International Union of Forest Research Organizations
Union Internationale des Instituts de Recherches Forestières
Internationaler Verband Forstlicher Forschungsanstalten
Unión Internacional de Organizaciones de Investigación Forestal

IUFRO World Series Vol. 30

Asia and the Pacific Workshop

Multinational and Transboundary Conservation of Valuable and Endangered Forest Tree Species

Editors:

Sim Heok-Choh, Syuqiyah Abdul Hamid, Li Mei

Extended Abstracts

From the Workshop held in
Guangzhou, China
5–7 December 2011

Jointly organized by:

Asia Pacific Association of Forestry Research Institutions (APAFRI)
Research Institute of Tropical Forestry, Chinese Academy of Forestry (RITF-CAF)

In association with:

International Union of Forest Research Organizations (IUFRO)
Forest Research Institute Malaysia (FRIM)
Korea Forest Research Institute (KFRI)

ISSN 1016-3263

ISBN 978-3-902762-15-3

IUFRO, Kuala Lumpur 2012

Recommended catalogue entry:
Asia and the Pacific Workshop - Multinational and Transboundary Conservation of Valuable and Endangered Forest Tree Species. Sim Heok-Choh, Syuqiyah Abdul Hamid, Li Mei (editors). Extended Abstracts from the Workshop held in Guangzhou, China, 5–7 December 2011, jointly organized by Asia Pacific Association of Forestry Research Institutions (APAFRI) and Research Institute of Tropical Forestry, Chinese Academy of Forestry (RITF-CAF), in association with the International Union of Forest Research Organizations (IUFRO), Forest Research Institute Malaysia (FRIM) and Korea Forest Research Institute (KFRI). Kuala Lumpur, 2012 - 129 p. - (IUFRO World Series Vol. 30).

ISSN 1016-3263
ISBN 978-3-902762-15-3

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Published by:
IUFRO Headquarters, Vienna, Austria, 2012

Available from:
IUFRO Headquarters
Secretariat
c/o Mariabrunn (BFW)
Hauptstrasse 7
1140 Vienna
Austria

Tel.: +43-1-8770151-0
Fax: +43-1-8770151-50

E-mail: office@iufro.org
Web site: www.iufro.org

Printed by:
Info Meditasi, Taman Industri Balakong Jaya, Selangor, Malaysia

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The organizers of the Asia and the Pacific Workshop on Multinational and Transboundary Conservation of Valuable and Endangered Forest Tree Species would like to extend their deepest gratitude to the Korea Forest Research Institute (KFRI) for funding this workshop with its contributions to the International Union of Forest Research Organizations (IUFRO). We are especially grateful to Director Dr Xu Daping, for his support and approval to host the workshop by the Research Institute of Tropical Forestry (RITF), Chinese Academy of Forestry, in Guangzhou, China.

Appreciations should also be extended to Dr Li Mei and her team from RITF for handling most of the logistics in putting this workshop together. Dr Zhong Chonglu of RITF has provided valuable inputs which contributed to the success of this workshop.

Thanks also to all the other RITF and APAFRI staff for providing the administrative and secretariat support during the workshop.

Opening Address

Dr. Shin Joonhwan
Senior Research Scientist
Korea Forest Research Institute
Seoul, Korea

Dr. Liu Shirong, Vice President of Chinese Academy of Forestry;
Dato' Dr Abd. Latif Mohmod, Director General of Forest Research Institute Malaysia;
Dr. Sim Heok-Choh, Executive Secretary of APAFRI;
Dr. Xu Daping, Director of Research Institute of Tropical Forestry, Chinese Academy of Forestry;
Distinguished Speakers;
Ladies and Gentlemen;
Good Morning!

First of all, on behalf of the Korea Forest Research Institute, I would like to express my sincere gratitude and warm welcome to all participants in this Asia and the Pacific Workshop, "Multinational and Transboundary Conservation of Valuable and Endangered Forest Tree Species." My special thanks must go to APAFRI for organizing this workshop.

As more scientific information about global warming accumulates, climate change is emerging as the greatest environmental challenge of the twenty-first century. What is more, global threats such as poverty, population growth, air pollution, soil degradation, land use change, desertification and deforestation are intertwined with and all contribute to climate change. This requires unprecedented cooperation among the world's nations and strong support from international organizations concerned. Korea Forest Research Institute has made constant efforts for international cooperation as well as researches on climate change.

Ladies and Gentlemen:

Recently, forest genetic resources – one of the most fundamental and essential of all resources on earth – are seriously threatened. Their loss will touch each one of us and endanger future generations. I think we have to pay special attention to the valuable and endangered forest tree species. The lack of capacity to conserve and optimally utilize these resources undermines the foundation for sustainable development. Accordingly, the conservation and rational management of this heritage have become a major source of concern, and moreover, have been the subject of extensive debates within the framework of the Convention on Biological Diversity as well as UN Framework Convention on Climate Change.

I hope that the workshop will provide the opportunity for the participants to discuss different problems, issues and various approaches to multinational and transboundary conservation of valuable and endangered forest tree species.

Finally, I would like to close my speech by expressing my sincere wishes for the success of the workshop. And I hope that your stay here is memorable and your deliberations are fruitful.

Thank you very much!

Opening Address

Prof. Dr. Liu Shirong
Board Member of IUFRO
Vice President, Chinese Academy of Forestry
Beijing, China

Distinguished Guests and Participants;
Ladies and Gentlemen;
Good Morning!

It is my great honour to be invited to attend the Asia and the Pacific Workshop with the theme: Multinational and Transboundary Conservation of Valuable and Endangered Forest Tree Species in Guangzhou, China.

First of all, on behalf of IUFRO and the Chinese Academy of Forestry (CAF), I would like to convey congratulations to the successful convening of the conference, and to extend my heartfelt welcome and sincere greetings to all the participants. I would like to thank the generous financial contribution of Korean Government, and the efforts of Korea Forest Research Institute in the enhancement of this workshop. Also, I would like to appreciate APAFRI for its leadership and regional coordination to organize this workshop. In fact, this workshop is one of our activities for the Asia and Pacific region, we have kept the allocation of this contribution to APAFRI every year since 2007, and the APAFRI has used the fund for the organization of several conferences/ symposiums/workshops in this region. For example, partially finance a conference on traditional forest related knowledge in Kunming City of China in 2007, as well as other events in various countries in the region: 2008 in Kuala Lumpur, 2009 in Sri Lanka, 2010 in Manila, and this workshop in Guangzhou.

As you know, IUFRO is the **only world-wide** international organization devoted to forest research. IUFRO unites more than **15,000 scientists** in almost **700 Member Organizations** in more than 110 countries. IUFRO **promotes global cooperation** in forest-related research and **enhances the understanding** of the ecological, economic and social aspects of forests and trees.

CAF is the largest, comprehensive, and multi-disciplinary national research institution in China, mainly engaging in forestry research and development, and taking the lead of many national key research projects and international cooperation programmes. CAF has long been dedicated to developing international academic cooperation and exchange.

Ladies and Gentlemen:

It has been increasingly recognized that forest is a major component of terrestrial ecosystems and provides multiple important ecosystem services such as ecological functions, and wood and numerous other products, that significantly contribute to human well-being. Tens of millions of people depend on forests as a major source of subsistence and cash income, while hundreds of millions of people depend on forests to supplement their livelihoods. Also, forests play critical roles in sustaining the health of the environment by mitigating climate change, conserving biological diversity, maintaining clean and reliable water resources, controlling soil erosion, protecting coastal and marine resources, and providing low cost and renewable energy.

With the rapid economic and social development in responding to increasing population, people need more and more products from forests for fuel, construction and furnishing materials, ornaments, etc. The almost unlimited demand for wood and wood products has brought and is bringing huge pressure to forest and forest trees. Consequently, forests and forested area are reducing rapidly with deforestation and forest degradation, and many tree species that are very valuable resources, are becoming rare and endangered due to over-exploitation.

Many natural disasters resulting from climate change are exacerbating, typhoon, sand storm, pest and disease outbreaks, as well as other catastrophes, are increasing frequently. In return, these increasing natural disasters cause additional damage to valuable tree species. This situation is worse in the Asia and Pacific region.

It's our communal desire and challenge to seek opportunity to conserve those valuable and endangered tree species through multinational and trans-boundary cooperation. This workshop is envisaged to address the key issues by exchanging and sharing the state-of-art knowledge and experiences, and promoting international scientific and technological cooperation on valuable tree species conservation.

Again, I would like to thanks APAFRI for its delicate organization, and RITF for its kind hosting of this workshop, through which we are providing a platform to exchange and share the critical experiences and knowledge on the conservation of valuable and endangered tree species in this region, as well as to explore potential multinational collaboration and trans-boundary cooperation in such related research areas. Also, I am looking forward to your active discussion and up-to-date views and comments to further enhance the theme and content of this workshop.

