by collecting endangered plants, and if the plot is already developed, selection is then carried out following the principle of FGR Conservation. Plant species for conservation in the plot are selected according to several criteria:

- Local preference, endangered species, symbol of local specificity

- Decided by consensus by the community
- Provision of ecocomic and social benefits for the local cummunity
- Integrated with land management
- Follows the principle of FGR conservation

Table 1. Information of Demonstration plots of FGR Conservation at village level

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

Implementation

The initiative on FGR Conservation at village level was implemented by the secretariat of APFORGEN Indonesia in five demostration plots during 2007-2008. The implementation was in collaboration with the Centre for Biotechnology and Forest Tree Improvement Jogjakarta. Each location has different species for conservation depending on the consensus of the community. The plots were implemented in state land, community land and private land. The variation of land ownership used was to learn about the sustainability of the programme, because secure land tenure was needed. The experience in the process of establishing demonstration plots and providing technical assistance were lessons learnt which could be shared.

Experience from the implementation was disseminated to National Partners and other interested groups. To provide technical assistance, the APFORGEN secretariat published a Manual on FGR Conservation at Village Level. The manual was distributed to interested goups.

Lessons Learnt

The lessons learnt during the implementation of FGR Conservation at Village level could be listed as follows:

- Each location was unique and very specific. There were some universal factors but also some local specifics. Approaches used at one site could not be directly transferred but instead need justification and modifications.
- Participation is the key factor for a successful implementation. High level of participation would reduce the intensity of technical assistance, reduce subsidy and reduce incentive. Continuous technical assistance would encourage participation.
- The intensity of technical assistance in each location depended on the level of participation. However it was indicated that technical assistance should be provided continuously.
- The participation is highly influenced by the benefit that could be obtained from the programme. Most members of farmer groups could benefit directly from the availability of land and crop production.
- Motivator's role and leadership from the principle of the farmer group were also important to give daily direction for the members of the group
- Suppot from the local government was very important in order to sustain and develop the programme. Extending of the conservation areas was also possible because of support from local governments
- All locations needed a guarentee of secure land ownership, because this is a long-term programme.
- To provide direct benefit continuously, all demonstration plots were implemented as combinations of crops and trees as agroforestry.
- The knowledge of genetic conservation is too complicated for people at the village level. Hence the implementation in some plots was initiated by collecting rare species.

Future Challenge

Some challenges envisaged to be faced in the future could be listed as follows:

- The programme is long-term, which requires commitments for sustainability.
- The Programme could be continuously disseminated to encourage farmer groups at the village level to implement the initiative.
- The concept of the programme needs to be developed by taking into account the experiences from the implementation so far.
- Institutional aspects should be formulated in order to enable more stakeholders to be involved.
- Strategy of encouraging people to implement the intiative also hasto be developed continuously
- Self-sufficiency in budgeting needs to be developed

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Community-based Forest Restoration as a Means for Conserving Forest Genetic Resources: A Case Study of the Southern Part of Thailand

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The present study was carried out at Ban Thung Soong village (BTS) located in Krabi province, Southern Thailand. The objectives were to investigate the current status of diversity of forest trees, minor forest products, medicinal plants and their traditional uses, and to clarify the collaboration pattern among various stakeholders, including people in the community, forest officers, and researchers. The BTS village is located between latitudes 8° 27' and 8° 30' North, longitude 98° 42' and 98° 45' East, in the Ao Luek District, Krabi Province, southern Thailand. The total area of the village was 2060.76 ha consisting of community forest (346.57 ha), oil palm plantation (771 ha), rubber plantation (147 ha), fruit orchard (64 ha), settlement area (425 ha), and unclassified area (304 ha). There is a distinct rainy season (late April to December) and a dry season (January to April). During the rainy season, the average monthly rainfall was about 200-300 mm. The average monthly rain fall in the dry season was about 3-413 mm. The average annual temperature ranged between 16.9 to 37.3 °C. The highest temperature was 36.6 °C and the lowest 19.5 °C.

Releve's method of Mueller-Dombois and Ellenburg was applied for the tree diversity with permanent sample plots (40 x 40 m^2). Each plot was divided into 16 quadrants (10 x 10 m^2) to study all trees. In each quadrant, every tree with a diameter at breast height (dbh) exceeding 4.5 cm was measured and identified by its local name. Tree height and diameter at breast height were recorded. The four plots (4 x 4 m^2) were established at four corners of a permanent sample plot to investigate saplings. The local name and height of each sapling were recorded. Diversity of seedlings was investigated with a plot size of 1 x 1 m^2 at each corner of the permanent sample plot. The local name and height of seedlings were recorded. The results were analyzed using quantitative ecological methods, including important value index (IVI), relative density, density, relative frequency, relative dominance, Fisher's Index of Diversity, Shannon-Wiener Index of Diversity, Simpson's Index, Richness Index, Diversity Index, and Evenness Index.

Tree diversity in homegardens was studied with 10 sample households representing fruit orchards, timber orchards, and medicinal orchards. The species and tree position were identified and recorded. The plant composition, species richness, and similarity of species based on the vegetation survey were investigated. Mapping of the study plot and plants positioning in each homegarden were done by using Global Positioning System (GPS).

The survey for the diversity of medicinal plants was performed by interviewing four parataxonomists to obtain information about medicinal plants commonly used in the village, and followed by collecting plant specimens for taxonomical identification. The investigated areas were a community forest and areas around the homegardens. The survey of medicinal plant diversity was carried out with four sample plots (40 x 40 m^2.) in each study site. The collected specimens were compared with authentic specimens at herbaria. General information about the uses of minor forest products (MFP) was collected by using questionnaires. Some specimens of the MFPs in the forest and the homegardens were collected. The collected specimens were compared with authentic specimens at herbaria and consulted with parataxonomist.

The results of the tree diversity analysis showed that there were 70 tree species, 30 species of saplings, and 31 species of seedlings in the community forest. The tree density was 1638 tree ha^{-1}, while the density of saplings and seedlings were 18 906 ha^{-1} and 141 250 ha^{-1}, respectively. Diameter distribution of trees resempled the inverse J-shape, indicating that the community forest was in a stationary stage. For the Importance value index it was found that *Schima wallichii* (DC.) Korth had the highest relative density. *Eugenia rhomboidea* Ridl. and *S. wallichii* had the highest relative frequency. The highest relative dominance was recorded for *S. wallichii* and *Crypteronia paniculata* Blume. Regarding to IVI, the results demonstrated that *S. wallichii* was the dominant species, followed by *C. paniculata*, *Vitex pinnata* L., *E. rhomboidea*, and *Memecylon* sp. Within saplings, *Vatica* sp. and *Callophyllum tetrapterum* Miq. had the highest relative density. The species with the highest relative frequency were *Ixonanthes reticulata* Jack, *Ardisia lenticellata* Fletch., *Aporosa aurea* Hook.f., *E. rhomboidea*, *Carallia brachiata* (Lour.) Merr., and *Glochidion littorale* Blume. Thus the species with the highest IVI were *Vatica* sp. and *C. tetrapterum*. The sapling species with the highest relative density in the Community Forest was *Vatica* sp. The species with the highest relative frequency were *C. tetrapterum*, *C. brachiata* and *E. rhomboidea*. The relative density, relative frequency and IVI of seedling species revealed that the species with the highest relative density were *Vatica* sp. and *E. rhomboidea*. The seedling species with the highest relative density was *Vatica* sp. and the species with the highest relative frequency was *E. rhomboidea* and *A. lenticellata*. Therefore the highest IVI was for *Vatica* sp., followed by *E. rhomboidea*, *A. lenticellata, Euonymus javanicus* Bl. and *C. tetrapterum*, respectively.

The diversity of trees and their distributions around the homegarden confirmed interactions with people and their environment, and their cultural background. Most people agreed that the planted species had spiritual and ritual values, e.g. *Ficus longifolia Schott., Polyalthia longifolia* (Benth.) Hook.f. var. pandurata, *Carica papaya,* Linn., and *Angel marmelos,* Corr. Within each home garden, species producing food and fruits dominated, followed by timber and medicinal plants, respectively. People were conscious about their environment. They used a lot of species with aromatic attributes, and planted the trees according to wind directions. The varieties of species used in the homegardens meet the daily demands for food, fruit, timber, fuel wood, fodder and herbal medicine to a considerable scale. The average size of homegardens was 0.35 ha. A total of 132 perennial species were identified from the homegarden areas. The number of species for trees, shrubs, herbs, palms, and climbers were 58, 41, 17, 4, and 7, respectively. Species density declined with increasing size of the homegarden area. Smaller homegardens had higher species density than the larger ones. This may be attributed to the fact that farmers with smaller homegardens who are also economically insolvent attempt to exploit the garden for all of their domestic needs for tree products. Planting materials used were seedlings and vegetative propagation according to availability and genetic quality. The sources of planting materials were from older trees in the area, neighbours, private nurseries, and the Royal Forest Department. To collect quality seed and select mother trees, the local people employed their indigenous knowledge. Most of the fruit tree species used were multipurpose species. Most of the homegardens in the study site had timber tree species planted for future uses.