Thank you and wish the complete success of the workshop and all of you a healthy and happy time here in Guangzhou.

Thank you all!

Opening Address

Dr Abd Latif Mohmod
Director General, Forest Research Institute of Malaysia
&
Chairman APAFRI

Good Morning! Ladies and Gentlemen:

On behalf of APAFRI, I would like to welcome all of you to this Asia and the Pacific Workshop with the theme: Multinational and Transboundary Conservation of Valuable and Endangered Forest Tree Species, here in Guangzhou, China.

I would like to thank the Research Institute of Tropical Forestry, Chinese Academy of Forestry, for hosting this workshop here. Dr Xu Daping, the Director of RITF, who is also a member of the APAFRI Executive Committee, has graciously consented to host this activity when the APAFRI Secretariat proposed this in June. As the Secretariat is of limited capacity and capability, this had lifted a heavy burden off our shoulders. I am grateful too, to Prof Dr Liu Shirong, Vice-President of Chinese Academy of Forestry, who is also a member of the IUFRO Board, for his support to host this event here.

Many of you are aware that the fund for organizing this workshop is a portion of the Korean Government's contributions to the International Union of Forest Research Organizations (IUFRO). Since 2007, the Korean Government, through the Korea Forest Research Institute (KFRI), has allocated a portion of its contributions to IUFRO for activities to be carried out in the Asia Pacific for forestry practitioners of this region. APAFRI is honoured to be entrusted with the responsibilities of managing this portion of the fund. APAFRI has used the 2007 allocation for partially financed the International Conference on Traditional Forest-related Knowledge in Kunming China, the 2008 allocation for organizing an Asia Pacific Forest Health Workshop in Kuala Lumpur, the 2009 allocation for an Asia Pacific Forest Products Workshop in Sri Lanka, and the 2010 allocation for the Asia and the Pacific Symposium on Vulnerability Assessment in Manila Philippines. Proceedings for these four events have already been published by IUFRO as IUFRO World Series Volumes 21, 24, 27 and 29.

Ladies and Gentlemen:

Allow me to take this opportunity to briefly introduce APAFRI. APAFRI stands for Asia Pacific Association of Forestry Research Institutions. APAFRI's role is to act as a catalyst, facilitator, and information hub for forestry research in the Asia Pacific region. APAFRI aims to promote and assist in the development of the region's scientific research and development culture and capacity and to foster the establishment of institutional and professional collaborations among the region's forestry researchers. APAFRI's activities support sustainable management and utilization of forest resources at the local, national and regional levels. As of November this year, APAFRI's membership totaled 65 forestry research institutions, and 8 individual members. Most of the national research institutions and many universities in the region from Korea to Pakistan, and from China to Australia are members of our Association. Many of the participants present here today are staff members of active member institutions in APAFRI.

Next year, 2012, APAFRI will have its Sixth General Assembly. The Secretariat would soon send out announcement for this event. The General Assembly would elect a new Executive Committee, which would manage APAFRI activities for the next three years. The General Assembly would need to be hosted by a member institution, preferably tag on to a conference or workshop, to attract more member institutions to attend the General Assembly. APAFRI is continuously looking for opportunities to jointly develop programmes and services for its membership and alliances. We would like to seek more cooperation and collaboration from you all, members and non-members, to assist us in servicing the forestry sector in the Asia Pacific Region better in future.

I wish you all have a fruitful meeting here in this beautiful and exiting city.

Thank you.

Opening Address

Wang Chunling
Department of Wildlife Conservation and Nature Reserve Management
China State Forestry Administration

Ladies and Gentlemen,

Good Morning!

It is a great honour for me to have the opportunity to attend today's workshop on Multinational and Transboundary Conservation of Valuable and Endangered Forest Tree Species. On behalf of the Department of Wildlife Conservation and Nature Reserve Management, State Forestry Administration, which is the state council administration responsible for nation-wide wild plant conservation in China, I would like to congratulate for the successful opening of the workshop, to extend a warm welcome to colleagues from the Asia and the Pacific region, and to express my great thanks for your hard work and dedication to the conservation of forest biodiversity.

As you know, wild plants, including forest tree species, is the fundamental and the key element of the continental ecosystem and it is important strategic resource for the sustainable development of human society. China is a large country with very rich plant diversity, with almost 9000 forest tree species, and has been recognized as one of the hot spots in global biodiversity conservation. However, a large number of forest tree species are facing severe threats and their wild population is becoming smaller due to over-harvesting and habitat degradation. It is a big challenge to mitigate the reduction of the wild plant population.

Responding to such a challenge, the Chinese Government has attached great importance to the conservation of wild plants, and always adhere to the policy of sustainable development by consolidating the management of multi-functional conservation, such as to protect wild plant population and their natural habitats, to rescue the wild species, to encourage afforestation, and to balance the relationship between protection and utilization in a scientific way. In the past two decades, some legislation have been issued in China, such as the “Forest Law”, “Regulations on wild plant conservation”, “Regulations on nature reserve conservation”, and also the “List of wild plants of national importance” which included about 200 valuable and endangered tree species, like *Aquilaria senesis* and *Hopea hainanensis*. The State Forest Administration has launched a series of major initiatives and national projects, including the national project on natural forest protection, the national project on returning farm to forest, and the national project on wildlife conservation and nature reserve construction. Last year, we also formulated and promoted the implementation of the “National Project on Conservation of Wild Plants with Small Population” of which covered more than 60 valuable and endangered tree species.

Ladies and Gentlemen:

Wild plants are the fundamental for the survival of human beings and other creatures on the earth, they are our indispensable friends. Meanwhile, they also need a good living environment for sustainable development. I hope that this three-day workshop will provide a unique platform for academic exchange and sharing information and experiences about conservation of valuable and endangered tree species, and will promote further multinational cooperation and transboundary collaboration to explore more effective way to deal with the focus problems related to the conservation of valuable and endangered tree species, like climate change, natural disaster and forest disease. I really hope that this platform will transfer the wisdom and scientific research achievements of all delegates here into the huge resource and energy to bring about significantly better future to our earth.

Finally, I wish the workshop a great success! And wish all delegates a pleasant stay in China!

Thank you!

Opening Address

Liang Yongchao
Director
Department of Science and Technology Cooperation
Forestry Administration of Guangdong Province

Distinguished Guests and Friends;
Ladies and Gentlemen;
Good morning!

The Asia Pacific Forestry Workshop, proposed by the International Union of Forest Research Organizations, organized by the Asia Pacific Association of Forestry Research Institutions, and hosted by the Research Institute of Tropical Forestry, Chinese Academy of Forestry, is officially began this morning in Guangzhou, the beautiful 'flower city' of Guangdong Province. I, on behalf of the Forestry Administration Guangdong Province, would like to congratulate the successful convening of this workshop. I also warmly welcome all participants to this workshop, and wish you all have fruitful discussions during the next few days contributing to the future development of forestry in the Asia Pacific region as well the world.

During recent years, Guangdong Province has put in lot of effort in developing plantations of valuable tree species. The Province, in the process of rapid transforming the forestry sector, adopted several strategies including policy formulating, financial assistance and system restructuring, in promoting the development of valuable tree species plantations. Since 2008, the Province has established more than 21 300 ha (320 000 mu) plantations of valuable tree species such as *Santalum album* (sandal wood), *Dalbergia odorifera, Aquilaria agallocha*, teak, *Michelia macclurei, Castanopsis hystrix*, *Cinnamomum camphora*, etc. Currently, the Province has a total 9260 000 mu of broadleaf hardwood tree plantation. By 2015, the Province will add in another 67 000 ha (1 000 000 mu), and will be the Province with the fastest developing and the most number of species of valuable trees in China.

Developing valuable tree plantation has been an important strategy in forestry sector restructuring, economic development and poverty alleviation of upland communities, in the Guangdong Province. There is continuous strengthening of organizational leadership, logistic support, appropriate planning, good guidance and demonstrations, progressively promoting the planting of valuable tree species. Currently, private enterprises have become the main players in plantation development. Zhaoqing City, Guangdong Province, a pioneer in valuable tree plantation development, has established 10 70-ha (1000-mu) model bases with some 500 enterprises and a large number of workers since 2008. Some leading enterprises have also adopted a "company + base + farmers" business model, invited local communities to be partners by sharing land and/or labour.

To further promote the development of valuable tree plantation, the Province has initiated several programmes including '*Plant valuable tree species, increase green wealth*' sending seedlings to the villages, '*Greening Ten-thousand Villages*', etc., fully mobilizing the masses through hill land allocation, and utilizing private plots or "marginal lands" to cultivate highly ornamental and commercially valuable species, leading to further industrial development.