Results of the diversity analysis of medicinal plants showed that in the community forest, there were 115 species consisting of 84 dicotyledons, 27 monocotyledons, 1 gymnosperm and 3 ferns which belonged to 60 families. The largest group (12 different plants) was Rubiaceae. In the homegardens, there were 139 species consisting of 95 dicotyledons, 41 monocotyledons, and 2 ferns which belonged to 60 families. The largest group (11 different plants) was Zingiberaceae. The medicinal plants in the community forest consisted of 17, 30, 30 and 38 species of trees, shrubs, herbs and climbers, respectively. In the homegardens, there were 16, 35, 73 and 13 species of trees, shrubs, herbs and climbers, respectively. Medicinal plants in the community forest area are frequently used for tonic, antipyretic and hematinic purposes as well as for snake bites. Medicinal plants in the homegarden area are frequently used for antipyretic, carminative, tonic, muscle sprain, antidiabetic, abcess and hematinic purposes. The highest MFP families were Moraceae with 5 species, 3 species of Euphorbiaceae, Runiaceae, and Myrtaceae, respectively. Families such as Anacardiaceae, Gnetaceae, Guttiferae, Moraceae, Myrtaceae, Opiliaceae, Rubiaceae and Theaceae are edible plants. Non-edible plants consisted of ornamental plants, chemical components (exudates and extracts), non-industrial timber, fibers and leaves. There were 13 families with 16 species of MFPs having potential uses as wood. The uses of MFPs as non-industrial timber consist of the families of Anacardiaceae, Burseraceae, Celasteraceae, Dilleniaceae, Flacaourtiaceae, Ixonanthaceae, Labiateae, Lauraceae, Leguminosae-Caesalpinioideae, Lythraceae, Melastomataceae, Meliaceae, Moraceae, Sapindaceae and Theaceae.

Planning for community-based resource management methods was pursued through participatory process by presenting the results of the study and discussing with the village committee. The community agreed to rehabilitate or enhance the resources with five measures: (i) Enrichment planting in the community forest area with *Dipterocarpus alatus* Roxb., *Michelia champaca* L., *Gracinia cowa* Roxb., *Cinnamomum porrectum Roxb., and Ficus spp.*, (ii) Planting with *Boesenbergia rotunda* L. and *G. cowa* in the homegardens, (iii) Planting around the fruit orchard, within the oil palm plantation, and rubber plantations to promote a multi-storey canopy structureCoconut, rattan, *G. cowa, and C. porrectum*. were selected to be planted with the target proportion of at least 20% in the monoculture plantations. (iv) Mixed tree species planted in the lowland farming system, to promote and provide wood for basic consumption. Species selected were *D. alatus, M. champaca, Eucalyptus deglupta* Blume, *Acacia mangium* Willd., coconut, *G. cowa*, and rattans. (iv) Along the canal in the village, within a strip of 50 m of width from the canal blank, *Ficus* spp., rattans, bamboo, and banana were planted to protect and to act as the barrier along the 8 km river line in the village. All planting materials were selected on the basis of a good genetic quality, through assistance from forest officers in the area. This paper confirmed the collaboration among various stakeholders through community-based conservation and restoration of forest genetic resources.

Community Involvement in Forest Genetic Resources Conservation and Management after Recovering from Natural Disaster

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Myanmar is a developing country, and agricultural practice is a major livelihood for 70% of the population living in the country, hence forest degradation is unavoidable. The annual rate of forest depletion is increasing with population growth, leading to loss of habitats across Myanmar. The country is still richly endowed with diverse habitats of flora, fauna, natural and cultural resources.

The Forest Department has been managing the forest resources on sustained yield basis since 1856. Priority of forest management in the past was maximum timber production to raise national revenues. The management system rarely considered the consequences of unintended impacts on the social, environmental, ecological and sustainability aspects.

Forest genetic resources (FGR) are critical suppliers for the people and the nation's economy and also for the environment. At present, participatory forest management approaches as well as natural resources management approaches would contribute to the sustainable development of not only environmental stability, but also, more importantly, the national economy and the participating communities (stakeholders). The technical aspect alone is not enough for mutual benefits of FGR conservation and community development.

Methodology

This descriptive study made use of secondary data and information related to FGR conservation and management, community development and participatory forest management.

Strengthening Protected Areas System for FGR C&M

Protected areas system (PAS) is the most suitable strategy for FGR conservation which is mainly for protecting cultural practices of gap planting, natural regeneration, forest plantation in the Permanent Forest Estate (PFE) and *in situ* conservation activities. Community participation and involvement in all PAS areas and reforestation activities is emphasized for the future of forestry programmes. There is little participation of local people in management of protected areas and hence, future plans call for coordination and cooperation with the local people.

Community involvement and management level performance

Community Forestry Instructions (CFI) was launched in 1995 for managing natural resources with people's participation. Up to the present, 36 703 ha of Community Forests have been established throughout the country. Moreover, tree planting programme is another successful activity with people's interactive participation. In order to implement participatory resources management system successfully, the strengths, weaknesses, opportunities and threats of the current environmental management approach need to be analyzed.

Private sector involvement in plantation establishment is elaborated, and the importance of local as well as foreign investment is stressed. Technological inputs are also essential components to improve forestry sector development.

Forestry sector after the Cyclone Nargis

Coastal environment and Natural Resource Management in all the coastal zones for countering against future disasters are stressed after the recent Nargis Cyclone damage. Emergency measures were taken immediately to meet the essential needs of affected communities. Later, relief operations included efforts to rehabilitate natural resources including trees and forest, and to facilitate timber production. During the cyclone, trees were snapped, uprooted and undermined by the waves and strong currents, and houses and fishing boats were destroyed. In addition to physical damage, trees, particularly planted trees, were affected by soil salination. Much of the coastal forests had been cleared or degraded in affected areas prior to the cyclone. Bringing forests and trees back into the landscape to increase coastal protection and provide forest products and environmental services will help achieve the goal of "building back the nature".

Results and discussion

The damage assessment for the environment was conservatively estimated only on the basis of replacing the damage to existing mangrove forests, both natural forests and plantations, and the loss was based on the loss of environmental services in the natural forests. Some 17 000 ha of natural forest and 21 000 ha of forest plantations were damaged, with an estimated cost around 14 billion kyat (approximately 2.2 billion USD). Loss of environmental services of the natural mangrove forests was estimated at about 46 billion kyat (7.2 billion USD).

There is a need to harmonize various environmental management efforts in the coastal zone. This will help reduce disaster risk and also create opportunities for sustainable livelihoods for the affected communities. There is a longer term need for improving and rehabilitating the country's natural defenses against floods and other hazards, such as cyclones and tsunamis, through ecosystem preservation and replanting of mangroves along the coastal belt.

Reforestation and rehabilitation of mangrove forests in the National Disaster Preparedness and Protection Programme are stated as follows:

- Restoration of protected mangrove areas
- Designation of prevention zone and restoration of mangrove forests
- Establishment of plantation by private sector
- Establishment of community forest
- River banks planting with people's participation
- Cooperation with local and international organizations.

In order to achieve effective people's participation, there is a need for more effective sensitization by the extension staff of the government, NGOs and organizations in the focus areas. Conservation of the old natural forests and measures to stop deforestation would certainly help to mitigate global warming.

Conclusion

Conservation of FGR is impossible without local people's participation, although participation is not the only prerequisite for sustainable forest use. The resident staff members in rural areas deal directly with people on behalf of the forestry department. Self-help management of trees and forests by or with people is potentially one of the most effective ways of sustainably managing forest resources in Myanmar. One major challenge is to ensure that all staff members are well trained and informed in the more technical areas of conservation, management and utilization of FGR.

A development towards greater participation in forestry and conservation will require knowledge on participatory approaches and ways to implement them. It is thus crucial that staff members who deal with local communities are trained in these matters. With collaboration of international technology and funding involvement, the future crisis of natural resources can be eliminated. Nowadays, tree planting becomes an important strategy not merely for the financial aspect, but for carbon sequestration and ecosystem stability. Reforestation contributes significant tangible and intangible benefits such as environmental enhancement, increase in biodiversity and higher economic returns.

Myanmar, therefore, will be a country worth investing to mitigate the global warming for the benefit of global communities as a whole.

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An Introduction to the Involvement of Communities in the Conservation of Forest Genetic Resources in China

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Forest genetic resources (FGR) refer to the actual or potential values of hereditary variation contained in forest trees and shrubs (Palmberg-Lerche and Souvannavong 2008). As critical components of biodiversity, FGR receive great attention in terms of conservation, management and utilization from governments, scientists and communities（FAO, FLD, IPGRI 2004）.

Fragmentation and degradation of natural forests are very serious issues, and valuable timber species are disappearing or have become extinct in China. Obviously, China's forest biodiversity suffers from the explosive increase in the intensity and extent of human activities. Moreover, climate change is a severe concern because of the growing uncertainty about the consequences for biodiversity. Therefore, attention and efforts are paid towards the conservation and management of FGR in relation to climate change（Koskela *et al* 2007）.

It has been noticed that community participation is very important for ensuring the success of forest conservation, especially for a country like China with a high population pressure and economic requirements for forest resources. An attempt is made here to highlight community involvement in the conservation and management of FGR in China.

Methodology

A review of the activities of conservation and management of FGR in which community efforts were involved in China, based on policy analysis, literature examination and data collected from projects of poverty alleviation and rural development.