Meanwhile, Guangdong also attached great importance to the protection and conservation of rare and endangered tree species. Prevention and control against forest diseases and insect pests have been strengthened; international cooperation and exchange have been enhanced; contributing towards transforming the Province into a champion in modern forestry. During this process, we will encounter some problems and difficulties in areas such as finance, technology, management and personnel, and in this connection, we sincerely hope to have the support and assistance of international organizations, national officials and experts on forestry. Let us all work together to conserve and sustainably manage the forests which is vital to the human survival.

Here, let me once again thank the International Union of Forest Research Organizations and the Asia Pacific Association of Forestry Research Institutions, for choosing to convene this workshop here. Thanks also to the State Forestry Administration, the Chinese Academy of Forestry, as well as all the international and local officials and experts for their participation in this workshop. I hope all of you would come to Guangdong Province often, and let us all work together contributing towards solving global climate changes problems. Finally, I wish all of you good health, prosperous and have a successful workshop!

Thank you!

Opening Address

Dr Xu Daping
Director and Research Professor
Research Institute of Tropical Forestry, Chinese Academy of Forestry
Longdong, Guangzhou 510520, China

Good Morning!
Ladies and Gentlemen:

You are warmly welcome here in Guangzhou, to participate in the Asia and the Pacific Workshop with the theme: Multinational and Transboundary Conservation of Valuable and Endangered Forest Tree Species.

Our institute had studied conservation on valuable and endangered tree species since it was established in 1962. For example, we have carried out studies on conservation of *Santalum album*, *Dalbergia odorifera*, *Hopea hainanensis*, *Swietenia macrocarpa, Manglietia glauca*, *Pterocarpus macrocarpa*, *Tecotona grandis,* and others.

We are very pleased and honoured to host this workshop, and like to thank Korea Forest Research Institute (KFRI), International Union of Forest Research Organizations (IUFRO), Asia Pacific Association of Forestry Research Institutions (APAFRI), Forest Research Institute Malaysia (FRIM), State Forestry Administration of China (SFA), Forestry Administration of Guangdong Province of China (FAGP) for their contributions to the workshop.

I believe that all of us here will treasure this opportunity to exchange and share experiences and knowledge, to explore potential multinational collaboration and transboundary cooperation, to improve our communication on such areas as related to our workshop theme.

We wish that we will have a great successful workshop.

We also wish all our friends here a healthy and enjoyable stay in Guangzhou, and have a safe journey back home after this three-day workshop.

Thank you.

Management of Transboundary Landscape for Conservation of the Sundarban Biodiversity

Laskar Muqsudur Rahman
Forest Department, Bangladesh
Email: laskarmr@yahoo.com

Transboundary natural resource management is generally regarded as a relatively recent phenomenon, despite historical evidence that it has occurred wherever resources that span national or other jurisdictional boundaries are managed cooperatively. Transboundary conservation was highlighted extensively as a new frontier in conservation and development practice due to the possibility of simultaneously achieving biodiversity, socioeconomic, and peace and security goals. Worldwide, an impressive array of transboundary conservation initiatives is being implemented on virtually all continents and countries (Sandwith and Savy 2005). There are indeed numerous examples of long-standing cooperative resource management arrangements in river basins, lakes, marine areas, and mountains throughout the world, involving local communities and other authorities in traditional heritage territories (Singh 1999). The diversion of Ganges water at Farakka in the upstream in India has caused increasing river salinity in Bangladesh. The adverse effect of increased salinity on the ecosystem of Sundarban is displayed by the top dying of Sundari and loss of agriculture (Mirza 2004). The agreement reached by the two neighbouring countries in 1996 over the sharing of Ganges waters was hailed as a landmark treaty, in resolving the dispute (Pathania 2003). This paper describes the concept, brief history, objectives and strategies of transboundary conservation of biodiversity with emphasis to transboundary conservation of biodiversity in the Sundarbans.

Brief history of transboundary conservation initiatives

As early as 1780, a Treaty of Alliance between the King of France and the Prince-Bishop of Basel stated that nothing 'is more proper for maintaining good relations and peace between two bordering states' than punishing offenses related to forests, hunting, and fishing. Designating 'an equal and uniform jurisprudence' over these issues within their shared border region, this treaty was also notable for stipulating that the two parties adopt the early conservation-oriented French Forest Ordinance of 1669 (Chester 2006). A number of international peace parks have been established to demonstrate amity between neighbouring countries and to facilitate the preservation of wildlife, habitat, and natural beauty. The first such transboundary marine protected areas, Kosterhavet (Sweden) and Ytre Hvaler (Norway) was established in 1914 (Lewis 2011).

The modern concept of a peace park apparently originated in the 1924 Krakow Protocol, which aimed to resolve a boundary dispute between Poland and Czechoslovakia left over from World War I (Chester 2006). At the time these protected areas were created, the idea of fostering peace through nature was not indicated as a goal. Rather, the protected areas were seen as an opportunity to preserve a natural landscape that happened to cross an international border. In 1932, the United States and Canada created two such trans-border parks: the International Peace Garden in Manitoba and North Dakota, and Waterton-Glacier International Peace Park in Alberta and Montana, as a formal means to commemorate the bonds of peace and friendship between the two nations (Schoon 2008). In the following year, 1933, the interest in transboundary conservation received a further boost when European powers signed the London Convention Relative to the Preservation of Fauna and Flora in their Natural State (Mittermeier *et al.* 2005).

Several authors have argued to broaden the definition of national security to include the environment, giving rise to the concept of environmental security (Cook 2007). Growth in transboundary protected areas around the world has occurred through the initiative of the World Bank, IUCN, and many other inter-governmental and non-governmental organizations (Schoon 2008). Over the years, several other border-spanning protected areas have been carved out, but the idea has been slow to catch on (Lewis 2011). The 2007 global inventory of TBPAs identified 227 TBPA complexes incorporating 3,043 individual protected areas or internationally designated sites (Lysenko *et al.* 2007).

Transboundary efforts in Asia

Recently there are transboundary initiatives in Asia as well. In the Siachen Glacier located on the border of both India and Pakistan over 30% of the endemic flora is threatened and some species are believed to be extinct due to war conflict (Ahmedullah 1997). The creation of a Peace Park may contribute to resolving this half-century-old international conflict and preserving a unique high mountain environment currently being subjected to irreparable devastation (Ali 2002). The International Centre for Integrated Mountain Development (ICIMOD) is implementing transboundary biodiversity management in the Kangchenjunga complex, shared by Bhutan, China, India and Nepal, which is an important part of the Himalayan 'Biodiversity Hotspots' (Chettri *et al.* 2008). The DMZ Forum and the Korean Federation for Environmental Movement (KFEM) had taken the challenge to protect numerous globally rare and endangered plants in the Demilitarized Zone (DMZ) between the Democratic Peoples' Republic of Korea (DPRK-North Korea) and the Republic of Korea (ROK-South Korea) (DMZ Forum 2010). Another transboundary effort in Asia is the management of the Emerald Triangle Protected Forests Complex to promote biodiversity conservation between Thailand, Cambodia and Laos PDR (ITTO 2010). Bangladesh in collaboration with the other three South Asian countries: India, Nepal and Bhutan, is going to launch a project on strengthening regional cooperation in wildlife protection in Asia. The aim of the project is to conserve wildlife and tackle illegal trade of the wildlife across the borders (World Bank 2011).

The Sundarbans

The Sundarbans forest is the largest estuarine mangrove forest in the world located in 24 Paraganas districts of West Bengal (India) and Bangladesh (Figure 1). All the three wildlife sanctuaries in Bangladesh Sundarbans became inscribed as a UNESCO world heritage site in 1997 (Rahman 2000). Prior to this the Indian Sundarbans was inscribed on the World Heritage List in 1987. In 1992 the Sundarbans Reserved Forest in Bangladesh was designated as a Wetland of International Importance under the Ramsar Convention, and Sundarbans in India has been nominated as a Ramsar site. The Sundarbans spans 10,000 km^2, about 6,000 km^2 of which is in Bangladesh. It represents a single ecosystem divided between the two countries. The Sundarbans of Bangladesh houses about 334 plant species. A list of common plant species of the Sundarbans is given in Table 1.It also supports about 425 species of wildlife including the Royal Bengal Tiger (*Panthera tigris*). Besides, there are about 400 species of fish. In the freshwater zone, the dominant tree species is Sundari (*Heritiera fomes*) with variable components of Gewa *(Excoecaria agallocha)* and Golpata *(Nypa fruticans)*; the moderately saline zone is characterized by Gewa as the predominant species with varying assortment of Sundari; and the saltwater zone is more or less a closed chapter of Goran *(Ceriops decandra).* Other available varieties include Keora (*Sonneratia apetala*) and Bain *(Avicennia officinalis)*. It acts as a vital protective barrier protecting the mainland from flooding, tidal surges and cyclones.