Results and discussion

Effect of forest land tenure on the conservation of FGR

Forest ownership has become more diversified since 1990s, as the economic reform developed. The government policy encourages the public, individuals and private sector to grow trees and plantations on state land leased to tree growers for a period from 50 to 70 years, which results in accelerating privatisation of forest ownership. Following the agricultural system, the forestry sector has adopted a household-responsibility system under which households ensured by law can manage their own forest resources and utilize the forest products. Working with stakeholders, or participatory forestry in the conservation and management of FGR, is the basic principle to follow in decision-making, when designing projects for tree planting and gene conservation or poverty alleviation activities (http://www. forestry.gov.cn/jtlqgg/default2.aspx?id=3009)

Forest land tenure and farmers' wishes are critical for the success of any conservation project of FGR. For instance, the local communities are encouraged to join programmes such as 'forest closure' and natural forest protection. The Forestry bureau and related organizations provide farmers with material incentives such as planting stocks or fertilizer. The species which are more adaptive to local environment and are commercially valuable should be integrated into conservation programmes.

Local attitudes to the remains of natural forest

China's forest vegetation has been much fragmented. This resulted from profound changes in land use, with landscapes becoming dominated by agricultural ecosystems, and small patches and corridors of native forests remaining, as well as bush communities in isolated valleys and along water courses, which is especially true in southern China (Wang 2004). The small remnants of the original forests, locally called 'fengshui forests', are sometimes found in villages and around areas of cultural significance. These contain old indigenous trees from the original forest and represent rich biodiversity. The fragmented native forests and poorly growing pine plantations are coexisting in mosaic with agricultural fields.

Generally, plantations of *Pinus massoniana* and *P. elliottii* and eucalypts stand on the top of hills. The local communities believe in so called 'fengshui forest' which will bring them good fortune or great luck, therefore, local people will not let the remaining woods to be removed. In many cases, the remnants contain giant trees and diversified plants and animals, some of which are very aged trees of *Gingko biloba, Platycladus orientalis, Cupressus, Pinus, Podocarpus* spp., *Cinnamomum camphora, Ficus* spp., *Sophora japonica* and others.

Conservation of the local species and varieties

There are a number species or varieties of woody plants in different regions of China. The genetic resources of these species are sustainably maintained by local communities, because traditionally these resources are very important for their livelihood. Tree breeding and genetic improvement of such species is carried out by farmers from generation to generation, similar to breeding of agricultural crops on farmland. *Carya cathayensis*, for example, an endemic species limited to an area in the Zhejiang and Anhui Province, is traditionally used in agroforestry systems for nut production and soil conservation. *Pteroceltis tatarinowii,* another example, very adaptive to limestone soil and exposure sites, is historically used for producing a special paper for traditional Chinese painting and calligraphy. There are a great number of species that are traditionally used and protected by communities, without any risk in gene conservation for these species with participation of local communities.

Conservation of genetic resources of more valuable indigenous species

In contrast to the species which can be used in agroforestry systems or local planting programmes, a number of indigenous species are very important for plantation forestry for timber production, normally in long rotation. There would be some difficulties to attract communities to join conservation programmes for these species. The genetic resources of these species are critical for specific regions of the country, as superior populations or genetic variations have been acknowledged through provenance testing. Local people are willing to use these genetic materials in the establishment of family-owned plantations, after being made aware of the superiority of the genotypes. Forestry industries, for instance Stora-Enso, raised seedlings of indigenous species, while growing eucalypts, and freely distributed the seedlings to the local people.

Protecting natural stands for sustaining non-wood forest products

In Yunnan many local communities now have strong interest in maintaining and conserving their local natural forests because they can now earn a lot of money by collecting and selling the delicious wild mushrooms that grow in their collectively owned local forests. Matsutake, for example, is an economically important wild mushroom that contributes greatly to rural livelihoods and local economies in many parts of the northern hemisphere. The local people would lose a potential source of income if they harvested the trees from natural forest. They realize that the natural crops of mushrooms increase and provide them with much better income than what they could get from timber. In many cases, increased attention of the communities is being given to the sustainable utilization of non-timber forest products.

Community awareness of FGR conservation

To improve awareness of communities in conservation and sustainable use, it is necessary to organize training and extension services to households. Beneficiary training on basic tree planting, forestry knowledge and environmental awareness building should be provided. It is desirable to mobilize women to take part in the training campaigns. In China, some rural development projects, which were mostly assisted by FAO, UNWFP or IFAD, included training and extension activities. Training courses should cover the following aspects: importance of FGR for present and future generations; basic forestry knowledge and the techniques to properly plant and manage trees and forests; and the choice of species and varieties. The beneficiaries would be supported with training and know-how to operate and maintain and protect their environment and forest resources.

To ensure the implementation of FGR conservation projects, it is necessary to mobilize communities to take part in the activities. In other words, a participatory conservation and management strategy should be adopted. Local communities should understand more about the significances and must be willing to join in activities for the conservation and management of FGR.

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Legal Framework for Forest Genetic Resources Conservation and Management in India

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India is one of the eight centers of origin of cultivated plants (Vavilov 1951) and one of the 12 mega gene centers of the world, possessing 11.9% of the world flora. The country accounts for approximately 2.5% of the world's land surface area and 1.8% of the world's forest area. Floristically India is extremely rich, its botanical wealth amounting to over 15 000 species of higher plants, of which approximately 4900 species or 33% are endemic. The growing attention to conservation reflects the increasing concern about long-term maintenance of productivity of forests and forest ecosystems. The Government of India has adopted several schemes under the National Forestry Programmes to achieve sustainable forest management and the national goal of one-third of land area under forestor tree cover, and also to have linkages with livelihood and poverty alleviation issues of forest-dependant communities (Mandal 2005). The acts of the Government of India are intended to guarantee and regulate the access to, and the conservation and regulation of the natural resources. These acts are the basis for the protection of the flora and fauna of the country. Within the framework of the legislation, there are national parks and wildlife sanctuaries, wetland reserves and a network of biosphere reserves.

Policy framework

The National Forest Policy 1988 has conservation as one of its basic objectives. It emphasizes the conservation of the natural heritage of the country by preserving the natural forests with a vast variety of flora and fauna, representing the biological diversity and genetic resources of the country. Based on the recommendations of international negotiations, concerned on biodiversity and conservation, India has enacted laws to protect its biological resources. Various important acts and bills as approved by the Government of India are for the conservation, regulation and access to genetic resources of the country. The most important ones are The Indian Forest Act1927, Wild life Protection Act 1972, Forest Conservation Act 1980, Biological Diversity Act 2002, Protection of Plant Varieties and Farmers' Rights Act (PPVFR) 2001 and The Seed Bill 2004. Recognizing the role of forests in rural livelihoods and in securing environmental security for future generations, the Government of India have formulated the National Forestry Action Plan (NFAP) which is a comprehensive work plan for the next twenty years to achieve the goal of sustainable development of forests, and also to increase the forestor tree cover in the country to 33 percent of the land area, as mandated in the National Forest Policy, 1988 (Mandal 2005).

Prior to the formulation of a comprehensive Indian Forest Act in 1927, several acts and amendments covering forest administration in British India were enacted – the Indian Forest Act 1878, the Act of 1890, the amending Acts of 1891, 1901 and 1911, the repealing and amending Act 1914, the Indian Forest Amendment Act 1918, and the Devolution Act 1920. The act of 1927 provides enabling provisions to make rules and regulations, which makes it quite distinct from other acts of that time. It is this distinct provision that enabled this central act to stay in force when forests were under the provincial governments. The act has 86 sections in 13 chapters which address reserved forests, village forests, protected forests, control over forest and lands not being the property of the government, duty on timber and other forest produce, control of timber and other forest produce in transit, collection of drift and stranded timber, penalties and procedure, cattle trespass, forest officers, subsidiary rules and miscellaneous regulations.

The Wild Life (Protection) Act 1972 provides protection to wild animals, birds and plants, with a view to ensure the ecological and environmental security of the country. The new provisions of the act, following the amendment of 2002 pertain to establishing the Zoo Authority of India to oversee management of all zoos in the country, protection of rare and endangered species of plants and animals, and providing individuals with the power to file complaints against offenders. The act has 11 chapters and 121 sections and categorizes animals, birds, and plants in six schedules (MoEF 2006).

The Forest Conservation Act 1980 was enacted to control indiscriminate diversion of forestland. Under this legislation, approval of the Central Government is required before any forestland is diverted for non-forestry purposes. Moreover, the transfer is allowed only with the provision that compensatory plantations or afforestation are raised in an equivalent area of non-forestland or twice the area in degraded forestlands. In 1988, the act was amended to make the existing provisions more stringent. This act is, by far, the most important tool as the Government of India has to regulate and control the change in the land use of recorded forestland.

The Government of India has also enacted the Biological Diversity Act 2002 under the United Nations Convention on Biological Diversity, signed in Rio de Janeiro on 5 June 1992, of which India is also a party. This act identifies the strategies and actions that need to be taken with regard to access to genetic resources, their conservation, sustainable use, and fair and equitable sharing of benefits. The act envisages the establishment of a National Biodiversity Authority, State Biodiversity Boards and local level Biodiversity Management Committees to provide for regulated access to biological resources and traditional knowledge associated with them.

India has ratified the Agreement on Trade Related Aspects of the Intellectual Property Rights. To give effect to this agreement, the Protection of Plant Varieties and Farmers' Rights Act (PPVFR) was enacted in 2001. As per the act, plant varieties are defined as groupings of plants (excluding microorganisms) within a single taxon of the lowest rank, which can be defined by the expression of the characteristics resulting from a given genotype of that grouping. The Seed Bill 2004 is to provide for regulating the quality of seeds for sale, import and export and to facilitate production and supply of seeds of quality, and for matters connected therewith or incidental thereto. The Wild Life (Protection) Act 1972 provides protection to wild animals, birds and plants, and for matters connected therewith or ancillary or incidental thereto, with a view to ensure the ecological and environmental security of the country.

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Regional Strategy and Action Plan for the Conservation, Management and sustainable Utilization of Forest Genetic Resources in the Pacific

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The Pacific region covers a wide geographic area, estimated to be about one-third of the Earth's total surface, with an extensive range of habitat for forests and trees, resulting in a large range of forest types. Forests and trees play significant roles in the economic, social, environmental and cultural lives of the Pacific Islands. However, significant loss of the region's biodiversity has become a major concern due to destructive human activities associated with mining, agricultural clearing and unsustainable logging, and, recently, attributed largely to climate change.

The regional strategy and action plan

A regional strategy and action plan for the conservation, management and sustainable utilization of forest genetic resources in the Pacific was formally endorsed by Pacific Heads of Agriculture and Forestry Services, and approved by Ministers of Agriculture and Forestry, at their regional meeting in Apia, Samoa in September 2008.

The Action Plan has identified 11 priority research and development themes that need to be addressed to improve the conservation, management and sustainable utilization of the forest genetic resources. The priority research and development themes are as follows:

- Germplasm supply and exchange
- Food security, nutrition and health
- Reforestation and forest rehabilitation
- Climate change
- Traditional knowledge
- Environmental services provided by forests
- Invasive species, pests and diseases
- Forest and tree products market development
- Community and agroforestry management
- Endangered species, populations and habitats
- Sustainable forest management

Each theme is directly linked to germplasm supply and exchange, without which there would be little progress in each of the other themes. Germplasm supply and exchange depends on continuing research and development in each of the other themes.

There are also a number of cross-cutting issues that are considered critical to the overall implementation of the Action Plan, namely:

- Education and public awareness
- Capacity building and institutional strengthening

- Forest policy and governance
- Monitoring and evaluation
- Funding and other resources

The relationships or interlinkages of the different themes and cross-cutting issues are shown in Fig. 1.

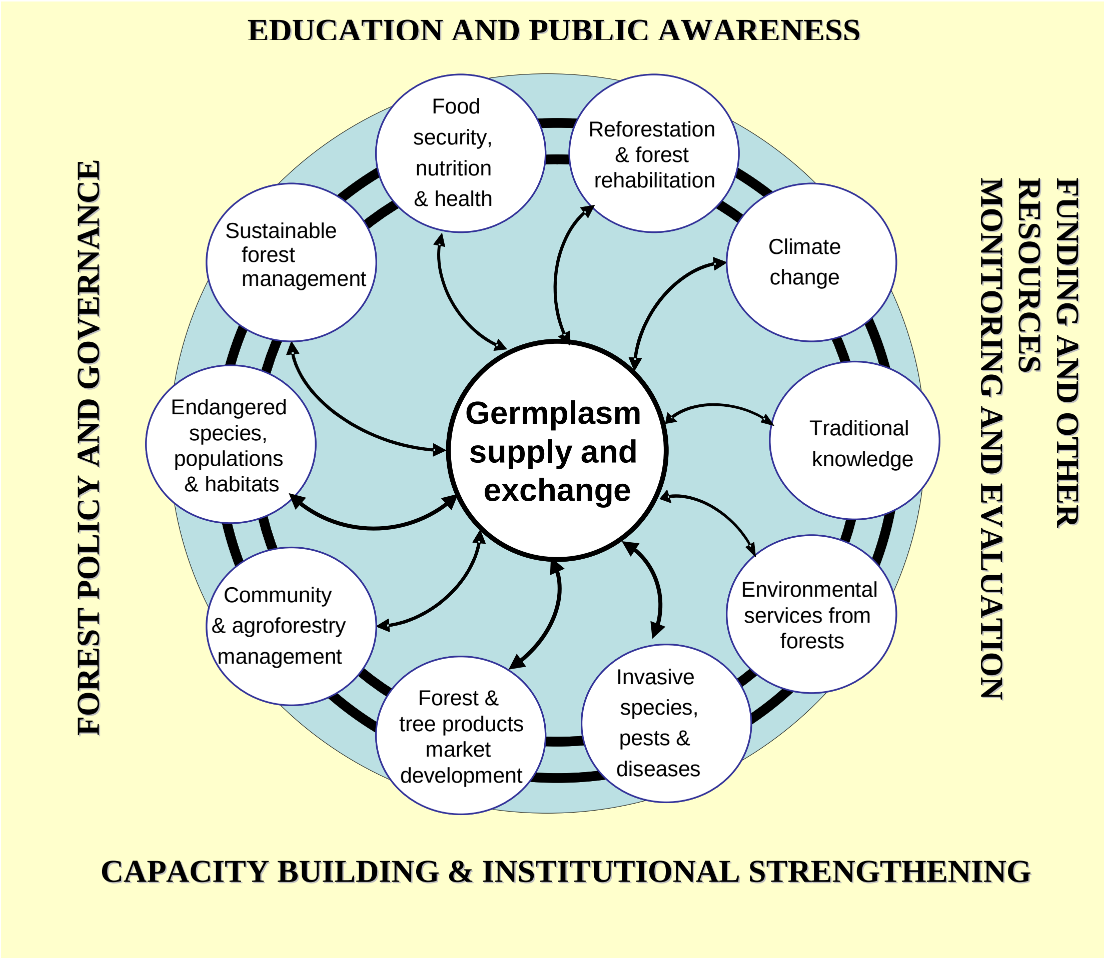

Figure 1. Relationships of the themes and cross-cutting issues of the regional strategy and action plan for the conservation, management and sustainable utilization of forest genetic resources in the Pacific.

One of the major recommendations under the Action Plan is the establishment of a regional tree seed centre within the Centre for Pacific Crops and Trees (CePaCT). To this end, the SPC recently completed the construction of a new 2-storey building in Narere, Fiji, with one of its floors dedicated to the regional tree seed centre. The vision for the seed centre is to assist Pacific Island Countries and Territories (PICTs) to collect and share germplasm of priority tree species. It is envisaged that CePaCT with the regional tree seed centre will eventually be a Centre of Excellence for both crops and tree genetic resources, providing technical support, training, information and advice to the PICTs. This role will cover fields such as seed technology, propagation techniques (tissue culture methods can be developed for selected species) and establishment of seed production areas for priority species difficult to collect from the wild. A focus of the tree seed centre programme will be the development of a Material Transfer Agreement (MTA) for the exchange of tree germplasm, which will cover all issues relating to exchange, such as access and benefit sharing and related intellectual property rights (IPR) matters. The tree seed centre will act as a regional focal point for coordination and implementation of priority tree germplasm collection, storage, distribution and research.

Conclusion

The Regional Strategy and Action Plan is a significant document that will serve as a framework for planning and implementing the conservation, management and sustainable use of forest and tree genetic resources within the PICTs. The Action Plan will thus be a useful guide for the PICTs in developing and implementing relevant policies and activities within their own national and local settings. As a whole it will contribute to the security and development of Pacific forest and tree genetic resources for present and future generations.

Through effective conservation, management and utilization, the forest genetic resource will play an important role to meet the challenges of food and nutritional security and climate change in the Pacific region.

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Sustainable Forest Management and Conservation of Forest Genetic Resources: Initiatives in India

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Unprecedented growth, expansion of urban areas, development of roads, expansion of agriculture, and global warming have brought about a tremendous pressure on forest resources and ecosystems. Decline in forest resources led to the evolution of sustainable forest management. Sustainable forest management (SFM) aims at maintaining and enhancing the economic, social, genetic and environmental values of all forests for the present and future generations. The concept of SFM is not new to India, though many initiatives have been taken in recent decades to bring the SFM approach being adopted in the country in tune with those of other countries. Various initiatives that have been taken up include the development of Criteria and Indicators (C&I) for SFM, and guidelines of Strengthening of Monitoring, Assessment and Reporting of SFM (MAR-SFM) for harmonizing it with similar actions elsewhere in the world. These include different approaches, which have been or need to be adopted for the conservation of the rich forest genetic resources of India. Over the years since their creation, the criteria and indicators approach developed as a potent tool for assessment, monitoring and reporting of sustainability of forest resources. Sustainable forest management encompasses all the three components of sustainability, viz. ecological, economic and socio-cultural well-being. It has been defined by the International Tropical Timber Organization (ITTO, 1998) as "the process of managing permanent forest land to achieve one or more clearly specified objectives of forest management with regard to the production of a continuous flow of desirable forest products and services without undue reduction of its inherent values and future productivity and without undue undesirable effects on the physical and social environment". This paper provides an insight into the initiatives that have been taken for SFM processes in India and for dovetailing them with conservation of FGR.

Criteria and Indicators for assessing SFM, developed as a part of the Bhopal-India process in 1998, have now been refined at the national level. These incorporate criteria and indicators based on forest genetic resources. The C&I are now being dovetailed into the working plan process and field-tested in selected states of the country. The C&I as well as strengthening of MAR-SFM in India also involve conservation of FGR, which are found in the rich and diverse forests of India, representing 16 major groups and over 300 forest types.