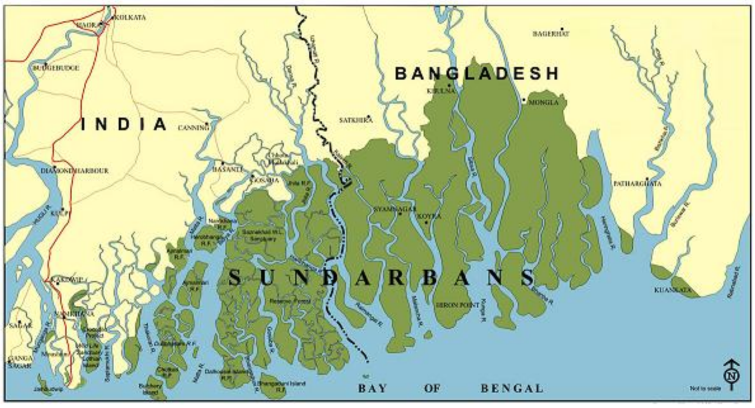

Figure 1. The Sundarbans Forest (Adapted from: www.wwfindia.org)

The Sundarbans also plays an important role in the economy of southwestern coastal Bangladesh as well as in the national economy. It is the single largest source of forest produce in the country. The forest provides raw materials for wood based industries. In addition to traditional forest produce like timber, fuelwood, pulpwood, etc., large scale harvest of non-timber forest products such as thatching materials, honey, bee-wax, fish, and crustacean resources, takes place regularly. The major threats to biodiversity come mainly from the growing human population and consequently, overexploitation of both timber and fauna, and conversion of land to agriculture and aquaculture and recently intrusion of salinity. The *Heritiera fomes* suffers from top-dying. *Nypa fruticans* and *Phoenix paludosa* are declining rapidly. As a long-term consequence *Heritiera fomes* is being replaced by *Excoecaria* *agallocha*. In general, the forest structure is becoming simpler and the average height of the trees is decreasing.

Table 1. Common plant species of the Sundarbans forest

Plant species	Family	Local name
1. *Acanthus illicifolius* L.	Acanthaceae	Hargoja
2. *Acrostichum aureum* L.	Adiantaceae	Hodo
3. *Aegialitis rotundifolia* Roxb.	Plumbaginaceae	Sitali
4. *Aegiceras corniculatum* (L.) Blanco	Myrsinaceae	Khalsi
5. *Amoora cucullata Roxb*.	Meliaceae	Amur
6. *Avicennia alba* Blume *	Avicenniaceae	Kalo Baen
7. *Avicennia marina* (Forsk.) Vierh. *	Avicenniaceae	Sada Baen
8. *Avicennia officinalis* L.	Avicenniaceae	Baen
9. *Barringtonia racemosa* (L.) Spreng.	Lecythidaceae	Kumbhi
10. *Bouea burmanica* Griff.	Anacradiaceae	Muriam
11. *Brownlowia lanceolata* (L.) Kostern.	Tiliaceae	Sundari Lota
12. *Bruguiera gymnorrhiza* (L.) Lamark	Rhizophoraceae	Bakul Kankra
13. *Bruguiera parviflora* (Roxb.) Arn. Ex Griff.	Rhizophoraceae	Bhater Lathi
14. *Bruguiera sexangula* (Lour.) Poir. *	Rhizophoraceae	Kankra
15. *Cerbera manghas* L.	Apocynaceae	Dacor
16. *Ceriops decandra* (Griff.) Ding Hou.	Rhizophoraceae	Goran
17. *Ceriops tagal* (Perr.) C.B. Robinson	Rhizophoraceae	Mat Goran
18. *Cynometra ramiflora*L. L.	Caesalpiniaceae	Shingra
19. *Diospyros peregrina* (Gaertn.) Gurke	Ebenaceae	Gab
20. *Eugenia fruticosa* (DC.) Roxb.	Myrtaceae	Bon Jam
21. *Excoecaria agallocha* L. *	Euphorbiaceae	Gewa
22. *Excoecaria indica* Müll. Arg.	Euphorbiaceae	Ormut
23. *Ficus* retusa L.	Moraceae	Jir
24. *Flueggia virosa* (Roxb. ex Willd.) Voigt.	Euphorbiaceae	Sitki
25. *Heritiera fomes* Buch.-Ham. *	Sterculiaceae	Sundari
26. *Hibiscus tiliaceus* L.	Malvaceae	Bhola
27. *Intsia bijuga* (Colebr.) Kuntze	Caesalpiniaceae	Bola
28. *Kandelia candel* (L.) Druce	Rhizophoraceae	Goria
29. *Lumnitzera racemosa* Willd.	Combretaceae	Kripa
30. *Mallotus repandus* (Willd.) Muell.-Arg.	Euphorbiaceae	Bon Natai
31. *Millettia pinnata* (L.) Panigrahi	Fabaceae	Karamja
32. *Nypa fruticans* (Thunb.) Wurmb. *	Arecaceae	Golpata
33. *Oryza coarctata* Roxb.	Poaceae	Dhansi
34. *Pandanus odoratissimus* L.	Pandanaceae	Keya Kanta
35. *Petunga roxburghii* DC.	Rubiaceae	Narikili
36. *Phoenix paludosa* Roxb.	Arecaceae	Hental
37. *Rhizophora apiculata* Blume	Rhizophoraceae	Garjan
38. *Rhizophora mucronata* Lam.	Rhizophoraceae	Boro Garjan
39. *Salacia chinensis* L.	Celastraceae	Kotborai
40. *Schumannianthus Dichotoma* (Sal.) Willd.	Marantaceae	Murta
41. *Sonneratia acida* L.f. *	Sonneratiaceae	Ora
42. *Sonneratia apetala* Buch.	Sonneratiaceae	Keora
43. *Sonneratia caseolaris* (L.) Engl.	Sonneratiaceae	Choila
44. *Tamarix indica* L.	Tamaricaceae	Nona Jhau
45. *Typha elephantina* Roxb.	Typhaceae	Hogla
46. *Xylocarpus granatum* König	Meliaceae	Dhundul
47. *Xylocarpus mekongensis* Pierre	Meliaceae	Passur

* plants are rare and threatened

In the Indian portion, the mangrove vegetation of Sundarbans consists of 64 plant species. Gewa (*Excoecaria agallocha*), Kankra (Bruguiera gymnorrhiza), Khalsi (*Aegicerus corniculatum*), Dhundal

(*Xylocarpus granatum*), Passur (*Xylocarpus mekongensis*), Garjan (*Rhizophora mucronata*), Sundari (*Heritiera fomes*) and Goran (*Ceriops decandra*) are major mangrove tree species found to occur in these forests. Total flora and fauna of the Sundarbans has also been estimated differently in India and Bangladesh. The natural environment and coastal ecosystem of the Sundarbans in India, is also under threat of physical disaster due to unscientific and excessive human interferences (Sahgal *et al.* 2007).

Transboundary conservation of the Sundarbans

Both Bangladesh and India are parties to the Convention on Biological Diversity 1992 and Ramsar Convention on Wetlands 1971. Recognizing that the Sundarbans represent a single ecosystem divided between the two countries, Bangladesh and India signed a bilateral Memorandum of Understanding on 6 September 2011, for joint conservation of the Sundarbans. Conservation and protection of natural resources will, not only sustain the productivity and environmental functions of the ecosystem, but also preserve and sustain international relations. Bilateral efforts such as protection, regeneration, habitat restoration and rehabilitation, scientific research, appropriate management, capacity development, and above all prevention of activities that adversely affect the biodiversity and ecosystem, would eventually increase the potential for sequestration of carbon and ecotourism opportunities for both countries. This would in turn create synergy and generate greater revenue and income opportunities to the local communities.

With a view to exploiting the potential of the Sundarbans for development and alleviation of poverty, both Bangladesh and India agree to consider and adopt appropriate joint management and joint monitoring of resources; explore the possibility of implementing conservation and protection efforts.
Both countries will map and delineate the human settlements on respective sides so that a better understanding emerges of the relationship between human settlements and the ecosystems. The countries will further develop a management plan that utilizes this information to address issues of livelihood, deprivation by flooding and other climate related disasters, man-animal conflict, pollution, resource depletion, etc. Bangladesh and India will also identify opportunities for livelihood generation that do not adversely affect the Sundarban ecosystem through development of management plan.

The two countries are committed to the advancement of collaboration in sharing relevant information between the concerned officials, exploring the possibilities of joint research and management projects, sharing technical knowledge with the common goal of conservation and management; promotion of capacity building exercise and exchange visits of forest officials of field level in order to better understand and share ideas and problems of management, biodiversity conservation, climate change adaptation and promotion of sustainable socio-economic development, and ecotourism.