The initiatives for conservation of FGR as a part of C&I and strengthening of MAR-SFM have been examined in detail, and a package of approaches have been brought out.

Methodology

Evolution of the process of SFM in India and the inclusion of FGR in this process are analyzed. In 1999, a workshop on *Development of National Level Criteria and Indicators for the Sustainable Management of Dry Forests in Asia* was held at the Indian Institute of Forest Management (IIFM), Bhopal, with support from the Food and Agriculture Organization of the United Nations (FAO) and the United Nations Environment Programme (UNEP), in collaboration with the ITTO, the United States Department of Agriculture Forest Service, and the IIFM. In total 10 Asian countries including India jointly developed a regionally applicable set of national-level criteria and indicators relevant for dry forests in the region (FAO 2000). The criteria and indicators approach developed with the development of a specific set of criteria and indicators for specific forestry conditions through international processes among the participating countries (Rawat *et al.* 2008).

Results and discussion

India is one of the eight centers of origin of cultivated plants (Vavilov 1951) and one of the 12 mega gene centers of the world, possessing 11.9% of world flora. The Government of India has adopted several schemes under National Forestry Programmes to achieve sustainable forest management, their conservation and the national goal of one-third of land area under forest/tree cover. The concept of forest management in India has been broadened to include economic, environmental, social, and cultural dimensions, in line with the National Forest Policy. Critical information on the status, distribution, extent and threats to genetic diversity is a prerequisite for planning effective FGR conservation and management strategies. 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, and regulations governing seed collection and transfer in socio-economically important tree species. Considerations related to FGR in India have been integrated within broad frameworks, such as National Forestry Programmes and biodiversity action plans (the Biodiversity Bill 2002).

The worldwide initiatives to achieve SFM have been focused on the criteria and indicator (C&I) system for assessing the fulfillment of the objectives of managing and conserving the FGR on a sustainable basis. The Indian initiative of criteria and indicators approach for sustainable forest management and conservation was spearheaded by the IIFM in collaboration with the ITTO, the Forest Research Institute (FRI) of India, and the Ministry of Environment and Forests, Government of India (IIFM 1999, 2000). The criteria of the Bhopal-India process encompass all aspects of sustainability, i.e. ecological, economical and socio-cultural. A series of national technical workshops and consultation meetings were held to sensitize communities, forest managers, NGOs and researchers about the need for developing a set of criteria and indicators for the national and state/forest management unit (FMU) levels. A total of 8 criteria and 51 indicators specific to Indian forestry conditions were developed after a consultative process, involving a gamut of stakeholders. The C&I are now being dovetailed into the working plan process and field-tested in selected states of the country for FGR conservation. The indicators of the Bhopal-India process were revisited through a workshop in March 2005, when a refined set of 8 criteria and 43 indicators were developed (IIFM 2005).

The National Working Plan Code 2004 mentions incorporation of criteria and indicators in the working plans for monitoring and evaluation of sustainable forest management. Some working plans have already incorporated the aspects of criteria and indicators of sustainable forest management, e.g. the Working Plans of Haldwani and Tarai East Forest Divisions of Western Circle of Uttarakhand (2006/2007 to 2016/2017). Many other State Forest Departments are also working towards the incorporation of criteria and indicators in their working plans (Rawat *et al*., 2008). The Ministry of Environment and Forests, Government of India, already created a Sustainable Forest Management (SFM) Cell in the Ministry in 2006. It is expected to act as a national-level focal point towards SFM in the country (Rawat *et al*. 2008). It is also in the process to create SFM Cells in each state to attend all matters related to sustainable forest management and conservation of forests. The Forest Research Institute, Dehradun, has implemented a FAO-supported MAR-SFM project, and is associated with the process of revising the National Working Plan Code and field testing of C&I for SFM.

The criteria and indicators approach for sustainable forest management of forest genetic resources will provide a great help in monitoring and providing feedback on the implementation of National Forest Policy programs in the country.

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Advanced-generation Breeding and Deployment of *Acacia* and *Eucalyptus* Species and Hybrids in Some Asian Countries

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In consultation with the lead scientists in the respective countries, summarized information has recently been updated on advanced-generation breeding and deployment of key *Acacia* and *Eucalyptus* species, including clonal forestry with interspecific hybrids, in Australia and several Asian countries. The area of plantations under review is over 4.5 million ha.

Results and discussion

Despite differences between countries, several common trends were noted (Table 1).

Table 1. Characteristics of breeding and deployment populations of key *Eucalyptus* and *Acacia* species and interspecific hybrids in selected countries.

Country	Species	Plantation area, 2009 (ha)	% clonal	Size of breeding pop.[1]	Generations of breeding[2]	Clones deployed operationally
Australia	*E. globulus*	500 000	0	220	3	
China	*E. dunnii*	> 100 000	0	300	1	0
	E. grandis	> 60 000	80	>300	2	8
	Eucalyptus hybrids[3]	>1 500 000	100	>1000	1-2	20
	E. globulus & *E. maidenii*	>120 000	0	200	1	0
Southern India	*E. camaldulensis* & *E. tereticornis*	>1 000 000	25	150 40	2 2	40 10
Thailand	*E. camaldulensis* & *hybrids*	700 000	> 90	300	2	10
Vietnam	*E. urophylla*	300 000	<10	140	2	6
	A. auriculiformis	92 000	0	150	2	0
	A. mangium	154 000	0	120	2	
	Acacia hybrid	232 000	100		1	12
Indonesia	*E. pellita*	100 000	<10	225	2	10
	A. mangium	1 100 000	0	660	2	
	A. crassicarpa	300 000	0	300	2	

[1] number of unrelated open-pollinated families from above-average provenances
[2] 2 = second-generation progeny trials established, 3 = third-generation progeny trials established
[3] combinations of *E. grandis*, *E. urophylla, E. camaldulensis* and/or *E. tereticornis*

The pure-species breeding programmes are all open pollinated, except for *E. globulus* in Australia. The breeding populations, expressed as the effective population size which equates to the number of unrelated selections (White *et al*. 2007), tend to be relatively small in Southern India and Vietnam, where many populations consist of less than 200 individuals. In contrast, in Indonesia and in China, large diverse breeding populations are available for most of the key species. In most of the case studies listed in Table 1, first-generation breeding populations were established as provenance-progeny trials using family collections from well-spaced seed trees from natural provenances of the species in Australia (and/or Papua New Guinea and Indonesia, for several species). The effective population size is less than the total number of families introduced, because in all cases, these trials included families from one or more provenances that were clearly below-average for growth, and these have not contributed to selections for second-generation breeding (e.g. Varghese *et al*. 2008). In southern India, the number of families introduced from the best-performing provenances of *E. camaldulensis* (Kennedy, Laura and Morehead Rivers in northern Queensland) in the mid-1990s was less than 40 (Varghese *et al*. 2008). At least one private company in India has recently obtained a much larger breeding base of these provenances, with over 200 families. The genetic base of second-generation populations has been further narrowed in some cases by poor flowering of many families in the open-pollinated first-generation breeding populations. For *E. camaldulensis* and *E. tereticornis* in southern India, the effective population size was only 7-45% of the total number of trees retained in four seed production areas following selective thinning, because of low levels of fertility (Varghese *et al*. 2009).

Further infusions of additional genetic resources from the best natural provenances appears warranted in many breeding programmes, in order to increase the levels of genetic gain achievable in the short term (White *et al*. 2007), expand the genetic base for long-term breeding, and to provide resistance to pests and diseases and greater adaptability to changing climates. In some countries, large areas of plantations have been established using bulk seedlots of the best natural provenances, as exemplified by *E. camaldulensis* in Thailand. Phenotypic selection of outstanding individuals in plantations of known superior provenance origin then offers a quick and effective route to broaden the genetic base of the breeding population.

Often, as is the case with *A. mangium* breeding in Indonesia, government agencies and large private companies run separate breeding programmes. Exchange of selections between different breeding programmes then provides another way of expanding the size of breeding populations, and some countries have set up collaborative tree breeding associations similar to Australia's Southern Tree Breeding Association (http://www.stba.com.au).

Exchange of selections between countries is another option that has already been taken up in some cases, for example *E. urophylla* selections have been exchanged between China, Thailand and Vietnam. However, care is needed to avoid exchange of closely related material. Maternal pedigrees can be tracked back to the original natural-provenance families (e.g. CSIRO-ATSC provenance and family collection numbers), but this is not always done in practice. Existing seed centre databases in most countries do not contain pedigree information, so checking has to be done manually. Information from molecular genetic markers could also be used to check relatedness of selections (Butcher and Southerton 2007).

Levels of realized genetic gain in growth traits relative to best natural provenances demonstrated in pure-species breeding programmes have in several cases been modest (Nirsatmanto *et al*. 2004, Varghese *et al*. 2009). However, for *A. auriculiformis* in Vietnam, very clear growth superiority to inferior local land races was evident (Hai *et al*. 2008). Breeding to date has in most cases focused on improving volume production and tree form, although definition of economic breeding objectives and incorporation of wood properties into multi-trait improvement indices, is now under way.

Many breeding programmes are still failing to deliver sufficient improved germplasm to meet the requirements of growers, particularly smallholder farmers. Clonal programmes (*E. camaldulensis* in India and Thailand, and *Acacia* hybrid in Vietnam) have expanded rapidly in the last decade and are successfully delivering fast-growing planting stock to many growers. *Acacia mangium* and *A. crassicarpa* are not amenable to operational clonal propagation, and it is difficult to dedicate sufficient area to seed orchards of elite material to supply sufficient seed of these species. Many smallholder growers continue to use planting stock raised from seed obtained at low cost from unpedigreed plantations or even from roadside trees, which is subject to inbreeding and resulting in poor performance (Harwood *et al*. 2004).

Clonal forestry with selected superior interspecific hybrid clones has become very important in several countries This is notably the case for the *A. mangium* x *A. auriculiformis* hybrid in Vietnam, where over 230 000 ha of this hybrid taxon have been planted, making it more important than pure-species acacias. Breeding programmes producing interspecific hybrids have generally based on small numbers of pure-species selections, with F1 hybrid families produced by controlled pollination, followed by testing of seedlings and then cloning and re-testing of the best seedlings. In Vietnam, over half of the 10 or so hybrid clones used in production plantations were identified as natural F1 hybrids in plantations of *A. mangium* (Kha 2001). Efforts to expand the genetic base of acacia hybrid in Vietnam are now underway.

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Gene Repositories for Conservation of Unique Alleles: A Case Study in *Casuarina equisetifolia*

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Forests are the single most important repositories of terrestrial biological diversity. The world's forest genetic resources are both threatened and underutilized. Research is crucial to understand and address these threats, and to develop effective strategies for conservation and sustainable use. Because forest genetic resources (FGR) consist of thousands of useful species of which very few are domesticated, little is known about their biology, conservation, variation and potential. Furthermore, populations of many of these species are threatened by factors ranging from over-harvesting to land conversion and climate change. Increasing concern for environmental degradation has broadened the scope of genetic conservation to include non-commercial species for their intrinsic values (Namkoong 1986, Ledig 1988). Since commercial tree species, unlike agronomic crops, have long rotation times and are planted in wild land settings, diversity is important for adaptability as well as increased productivity.

The study of adaptation is fundamental to forestry and forest genetics conservation. Functional genomics provide new tools to study adaptation in trees. Despite remarkable progress, limited reports are available on the nature of genetic variation that underlies adaptive forest tree phenotypes. Comprehensive understanding will require discovering, annotating and cataloguing all genes in the forest tree genome. One approach towards achieving this goal is to sequence the entire genome and infer the genes from the DNA sequence. This approach is currently not feasible in all forest trees because of their large genome size and the cost involved in sequencing. An alternate approach is to study the transcriptome during stress conditions and elucidate the role of specific genes and their interactions, which in turn will determine the adaptability and survival of the species. To date, most genomics programs in plants have been directed at a limited range of species, selected either because of their status as model organisms or because of their economic importance. John and Spangenberg (2005) have coined the term Xenogenomics which refers to the discovery and functional analysis of novel genes and alleles from indigenous and exotic species, permitting bioprospecting of biodiversity using high-throughput genomics experimental approaches.

Casuarina equisetifolia is a true multipurpose tropical species, providing a range of products and services for industry and local users. The high levels of salt tolerance and ability to fix nitrogen have made it an important species for bio-shielding to control erosion in coastal areas, for land reclamation and soil improvement. Hence, the present study was undertaken to identify transcripts from *C. equisetifolia* which are differentially expressed during a pathogen infection.

Methodology

Plant material and optimization of elicitor treatment

Callus cultures from epicotyl tissues of *C. equisetifolia* subsp. *Equisetifolia*, obtained from a species trial at Panampally, Kerala, were established in MS media with 1 mg l^{-1} BAP and 1 mg l^{-1} NAA. The cultures were subsequently subcultured and maintained in the same media for further experiments. Elicitor was prepared from the cell wall of the fungus *Trichosporium vesiculosum*, and the time for optimal elicitation was determined by exposing the calli for 12, 24 and 48 hours in 1 ml of the prepared elicitor. Transcript profiling was done with the arbitrary primer P4 (Delta Differential display kit, Clontech Laboratories Inc., Palo Alto, CA).

Transcript profiling in elicitor-treated and untreated calli

Total RNA was isolated from 100 mg of both elicitor-treated and untreated callus tissue using the RNeasy Mini Kit (Qiagen, Hilden, Germany). The quality of RNA was checked on a 1% agarose gel and concentration was determined spectrophotometrically. First strand cDNA was synthesized from both control and elicitor-treated RNA using the Delta Differential display kit (Clontech Laboratories Inc., Palo Alto, CA). The first strand cDNA synthesized from both control and treated RNA was amplified using 9 arbitrary (P) primers and 9 Oligo d (T) primers provided in the Delta Differential display kit (Clontech Laboratories Inc., Palo Alto, CA) individually and in pairwise combinations. The products were separated on a 4% denaturing PAGE and stained with silver nitrate as described by Bassam *et al.* (1991) with few modifications. Differentially expressed amplicons were eluted, amplified, cloned and sequenced. The differential expressions of the amplicons were also confirmed through reverse northern. The sequence data were edited and their homologies with existing genes were determined using NCBI (www.ncbi.nlm.nih.gov). Phylogenetic analyses of selected fragments were conducted using the software MEGA 4.1 (Beta 3) version.

Results

Optimization of elicitor treatment

The first strand cDNA synthesized from all the three treated samples (12, 24 and 48 hours) were amplified using the primer P4 and was resolved on a 4% polyacrylamide gel and analyzed Maximum numbers of bands were observed in 48 hours treatment and hence further profiling was done using the 48 hours treated cDNA.

Transcript profiling in elicitor treated and untreated calli

Transcript profiling was conducted in control and elicitor treated *Casuarina* calli using 81 primer combinations. In total 150 differentially expressed transcripts were excised, amplified, cloned and sequenced. The sequences obtained were analyzed using the public domain database (NCBI) and some of the sequences were found to have significant homology with the known genes in the database. Homology studies revealed that the major groups of transcripts over-expressed during elicitation included heat shock proteins, cytochrome oxidase and proteasomes involved in programmed cell death (PCD), Resistance (R) genes and signal recognition particle involved in Hypersensitive reaction (HR), cell wall proteins like arabinogalactans (2%), other stress-related transcripts like Poplar EST during mild and severe drought stress (4%), genes involved in symbiotic association like nodulin (2%), and systemic acquired resistance (SAR) genes like chitinase and glucanase. Defense-related transcripts contributed 14% of the differentially expressed transcripts. Phylogenetic analysis of selected transcripts revealed that the sequence of *Casuarina equisetifolia* was distinct from the sequences of other tree species.

Discussion

This report showed that exposure of *Casuarina* calli to elicitor resulted in substantial responses including activation of hypersensitive reaction, programmed cell death and systemic acquired resistance. The increased transcript levels of chitinase and glucanase also indicated that they have important roles in conferring resistance against pathogen infection in *Casuarina*. A significant number of differentially expressed genes (70% of the entire group) with unknown functions were identified. This is similar to the xenogenomic studies conducted for *Lachnagrostis adamsonii, Deschampsia antarctica, Microlaena stipoides* and *Lachnagrostis robusta* for abiotic stress tolerance, wherein majority of transcripts identified for stress tolerance were categorized under genes of unknown function (John and Spangenberg 2005). The phylogenetic analysis also separated *C. equisetifolia* from the other tree species. Hence, these gene pools will not only be a novel resource for future transformation programmes in diverse genotypes, but would also be an important reserve for conservation of unique alleles.

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Innovation in Technology Development for Conservation and Sustainable Management of Utilizable Forest Genetic Resources in Tropical Forests of Central India:

Case studies on determination of sustainable harvesting limits of commercially important NTFPs with user community participation in in-situ conditions

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India is one of the twelve mega diversity regions that contain a vast variety of flora and fauna. The wide range of physical features and climatic conditions has given rise to diverse ecological habitats in the form of various forest types. These forests harbour about 7% of the world's flora, comprising of 328 families with 21 000 representative plant species. India has a recorded forest area of 76.84 million ha, which is 23% of the total geographical area of the country (FSI 2003). Forestry is the second largest land use after agriculture, and almost all the forest areas are owned by State governments.

About 300 million people in the poor rural and tribal communities depend on forest resources, particularly, non-timber forest products (NTFPs) for their livelihood. A large population of the country's livestock (about 18% of the world total) depends on forests for grazing, which is one of the important contributors to the serious damage to regeneration, growth and production of the natural tropical forests.

The fast depletion of forest genetic resources, commensurate with prevailing biotic factors in natural forests, has been a major concern of managers, policy makers and forest-dependent people. This has a direct impact on conservation, ecological perpetuation and socio-economic security of the region.

Conservation and sustainable management of forest genetic resources, particularly for commercially important NTFPs, are challenges in the government-owned tropical forests of India. Gradual deterioration and reduction of forest area and increasing demand coupled with invasion of alien species are the major factors which have imposed threats on the survival of most of the indigenous wild genetic resources. Those NTFP species subjected to over-exploitation have either disappeared or are on the verge of extinction in almost all potentially rich tropical forests of India.