An exercise needs to be conducted to identify and catalogue the diversity of flora and fauna that are found in the Sundarban along with their spatial distribution across both the countries. The countries will determine what areas and species are under pressure including those facing threat of endangerment and extinction. They will develop a comprehensive plan to tackle these threats along with a detailed action plan to adapt against perceived threats. A Working Group will be set up to define activities, responsibilities, time, and implementation, resources involved, according to the activities established as per Memorandum.

Conclusions

Transboundary conservation approaches have a profound impact on biodiversity conservation and the potential to influence social and political change around the world. As Bangladesh is surrounded by India on three sides, and the forest tracts are mostly at the border areas, it is inevitable to have joint efforts for conservation of their biodiversity in both the countries. In addition to national security the issue of environmental security is to be addressed as well. Regional and global cooperation is called for the conservation of the Sundarbans biodiversity. Evidently a vast endangered and vulnerable plant species are becoming extinct throughout the nation. Although it is intensively discussed at local and national levels, but land degradation and loss of habitats are still contributing to the gradual disappearance of biodiversity genetic pools. Action research is inevitable to list vulnerable species for effective planning for their protection. A network to facilitate the conservation efforts is of utmost importance.

References

Ahmedullah, M. (ed.) 1997. *Biodiversity of Jammu and Kashmir: A profile.* Indira Gandhi Conservation Monitoring Centre, New Delhi, India.195 p.

Ali, M. 2002. A Siachen Peace Park: The Solution to a Half-Century of International Conflict? *Mountain Research and Development* 22(4): 316–319.

Besançon, C. and Savy, C. 2005. Global list of internationally adjoining protected areas and other transboundary conservation initiatives. Mittermeier, R.A., C.F. Kormos, C.G. Mittermeier, P.R. Gil, T. Sandwith and C. Besancon 2005. *Transboundary Conservation: A New Vision for Protected Areas.* University of Chicago Press: Chicago, IL USA 372 p.

Chester, C.C. 2006. *Conservation Across Borders: Biodiversity in an Interdependent World*. Island Press: Washington DC, USA, 280 p.

Chettri, N., Shakya, B. and Sharma, E. 2008. *Biodiversity Conservation in the Kangchenjunga Landscape*. International Centre for Integrated Mountain Development (ICIMOD), Kathmandu, Nepal, 171 p.

Cook, H.B. 2007. Transboundary Natural Area Protection: Broadening the Definition of National Security. *In*: *Science and stewardship to protect and sustain wilderness values: eighth World Wilderness Congress symposium*, September 30–October 6, 2005; Anchorage, AK. Proceedings MRS-P-49. Fort Collins, CO: U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, 254–257 p.

DMZ Forum. 2010. *The DMZ: Description and History***.** http: //www. dmzforum.org /aboutus/ background.php

ITTO. 2010. *Management of the Emerald Triangle Protected Forests Complex to promote cooperation for transboundary biodiversity conservation between Thailand, Cambodia and Laos (Phase III),* International Tropical Timber Organization, Project Document Pd 577/10 Rev.1 (F), 92 p.

Lewis, M.W. 2011. International Boundaries, Peace Parks, and Elephants in Southern Africa. *GeoCurrents*. http://geocurrents.info/place/subsaharan-africa/international-boundaries-peace-parks-and-elephants-in-southern-africa

Lysenko, I., Besançon, C. and Savy, C. 2007. *2007 UNEP-WCMC Global List of Transboundary Protected Areas* [http://www.tbpa.net/page.php?ndx=21]

Mirza, M.M.Q. 2004. *The Ganges Water Diversion: Environmental Effects and Implications*, Kluwer Academic Publishers, Dordrecht, the Netherlands, xii+376 p.

Mittermeier, R.A., Kormos, C.F., Mittermeier, C.G., Gil, P.R., Sandwith T. and Besançon, C. 2005. *Transboundary Conservation: A New Vision for Protected Areas.* University of Chicago Press: Chicago, IL USA 372 p.

Pathania, J.M. 2003. Environment – *Unconventional Threat to Bangladesh. South Asia Analysis Group Paper no. 799.* [http://www.southasiaanalysis.org/%5Cpapers8%5Cpaper799.html]

Rahman, L.M. 2000. The Sundarbans: a unique wilderness of the world. Proceedings: *Wilderness science in a time of change conference*. U.S. Department of Agriculture, Forest Service, Rocky Mountain Research Station, Ogden, UT: 2:143–148 p. http://www.wilderness.net/library/documents/Rahman_2–18.pdf

Sahgal, B., Sen, S. and Grewal, B. 2007. *The Sundarbans Inheritance,* Sanctuary Asia-India. 160 p.

Sandwith, T. and Besançon, C. 2005. Trade-offs among multiple goals for transboundary conservation. [http://208elmp02.blackmesh.com/sites/default/files/Besancon_Sandwith.pdf.]

Schoon, M.L. 2009*. Building Robustness to Disturbance: Governance in Southern African Peace Parks*, School of Public and Environmental Affairs and Department of Political Science, Indiana University, Bloomington, USA [http://pqdtopen.proquest.com/#viewpdf?dispub=3344618]

Singh, J. 1999. *Global review: Lessons learned. Beyond boundaries: Transboundary Natural Resource Management in Southern Africa*. Biodiversity Support Programme: Washington, D.C. UNEP, WCMC, and WCPA. Protected Areas Programme, Transboundary Protected Areas. [http://www.unep-wcmc.org/protected_areas/transboundary/index.html]

World Bank 2011. *Strengthening Regional Cooperation for Wildlife Protection in Asia Project* ID: P121210 [http://go.worldbank.org/XM98CKFIR0]

Growth and Genetic Diversity of Native Tree Species Exchanged Between Vietnam and China

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Collaboration between the Forest Science Institute of Vietnam and the Research Institute of Tropical Forestry, Chinese Academy of Forestry, has seen an exchange of seeds for a number of provenances for a range of native tree species common in both countries. Field trials using four provenances of *Michelia baillonii* were established at Hoanh Bo, Quang Ninh Province, in August 2007. At Chieng Bom, Son La Province, two trials were established; one to compare five provenances of *Betula alnoides* (three provenances from China and two provenances from Vietnam) and a second trial to compare 30 families selected from within the five provenances of *B. alnoides* (17 families from China and 13 families from Vietnam) in August 2008.

This paper reports on the growth of the two species planted in field trials in Vietnam and the findings of analyses using the molecular markers RAPD and cpSSR to identify genetic diversity of the provenances and families for the two species.

Methodology

Field trials
Seedlings of four Chinese provenances of *M. baillonii* from Menghai, Puwen, Jingcheng and Jinghong, were planted in a replicated trial at Hoanh Bo, Quang Ninh Province, Vietnam in August 2007. The trial consisted of line plots of 50 trees of each provenance planted at 3 m intervals along the line. Each provenance was replicted three times in lines 3 m apart, giving an overall planting density of 1,100 trees/ha. This design was adopted from Burley and Wood (1976) and Williams *et al*. (2002).

A provenance trial of *B. alnoides* was established with three provenances from China (Menghai, Lingyun and Coheng) and two from Vietnam (Co Ma and Chieng Bom) at Chieng Bom, Son La Province, in August 2008, using a similar design as described above, 50-tree line plots, replicated three times.

The *Betula* progeny trial, also located at Chieng Bom, Son La Province, included 30 families of *B. alnoides* (17 families from China and 13 families from Vietnam), was also established in August 2008. Each family was represented in four tree line plots, replicated eight times. Again the overall density of the trail was equivalent to 1,100 trees/ha.

Field measurements and analysis
Diameter at breast height overbark (dbhob, 1.3 m above ground level) and tree height were measured for all trees in all trials in October, 2011.The data were analysed by GENSTAT 5 and Dataplus 3.0.

Genetic analyses
Doyle and Doyle (1990) described a means of extracting and analyzing chloroplast DNA from leaf material to compare the genetic diversity between samples using the RAPD molecular markers for five primers (OPH04, OPP19, RA46, RA159 and OPH08) and using cpSSR molecular markers for two primers (*trn*D – *trn*T).

This approach was used to compare chloroplast DNA from a total of 26 samples taken from four Chinese provenances of *M. baillonii* (Menghai, Puwen, Jingcheng and Jinghong) and 2 Vietnamese provenances of *M. mediocris* (Da Lat, Phu Tho). In addition, 130 samples were also collected for comparison of five provenances of *B. alnoides* (three from China and two from Vietnam)

Results and discussions

Field performance of M. baillonii
Analysis of diameter and height growth of *M. baillonii* after four years indicated significant differences *(P>0.05)* between the four provenances. The best performed provenance was from Menghai with a mean dbhob and height of 8.4 cm and 8.4 m, respectively. The poorest growth was observed in the Jinghong provenance with growth measurements of 3.7 cm and 2.8 m, respectively.