The National Forest Policy (NFP) 1988 of India defines the primary goals of forest management as firstly to conserve the natural environment, secondly to meet the requirement of local people (tribal and rural poor population) from the forest produces, and thirdly as a source of wood and other products for industries and other non-local uses (FSI and FAO 2004). A Joint Forest Management (JFM) system has been constituted, with the aim of "sharing of responsibilities for protection, production and decision making with local communities over forest lands between the forest department (owner stakeholder)", through judicious use of limited resources on a sustainable manner. Nearly all states of the Indian Union have passed the JFM resolution (1990), and more than 65 000 joint forest management committees (JFMCs) have been constituted (FSI 2003). The Policy paved the way for active participation of communities in forest management. It also emphasized the symbiotic relationship between people and the forests. It is now widely accepted that the rural people living in and around forests are the key stakeholders in the forest management process.

Nevertheless, increased demand for forest resources, particularly NTFPs, has led the user communities to disregard traditional or sustainable harvesting practices from natural forests. State Government owned forests provide a common property right. Consequently, local people have the right of free access to collect utilizable forest resources. Owing to increased utilization and commercialization of forest resources, local user communities have been encouraged to overexploit forest products. In the prevailing management system, extraction of NTFPs is not at all sustainable, neither in ecological nor in socio-economic terms. Continued unabated depletion of forest resources has imposed threats on the existence of several forest genetic resources (of high demand) in developing countries like India.

Considering the severity of problems of *in situ* conservation and unsustainable collection of forest genetic resources, several case studies were initiated by the State Forest Research Institute, Jabalpur, Madhya Pradesh. These case studies focused on development of integrated innovative technologies for *in situ* conservation and sustainable management of wild genetic resources with active participation of forest dependent communities at the forest management unit (FMU) level.

Methodology

Case studies were conducted employing an integrated participatory approach in tribal-dominated tropical forests of Central India, for the determination of sustainable harvesting limits for overexploited NTFPs. An experiment was designed with various treatments based on different harvesting intensities, i.e. Control (no harvest), T1 (20%), T2 (40%), T3 (60%), and T4 (80%) where underground plant parts (roots, rhizome, or tubers) were harvested. However, for plant species where leaves were harvested, one more treatment group i.e. T5 (100%) was undertaken. All treatments had five replications. Regeneration capacity of the species was estimated for all the treatments by using the Regeneration Index (RI) Method. Sustainable harvesting limits of the over-exploited forest resources were determined in *in situ* conditions by applying the formula

$$RI = (n_i / N) \times 100,$$

where n_i refers to number of plants generated and N to total number of plants harvested. Regeneration Index was calculated from the mean of plants harvested in the previous year and the number of plants subsequently regenerated. Maximum percentage of harvesting at which the maximum value of the Regeneration Indexwas achieved was considered as the sustainable harvesting limit.

Other parameters like phenology, growth rate and impact of prevailing biotic factors were also considered. Thus, sustainable harvesting rate has been ascertained by using a linear model. In the whole experiment the local user communities were the key observers. They were associated in each and every step of experiment, so that they were able to analyze the consequences of destructive harvesting on the regeneration potential of available resources in various treatments.

"Self-Assessment Technique" was employed through direct involvement of the user communities in inventory and status assessment of utilizable forest resources. The community members were trained to analyze the impact of destructive harvesting of resources by themselves.

Results and discussion

Determination of sustainable harvesting limit (SHL) and self-assessment techniques with active participation of user communities were found to be an effective tool for conservation and sustainable management of forest genetic resources (FGR) in natural tropical forests of Central India (Pandey and Saini 2001).

Results for the species-specific harvesting limits were found to be quite alarming, particularly for annuals and biennials whose roots were harvested. In this category, *Chlorophytum tuberosum*, *Dioscorea daemona* and *Asparagus racemosus* allowed harvesting limits of only 30%, 44%, and 52 %, respectively, to maintain sustainability *in situ*. However, other species i.e. *Curculigo orchioides* (68%), *Curcuma angustifolia* (64 %), *Plumbago zeylanica* (64%), and *Embelia robusta* (80%) showed comparatively higher sustainable harvesting limits (Table 1).

Bauhinia vahlii, a woody climber which contributed substantial annual incomes (Rs 5000-7000 or approximately 110-150 USD per family per year) to forest dependent communities, was found to be in a very precarious condition. Due to repeated overexploitation of its leaves as utilizable parts, almost all plants were found to have lost their vigour, including in flowering, fruiting and leaf growth. Leaves of this species were in high demand for making plates and cups, and harvested twice in a year in summer as well as in winter seasons. Bark from the stem was also used for making ropes. Findings of this experiment suggested that 58% harvesting of leaves irrespective of season should be permitted to maintain sustainability in qualitative and quantitative terms in natural forests.

Table 1. Sustainable harvesting limit (SHL) of overexploited NTFPs in tribal-dominated forest localities of Central India.

Species	Utilizable plant part	Sustainable Harvesting Limit (%)
Chlorophytum tuberosum (Safed musli)	Tuberous root	30
Dioscorea daemona (Baichandi)	Tubers	44
Asparagus racemosus (Shatawari)	Tuberous roots	52
Curculigo orchioides (Kali musli)	Roots	68
Curcuma angustifolia (Tikhur)	Rhizomatous roots	64
Plumbago zeylanica (Chitrak)	Roots	64
Bauhinia vahlii (Mahul bel)	Leaves	58
Embelia robusta (Baibidang)	Seeds	80

Unregulated harvesting, increased demand and market access in the absence of security, and unsustainable management are leading to greater rates of resource depletion year by year. Inconsistent knowledge of regulation, lack of documentation or records, inadequacy in implementation of regulatory mechanisms, and ignorance of traditional practices are not only depleting the NTFP resource base, but also creating a threat on regional biodiversity. Nevertheless, there is a lack of systematic and scientific approaches for developing mechanisms to halt unsustainable harvesting of these valuable resources *in situ*. Surprisingly, lack of consideration persists for reproduction, stock, yields, habitat requirement, ecology, regeneration potential and other characteristics of almost all NTFPs, which are being overharvested from natural tropical forests. In this context, development of skills and capability of the local user communities was found to be a viable tool for conservation and sustainable management of forest resources in natural forest ecosystem in the prevailing conditions. Ecological sustainability with institutional policy is imperative.

The common property nature of forest resources requires secure and enforceable regulated use rights as preconditions for the collective management and conservation of these resources. Poverty and attraction of market options, local politics, ineffective leadership and breakdown of enforcement have undermined community institutions and left natural resources to be plundered and exploited beyond the limits of their regenerative capacities. Ecologically, prevailing harvesting techniques at field level were found destructive and wasteful. As a general practice, forest dwellers collected almost all available resource without due consideration of sustainability to satisfy their immediate needs.

Community-based management

Strong self-regulatory institutions and community organizations with effective and transparent mechanisms for equitable sharing and conflict resolution should be encouraged. Investments in training and organizational capacity-building for the rural or tribal forest dwellers and communities should be emphasized in the technology development for sustainable and wise use of forest resources. In this context, there is a need to develop an innovative self-assessment technique which will improve the capabilities of the user communities for sustainable use of forest resources (Pandey *et al.* 2003; Pandey and Saini 2004).

Self-assessment technique: Community oriented co-management

There must be a comprehensive planning system for the assessment and management of utilizable forest resources at community level. A self-regulatory community assessment system seems to be an effective tool. User communitiesor forest dependent people at grass-root level should be trained for assessing status and sustainable use of the forest resources in *in situ* conditions by their own (Pandey and Saini 2001).

In one of the case studies, an innovative self-assessment technique has shown encouraging and positive impacts in sustainable harvesting and management of NTFPs in the natural forest ecosystem. Assessment of NTFPs through people's participation essentially has two components: (i) assessment of productivity, and (ii) assessment of current level of harvesting. By these actions, species-specific information of utilizable NTFPs could be assessed and monitored in a regular way through direct involvement of local people. This simple site-specific integrated approach has not only encouraged local people to conserve and sustainably use the available resources, but also motivated them to apply scientific species-specific regime based on the regeneration potential of the species.

Skills and capacity-building programme for user communities

Critical examination of JFM areas envisaged that success was not only related to forest protection but involved several other activities. A close scrutiny of approaches applied for monitoring, assessment and sustainable harvesting of forest resources reflected that the efforts were partly one-sided, either from the forest department or from outside professionals. There was no sign of community initiation for inventory, data collection, analysis and production towards sustainable management of utilizable NTFPs in community managed forests.

Strategic community oriented skills and capability development programmes with strict institutional management interventions have been found to be an effective tool for conservation and sustainable management of FGR in tropical forests.

There is a need to develop a competent and properly motivated work force and also to explain the conditions under which the recommended practices apply. A comprehensive planning system with strict legal provisions is needed for developing strategies for forest resource management through people's participation. This system requires (i) identification of potentially rich NTFPs areas in natural forests, (ii) resource inventories, (iii) present status/availability of the NTFPs (quantitative assessment), (iv) harvesting regimes, (v) consequences of over-use of resources on sustainability and (vi) value addition, market networking and trade of the collected resources. At community level, the technology imparted should be simple, energy efficient (economically viable) and environmentally friendly.

The prospect of socio-economic development through afforestation and reforestation in rehabilitated degraded forest area under JFM may be sought for conservation and sustainable management of FGR to facilitate climate change mitigation and adaptation. The JFMCs could play a vital role in developing integrated collaborative approaches with institutional stakeholders for afforestation and reforestation under the Clean Development Mechanism (CDM). The role of JFMCs in this regard has been discussed in the paper.

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Recommendations

The following recommendations were endorsed by the participants at the end of the symposium.

Recommendation 1

Recognizing the important roles of FGR, and the significant contributions of the ITTO project, the participants recommended a follow-up project be formulated. The participants further recommended that it be extended to cover all interested countries in Asia and the Pacific.

Recommendation 2

The participants recommended that the following objectives of the current project be re-emphasized in the new phase:

- To develop a regional programme to support national activities implementing conservation of forest genetic resources for sustainable use, in the changing scenarios of climate change.
- To develop regional mechanisms and coordination capacity for gathering, sharing, and analyzing information on conservation and use of FGR, contributing to the global efforts such as State of the World's Forest Genetic Resources Report.

Recommendation 3

Recognizing the increasing emphasis and growing debate on climate change and its impacts, the participants recommend that attention should be focused on forest genetic resources' roles in mitigation and especially the adaptation, as well as their vulnerability, to climate change.

Recommendation 4

The participants recommend that official endorsement, both at national and regional levels, should be obtained for the project and also APFORGEN shall be extended to interested countries in the Asia and the Pacific region.

Recommendation 5

The participants identified the following common areas of interest among participating countries:

- Development of the comprehensive national FGR strategies and action plans,
- Species priority setting for efficient FGR C&M,
- Evaluation, characterization, documentation and sharing the information of FGR,
- *In situ* and *ex situ* conservation,
- Exchange of genetic materials,
- Strengthening national programmes on FGR, and enhancement of the linkage between conservation of FGR and national forest programmes,
- Participation of local communities and the role of livelihood in conservation and sustainable use of FGR,
- Assessment of climate change impacts on FGR vulnerability, and management of FGR to facilitate adaptation,
- Assessment of impact on livelihood of local communities and its vulnerability to climate change, and implications on FGR conservation and sustainable management.

Recommendation 6

The participants identified several regional action items such as:

- Developing (sub)regional action plans for priority species,
- Developing institutional capacity for managing FGR,
- Developing guidelines for prioritizing species, assessing genetic diversity, and common strategies for FGR conservation wherever applicable,
- Strengthening national programmes and coordination.

Participants also identified capacity building needs, such as:

- Short- and long-term training courses, including e-courses, and exchange of scientists,
- Collaborations in developing training materials,
- Workshop and fellowships for scientists and professionals.

Recommendation 7

The participants stressed the importance of communication at national and regional levels to ensure the continuity of APFORGEN's activities.

Recommendation 8

The participants recommend that funding from various sources be identified and accessed to fund FGR activities in the Asia and Pacific regions. Collaborations of interested parties shall be actively sought to develop joint proposals

Appendix I

Programme

Day 1	***5 October 2009***

08:00 — *Registration*

09:00 – 10:00 — *Opening*
- Address by ITTO
- Address by FRIM
- Opening by NRE Malaysia

10:00 – 10:30 — *Coffee Break*

10:30 – 12:30 — *Keynotes* (Chair: *Leocadio Sebastian*)
- SFM and Conservation of FGR –*Ma Hwan Ok*
- The State of the World's FGR –*Oudara Souvannavong*
- Why FGR Matters? –*Judy Loo*

12:30 – 14:00 — *Lunch*

14:00 – 15:30 — *Status of Asia-Pacific FGR I* (Chair*: Judy Loo*)
- FGR Conservation & Management in Cambodia –*Chann Sophal*
- Current Status of FGR in China and National Strategies and Policie**s** – *Zheng YQ*
- Conservation & Sustainable Management of FGR in Fiji –*Sanjana Lal*
- FGR Conservation & Management in India –*GS Rawat*

15:30 – 16:00 — *Coffee Break*

16:00 – 17:30 — *Status of Asia-Pacific FGR* (Chair: *R Jalonen*)
- FGR Conservation & Management in Indonesia –*Bambang Trihartono*
- FGR Conservation During the Last Four Decades in Japan –*S Kurinobu*
- Status of Malaysia FGR - Their Conservation & Management Practices –*Lee SL*
- FGR Conservation & Management Practices in Myanmar –*AungZaw Moe*

19:00 — *Symposium Dinner*

Day 2	***6 October 2009***

08:30 – 10:00 — *Status of Asia-Pacific FGR* (Chair: *GS Rawat*)
- Forest Management, Conservation & Sustainable Utilization of FGR in PNG –*Robert Kiapranis*
- Status Of Philippines FGR Conservation & Management Practices –*E. Tolentino*
- Conservation & Management of FGR in Thailand –*Suwan Tangmitcharoen*
- FGR Conservation & Management In Vietnam –*Nyugen Hoang Nghia*

10:00 – 10:30 — *Coffee Break*

10:30 – 13:00 — *FGR and Biodiversity* (Chair: *E. Tolentino*)
- Setting Plant Conservation Priorities for Malaysia –*Saw LG*
- Exploring Genomics and Transcriptomics Approaches in Conservation of Tropical Forest Species –*Wickineswari R.*
- Genetic Variation In Populations of *Pterocarpus Indicus* from Five Selected Provinces in the Philippines Using Isozyme Analysis –*A Baja-Lapis*
- Genecological Study of *Shorea Albida* In Sarawak –*Bibian Diway*

- Genetic Variation in Threatened Conifer *Fokienia hodginsii* in Vietnam using ISSR Markers: Implications for Conservation –*Nguyen Minh Tam*
- Molecular Database for Classifying Shorea Species (Dipterocarpaceae) and Searching the Origin of Timber in Some Shorea Species –Y Tsumura

13:00 – 14:00	*Lunch*
14:00 – 16:00	*FGR Erosion, Impacts of Climate Change, and Biotic and Abiotic Disturbances* (Chair: *Saw LG*) • Impact of Climate Change on Forest Resources: Perspective Bangladesh–*M Al-Amin* • Optimum Population Sizes for Effective Conservation & Management of Tropical Plant Species –*Lee SL* • Outcrossing Tree Species is More Susceptible to the Negative Impact of Logging –*Ng KKK* • Impacts of Pathogen to FGR –*Sri Rahayu*
16:00 – 16:30	*Coffee break*
16:30 – 17:30	*FGR Erosion, Impacts of Climate Change, and Biotic and Abiotic Disturbances* (Chair: *K V Sankaran*) • The Status of *Rafflesia* Populations in Taman Negara, Malaysia. How Well Are They Being Protected? –*Tan AL* • Sacrificing Biologically Rich Forest and FGR For Livelihood of Climate Change Induced Flood Victims and Peace Building –*VD Sharma* • Climate Change and the Potential Risk to Forest Genetic Resources – *Anto Rimbawanto*

Day 3 7 October 2009

07:30	*Depart for FRIM*
08:30 – 12:00	*Regional Collaboration on FGR: Lessons Learned from APFORGEN and the ITTO Project* (Facilitator: *R. Jalonen*) • APFORGEN – Achievements and Action Plans • ITTO Project on FGR – Achievements and Outputs • Regional Collaboration on FGR – What's Next?
12:00 – 14:00	*Lunch*
14:00 – 17:00	*Tour FRIM Campus and Tourist Sites Nearby*
17:00	*Return to Hotel Istana*

Day 4 8 October 2009

08:30 – 10:30	*Community Involvement in FGR Conservation & Management* (Chair: *A Rahman A Rahim*) • FGR Conservation & Management at Community Village Level: An Alternative Approach –*C Nugroho* • Community-based Forest Restoration as Means for Conservation of FGR – *Damrong Pipatwattanakul* • Community Involvement in FGR Conservation & Management after Recovering from Natural Disasters –*Mu Mu Aung* • Involvement of Communities in the Conservation of FGR in China – *Wang HR* • Community Involvement in FGR Conservation & Management in Sri Lanka –*Anura Sathurusinghe*
10:30 – 11:00	*Coffee Break*

11:00 – 13:00	*FGR Conservation & Management: Regional and National Status, Policies and Strategies* (Chair: *Anto Rimbawanto*) • Legal Frame Work for FGR Conservation & Management in India –*HS Ginwal* • Regional Strategy and Action Plan for the Conservation, Management and Sustainable Utilisation of FGR in the Pacific –*Cenon Padolina* • National Status, Policies and Strategies for FGR Conservation & Management in Malaysia –*A Rahman A Rahim* • SFM and Conservation of Forest Genetic Resources: Initiatives in India – *SS Negi*
13:00 – 14:00	*Lunch*
14:00 – 15:00	*FGR Conservation & Management: Regional and National Status, Policies and Strategies* (Chair: *Sarath Fernando*) • Advanced-Generation Breeding of Acacia and Eucalypt Species and Hybrids: The Role of International Collaboration and Exchange of FGR –*Khongsak Pinyopusarerk* • Gene Repositories for Conservation of Unique Alleles: A Case Study in *Casuarina equisetifolia* –*M Dasgupta* • Technology Development for Conservation and Sustainable Management of Utilizable FGR in Tropical Forests of Central India – *RK Pandey*
15:00 – 16:00	*Panel Discussion* (Chair: *Oudara Souvannavong*) FGR Conservation & Management for Climate Change Mitigation and Adaptation
16.00 – 16:30	*Coffee Break*
16:30 – 17:00	*Recommendations and Closing*

Appendix II

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