Field trial of B. alnoides provenances and families
Growth of *B. alnoides* after three years, while less than that observed at the equivalent age for *M. baillonii*, showed there were significant differences in diameter and height between provenances and between families.

Mean dbhob and height of the Menghai provenance was significantly greater *(P>0.05)* than the other four provenances, Chieng Bom, Co Ma, Coheng and Lingyun, being 3.5 cm and 4.4 m respectively). Family differences were also significant *(P>0.05).* The best performing families were: 2625 (Coheng provenance) 4.4 cm and 5.5 m, CB9 (Chieng Bom provenance) 4.3 cm and 5.3 m, 2711 (Menghai provenance) 3.7 cm and 4.6m, 2705 (Menghai provenance) 3.1 cm and 4.4 m, and 1525 (Lingyun provenance) 3.0 cm and 4.4 m. These early results will be used to further select suitable genetic lines for developing plantations and may be applied to forest enrichment activities for sawlog production in Vietnam.

Genetic diversity of M. baillonii provenances
Four different provenances of *M. baillonii* from China and three provenances of *M. mediocris* from Vietnam were genetically analyzed by RAPD and cpSSR molecular markers. The analyses have shown clear differences between provenances within *M. baillonii* and between the *Betula* and *Michelia*. For *M. baillonii, g*enetic similarity between provenances was only 30% and they were divided into four groups with a difference of 45% in the genetic relationship. The first group included Puwen and Jingcheng which can be further subdivided into two subgroups.

Da Lat and Phu Tho provenances comprised the second group, which could also be subdivided into two subgroups.

The third and fourth groups have single provenance, Menghai and Jinghong respectively. Based on molecular analysis of the cpSSR maker data, there were no polymorphic DNA bands indicating that the genetic content in chloroplast DNA of *M. baillonii* is highly conservative. On this basis, the introduction of *M. baillonii* provenances from China into Vietnam can increase the genetic diversity of the species.

Genetic diversity of B. alnoides families
Analysis of all five RAPD markers showed polymorphic DNA bands with PIC values ranging from 0.2223 to 0.6862 for the provenances studied

At the family level, families within different provenances have very complex genetic relations. However there were clear differences between provenances.

Families of Ceheng provenance were quite stable and concentrated on branch No. 4. Similarly, families of Chieng Bom provenance were also stable and concentrated on branch No. 8. Families from the Lingyun, Menghai and Co Ma provenances showed high variability and occupied places on different branches. However branch No. 7 was commonly a location of emphasis (Figure 1).

The molecular analyses based on the cpSSR makers using *B. alnoides* did not show polymorphic DNA bands, even when using restricted enzymes. This means that the genetic content in chloroplast DNA of *B. alnoides* is also very highly conservative.

These early results will assist in the further selection of suitable genetic lines of both species with the aim of developing plantations and perhaps forest enrichment activities for sawlog production in Vietnam.

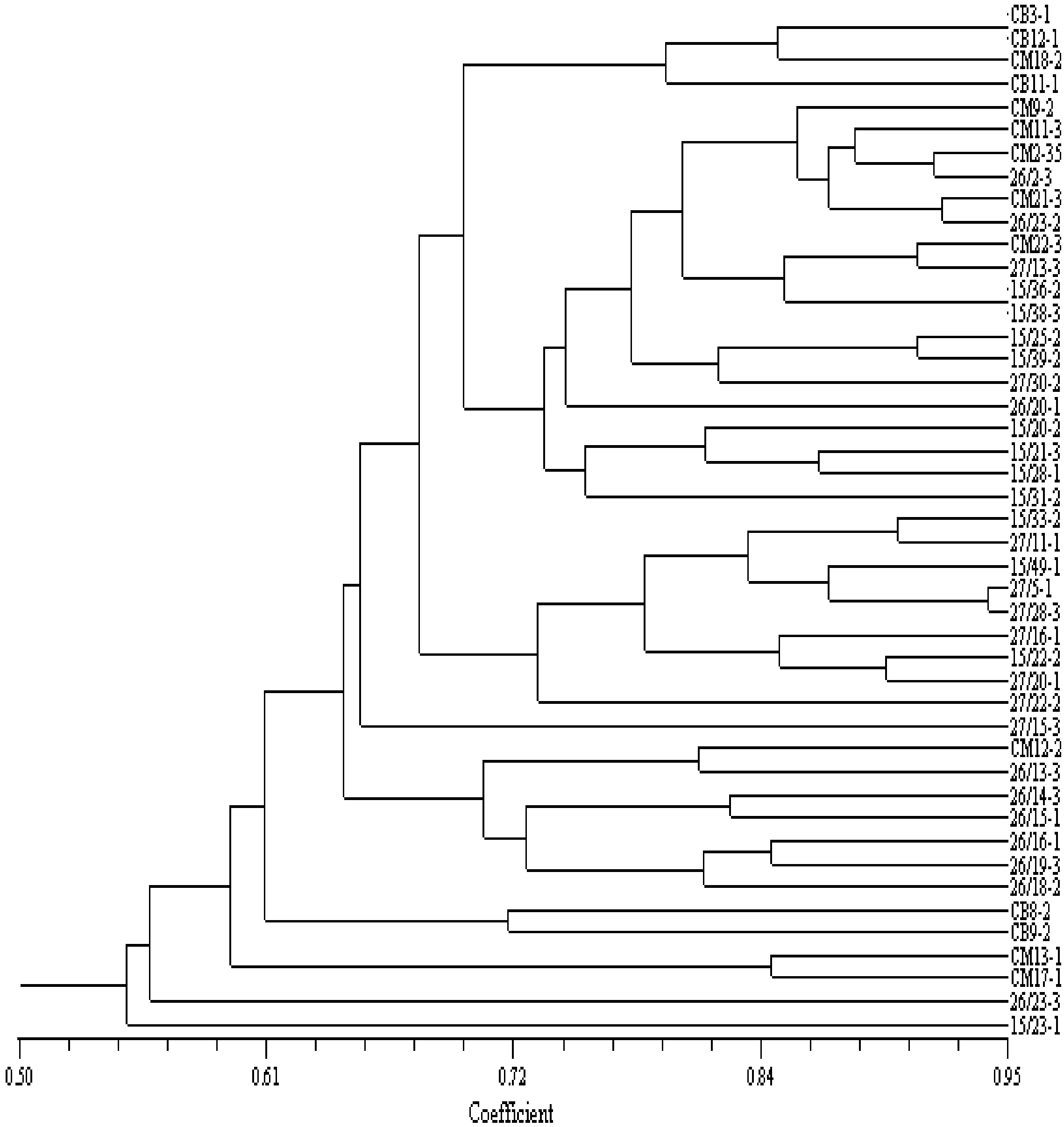

Figure 1. Dendrogram of relationship of *B. alnoides* families

References

Burley, J. and Wood, P.J. 1976. *A manual on species and provenance research with particular reference to the tropics.* Commonwealth Forestry Institute, Oxford.

Doyle, J.J. and Doyle, J.L. 1990. Isolation of plant DNA from fresh tissue. *Focus* 12: 13–15.

Williams, E.R., Matheson, A.C. and Harwood, C.E. 2002. *Experimental design and analysis for tree improvement*. CSIRO Publishing, Melbourne.

Mixed Plantation of *Santalum album* and *Dalbergia odorifera* in China

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Santalum album L.(East Indian Sandalwood or Sandal), an evergreen hemi-parasite tree species belonging to the Santalaceae family, is very famous for its fragrant heartwood which contains sandal oil that have many uses in perfumes, cosmetics, medicines, etc. (Srinivasan *et al*. 1992). Sandal was introduced to southern China since 1962, and now there are about 2000 ha of sandal plantations in southern China, most of which are established during the past 10 years. The cultivation technology of sandal including seed storage, seed germination, seedling raising, site selection, fertilization, nutrient management, host selection and management had been systematic studied; and a set of highly efficient cultivation techniques was well built up in the past decade (Liu 2009, Liu *et al*. 2009, 2010a, 2010b).

Dalbergia odorifera T. Chen, a semi-deciduous tree known as *Jiangxiang* in Chinese traditional medicine, is endemic to the Hainan Province of southern China, and belongs to the Leguminosae family. It is one of the most expensive rosewood in the world, highly renowned for its excellent wood properties and medicinal value (Wang *et al*. 2000).

The mixed plantation of *S. album* with *D. odorifera* could promote the growth of *S. album* through nitrogen fixation, which may accelerate the heartwood formation as a result of reduced growth due to the absorption of some water and nutrients by *S. album* (personal communication with local researchers and foresters). However, the detailed relationship between the parasite (*S. album*) and its hosts has not been fully understood yet. This study strived to reveal the possible mechanism between *S. album* and its hosts through a pot experiment, and further to prove that *D. odorifera* is one of the best long-term hosts for *S. album*.

Methodology

Four species (*Acacia confusa, Bischofia polycarpa, D. odorifera* and *Dracontomelon duperreranum*) indigenous to southern China were selected as pot hosts and then planted together with *S. album* in a pot, one *S. album* without host served as control. The plant growth, $\delta^{15}N$ signature, gas exchange parameters, leaf abscisic acid (ABA) content, and amino acids composition of xylem sap were measured to examine the effects of physiological changes before and after parasitized between *S. album* and its hosts. Nitrogen transfer between *S. album* and *D. odorifera* and the effect of nitrogen fixation on nitrogen transfer were also studied by an external ^{15}N labelling method.

Results and recommendations

Biomass, height, diameter and nitrogen concentration in 18-month old *S. album* were greater when *S. album* growing with two N_2-fixing hosts (*A. confusa* and *D. odorifera*) than with two non-N_2- fixing hosts (*B. polycarpa* and *D. duperreranum*) or with no host. Growth of *S. album* was better when growing without a host than growing with non-N_2-fixing host; this may indicate that non-N_2-fixing host might suppress the growth of *S. album*, so configuration a suitable host is very important to sandal.

Compared to the non-N_2-fixing hosts (3.14–4.32‰), $\delta^{15}N$ values in the N_2-fixing hosts (0.43–2.29‰) were closer to those in atmospheric N_2 (0‰). $\delta^{15}N$ values were similar between *S. album* (-0.08–1.64‰) and the corresponding N_2-fixing hosts. However, $\delta^{15}N$ is greater in the *S. album* if grew alone (2.97‰) or grew with non-N_2-fixing hosts (2.21–3.24‰), this may suggest that *S. album* can obtain most of nitrogen from its N_2-fixing hosts directly (Lu 2011).

Net photosynthesis rate (Pn) was highest when *S. album* growing with *D. odorifera* 190 days after transplanting, then followed by *A. confusa*, *D. duperreranum* and *B. polycarpa*, the control treatment has the lowest Pn. The stomatal conductance and transpiration rates were greater in *S. album* than in their hosts, except for *B. polycarpa*, but the instantaneous water use efficiency in *S. album* was lower than in any host. This data show that changes of gas exchange parameters may possibly dependent on the biological nature of each species.

Leaf ABA content were significantly higher in *S. album* (133.18–214.26 ng/g•FW) than in its hosts (52.64–170.27 ng/g•FW), and also greater in the parasitized hosts (52.64–170.27 ng/g•FW) than in the unparasitized controls (38.83–139.10 ng/g•FW) (Lu 2011). High content of ABA may be helpful in accelerating heartwood formation of sandal. In China, 6-year old sandal plantation was found to have formed heartwood naturally (Liu *et al*. 2011).

Both concentration and composition of xylem sap amino acids were similar between *S. album* and its N_2-fixing hosts, but quite different in the non-N_2-fixing hosts. This may indicate that *S. album* can absorb most crude nitrogen from N_2-fixing hosts, but little from non-N_2-fixing hosts.

Two-way N transfers were found between *S. album* and *D. odorifera*. Biomass (2.29–6.02 g/plant), N concentration (1.32–1.80%), N content (41.70–89.40 mg/plant) as well as ^{15}N contents (0.150–0.160 mg/plant) were all reached the maximum in both plants when *D. odorifera* was nodulated. N that has been transferred to *S. album* was 2.3 or 1.6 times greater than transfer to *D. odorifera* in the nodulated or non-nodulated pairs, respectively. This may show that there exist a great N transfer from the host (*D. odorifera*) to the parasite (*S. album*), and N transfer was enhanced by N_2 fixation (Lu 2011).

All those above data show that *D. odorifera* is potentially a very good long-term host for *S. album*. Therefore, mixed plantation of *S. album* and *D. odorifera* is a very good model to establish and will achieve great success in southern China.

Acknowledgements

The authors gratefully acknowledge the financial support from a 948 introduction project (2008-04-02) from State Forestry Administration of China and a technology innovation special project from Forest bureau of Guangdong province (2010KJCX002-01).

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References

Liu, X.J. 2009. *Effects of different culture technology on the growth of Indian sandalwood (Santalum album L.) seedlings in Guangdong, south China.* Master Degree Dissertation, South China Agriculture University, Guangzhou, P. R China (in Chinese with English abstract).

Liu, X.J., Xu, D.P., Xie, Z.S. and Zhang, N.N. 2009. Effects of different culture media on the growth of Indian Sandalwood (*Santalum album* L.) seedlings in Zhanjiang, Guangdong, southern China. *For. Stud. China* 11(2):132–138.

Liu, X.J., Xu, D.P., Yang, Z.J., Zhang, N.N. and Yang, L.J. 2011. Preliminary analysis of growth and oil composition from a 6-year-old sandal (*Santalum album* L.) plantation in Gaoyao, Guangdong, south China. *Sandal. Res. News*. 26:1–5.

Liu, X.J., Xu, D.P., Zhang, N.N., Xie, Z.S. and Chen, H.F. 2010a. Effects of gibberellin on seed germination and seedling growth of sandalwood (*Santalum album* L.). *Seed* 29(8):71–74 (in Chinese).

Liu, X.J., Xu, D.P., Zhang, N.N., Xie, Z.S. and Chen H.F. 2010b. Effects of pot host configuration on the growth of Indian sandalwood (*Santalum album*) seedlings in south China. *For. Res.* 23(6): 924–927 (in Chinese).

Lu, J.K. 2011. *The parasitism between hemiparasite Santalum album and its hosts*. Ph D dissertation, Chinese Academy of Forestry, Beijing, P.R China (in Chinese with English abstract).

Srinivasan, V.V., Sivaramakrishnan, V.R., Rangaswamy, C.R., Ananthapadmanbha, H.S. and Shankaranarayana, K.H. 1992. *Sandal (Santalum album L.).* Institute of Wood Science and Technology, Bangalore, India.

Wang, W., Weng, X. and Cheng, D. 2000. Antioxidant activities of natural phenolic components from *Dalbergia odorifera* T. Chen. *Food. Chem*. 71(1):45–49.

Strategy for Conservation of Genetic Resources of Valuable Hardwoods in East and Southeast Asia

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Eastern and southeastern Asian countries are very rich in the genetic resources of valuable hardwood species (VHSPs) (Kalinganire and Pinyopusarerk 2000, Lee and Krishnapillay 2004, Sumantakul 2004, Wang 2004). VHSPs are generally referred to a broad-leaved species or group of broad-leaved species which are characterized by relatively slow-growing but having special wood properties. The wood has good mechanical properties such as great strength and durability, as well as beautiful appearance, for example, nice colour, figure, fine texture and structure. All of these characteristics make the wood suitable for the manufacturing of high-value and high-grade end-products, and elegant and more expensive furniture such as the Chinese classical Ming Dynasty furniture (FAO 2001, 2005). Well known VHSPs are teak, rosewood and mahogany, and many more. An attempt is made in this paper to draw attention to the conservation of genetic resources and promotion of developing plantations of VHSPs.

Strategy for gene conservation of VHSPs

The Genetic resources of (VHSPs) are rapidly reduced due to land-use conversion and international timber trade. The world's total forest area is estimated to be 40 billion ha, covering 31% of the total land area. Primary forest accounts for 36% of forest area, unfortunately, net loss of primary forest is more than 40 million ha since 2000 (FRA 2010). Valuable hardwoods are mostly contained in the primary forests, especially in the tropical and subtropical regions. A number of VHSPs go through four stages: vulnerable, threatened, and endangered and finally becoming extinct in the process of primary forest destruction. A good example is *Dalbergia odorifera* T. Chen on Hainan Island, China. Moreover, genetic resources have been very much deteriorated, probably, what are today proposed for conservation are genetically inferior individuals left over from repeated heavy selective harvesting.
In terms of conservation strategy, forest genetic resources are conserved in two measures, *in situ* or *ex situ* (IPGRI 2001, Palmberg-Lerche 2002, IPGRI 2004a, 2004b), however, many VHSs are not well studied in genetic variation which makes *in situ* conservation more difficult (Lee and Krishnapillay 2004). In the world 12% of primary forest has been designated to be conserved areas of biological diversity as *in situ* conservation (FRA 2010).

Ex situ conservation is probably more critical for genetic resources of VHSPs. Most of the valuable hardwood species have not been domesticated yet, currently, very little knowledge is available for cultivation. Obviously, establishment of species/provenance trials, clone banks, gene conservation stands or other forms of conservation *ex situ* are all necessary.

It would not be over stressed that establishing industrial plantations, in long rotation, with VHSPs is essential, not only for valuable timber production but also for *ex situ* gene conservation since the plantations will be existing for 50 years and even longer. There are many technical difficulties in establishing plantations, such as availability of quality genetic materials, nursery technology and silviculture. As future demand for timber of VHSPs will be greatly increased, investment and efforts in planting valuable hardwoods must be encouraged.

Identifying priority species

To conserve the genetic resources effectively, criteria and priority species must be set. Priority should be given to those which are currently important in plantation forestry and tree breeding programmes as their genetic variations are well understood. Secondly, species potentially important in the future should also be considered.

VHSPs do not only mean the most "luxury species" – *Dalbergia, Tectona* and *Swieternia,* but also those tropical species other genera, such as *Dipterocarpus*, *Fraxinus, Juglans, Chukrasia, Magnolia, Phellodendron, Phoebe, Quercus, Shorea, Tilia, Toona, Zelkova* and etc. These species are all suitable for producing sawn timber or solid wood (FAO 2001, 2002, 2005).

The Chinese national standard for HONGMU (Rosewood) was issued in 2008. Thirty-three species in five genera: *Cassia*, *Dalbergia, Diospyros, Millettia* and *Pterocarpus,* have been designated as members of the Chinese 'luxury hardwood'. Of the 33 species many are not native to China; they are imported from tropical Asia, South America and Africa, but have been used extensively in the Chinese traditional furniture industry. Unfortunately, many tropical and subtropical species with better wood quality are excluded by the standard because they were not used in the Chinese classical furniture which made the timber of these species able to fetch only low price in the market.

Moreover, some genetic resources created after the species are introduced should also be considered as VHSPs for *ex situ* conservation, for example, *Eucalyptus cloeziana* in China, *Acacia auriculiformis* x *mangium* in Vietnam and selected clones of *Swietenia macrophylla* in Indonesia.

Encouragement to planting VHSPs

FAO (2002, 2005) predicted that wood quality will become more important in forestry and consumer fashion. People will buy products based on quality and uniformity. Those who produce the highest quality wood "will be the winners"; it is true for production of both solid wood and paper products.

Establishing industrial plantations with VHSPs for producing sawn timber and solid wood will receive more economic benefits and investment returns than plantations of short rotation and fast-growing tree species. However, there are some constraints in developing plantations in terms of both social and biological environments. It is essential in governmental policy to stimulate investment in plantation forestry of VHSPs.

Into actions

Many valuable hardwood species are trans-national in their natural distributions; therefore, it is necessary to establish bi- or multilateral cooperation to conserve their genetic resources. The followings are some suggestions for critical actions:

- institutionalize more scientific research into taxonomy, genetics and silviculture;
- encouragement and introduce incentive to private investment in plantations of VHSPs;
- shaping more enabling government policy and accessible resources;
- regional network established by APAFRI for conservation and research activities;
- establishment of International species/provenance trials of VHSPs, on the basis of equally benefit sharing of genetic materials and intellectual properties.

References

Anon. 2008. China's National Standard for Hongmu. GB/T18107-2000, Chinese)

IPGRI. 2001. *Forest genetic resources conservation and management* Vol. 2: In managed natural forests and protected areas (*in situ*). International Plant Genetic Research Institute, Rome, Italy.

IPGRI. 2004a. *Forest genetic resources conservation and management*. Vol. 1: Overview, concept and some systematic approaches. International Plant Genetic Research Institute, Rome, Italy.

IPGRI. 2004b. *Forest genetic resources conservation and management*, Vol. 3: In plantations and gene banks (*ex situ*). International Plant Genetic Research Institute, Rome, Italy.

FAO. 2001. *Promotion of valuable hardwood plantations in the tropics. A global overview*. Report based on the work of F. K. Odoom. Working Paper FP/4, Rome, Italy.

FAO. 2005. *State of the world's forest 2005*. Rome, Italy. 153 pp.

FAO.2010. *Global Forest Resources Assessment 2010, Main report.* FAO Forestry Paper 163. Rome, Italy. 378pp.

Kalinganire, A. and Pinyopusarerk, K. 2000. *Chukrasia* : Biology, Cultivation and Utilisation. ACIAR Technical Reports No. 49, 35 pp.

Lee, L.E. and Krishnapillay, B. 2004. Status of forest genetic resources conservation and management in Malaysia. *In* T. Luoma-aho, L.T. Hong, V. Ramanatha Rao and H.C. Sim (editors), *Proceedings of the Asia Pacific Forest Genetic Resources Programme (APFORGEN) Inception workshop*, Kuala Lumpur, Malaysia, 15–18 July, 2003. Pp. 206–228.

Palmberg-Lerche, C. 2002. Thoughts on genetic conservation in forestry. Unasylva 209(53):57–61

Sumantakul, V. 2004. Status of forest genetic resources conservation and management in Thailand. *In* T. Luoma-aho, L.T. Hong, V. Ramanatha Rao and H.C. Sim (editors), *Proceedings of the Asia Pacific Forest Genetic Resources Programme (APFORGEN) Inception Workshop*, Kuala Lumpur, Malaysia, 15–18 July, 2003. Pp. 265–289.

Wang, HR. 2004. Status of forest genetic resources conservation and management in the People's Republic of China. *In* T. Luoma-aho, L.T. Hong, V. Ramanatha Rao and H.C. Sim (editors), Proceedings of the Asian Pacific Forest Genetic Resources Programme (APFORGEN) Inception Workshop, Kuala Lumpur, Malaysia, 15–18 July, 2003. Pp. 134–149.

Plant Diversity among *Betula alnoides* Plantations and Adjacent Natural Forests

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Betula alnoides is a native, broadleaf tree species in southern China. It has become a major tree species for reforestation in tropical and subtropical mountainous areas of China (Zeng *et al.* 1998, Wang *et al.* 2004). However, only limited and basic research has been carried out on the biodiversity dynamics of its plantation under the context of conservation of species diversity in plantation, which is an important objective for sustainable forest management (Burton *et al.* 1992).

Specifically, this study was targeted at the following questions: (1) What are the differences (and degree of differences) in vegetation and structure among the *B. alnoides* forest communities; (2) Which forest community has the highest plant diversity; (3) What relationships are there among the communities; and (4) Does species diversity differ at different plantation ages?

Methodology

Study area
The study area is located at the Puwen Experimental Forest Farm in the Xishuangbanna Prefecture of Yunnan Province, China (101°6′E, 22°25′N). The climate is moist monsoon type of the northern tropics, with definite dry and wet seasons. The annual average temperature is 21°C and the annual rainfall is 1655 mm (Yunnan Academy of Forestry 1996).

Study methods
BAP1(13)(A 13-yr-old *B. alnoides* plantation (1)), BAP1(8) (An 8-yr-old B. alnoides plantation (1)), BAP1(5) (A 5-yr-old *B. alnoides* plantation (1)), and BAP1(3) (A 3-yr-old *B. alnoides* plantation (1)) were established on a clear-cut area of a Tropical montane rain forest (TMRF) with a spacing of 2 × 3 m. BAP2 (13) (A 13-yr-old *B. alnoides* plantation (2)) was established on a clear-cut area of a secondary forest.

BASF (*B. alnoides* secondary forest): A 13-yr-old BASF was established in a naturally regenerated forest.

TMRF (Tropical montane rain forest): TMRF is the regional climax community of forest succession. Three basic tree sample plots (20 × 20 m, 21 in total) were established in each community. Within each plot, five 5×5m^2 shrub layer plots and five 2×2m^2 herbaceous layer plots were established (Chen *et al.* 1999). The species, number, height, and coverage of all the plants within the plots were recorded.

Four diversity indices: species richness index (S), Shannon-Wiener Index (H'), Simpson Index (λ) and Pielou Evenness Index (J_{SW}), were computed to measure and analyze diversity characteristics. The Jaccard Index of Similarity was used to measure the similarity of species composition.

Results and discussions

Comparison of species richness
The species-group compositions of the seven communities are listed in Table 1. The ranking of species richness for the seven communities was: BAP1 (13) > BAP1 (8) > TMRF > BAP1 (5) > BAP2 (13) > BASF > BAP1 (3). There was no significant difference between BAP1 (5) (which was established on a clear-cut area of a TMRF) and TMRF, which indicates that species richness in a *B. alnoides* plantation established on a clear-cut area of a TMRF could recover in approximately 5 years.

Numbers of tree species in communities BAP1 (13) and TMRF were similar, at 45 and 44, respectively; both were higher than numbers of species in BAP2 (13) and BASF. The number of shrub species in BAP1 (13) was the highest (17 species), followed by BAP2 (13). Species richness values of herbs in the four BAP1 communities were highest. Numbers of shrub and herbaceous species in BAP1 (13) and BAP2 (13) were distinctly higher than those of the TMRF, which implies that along with the succession process of plantations, the number of shrubs and herbs showed a decreasing tendency.

Table 1. Plant species-group composition of the studied communities

Community	Number of species					
	Total	**Tree**	**Shrub**	**Herb**	**Vine**	**Fern**
BAP1(13)	109	45	17	20	18	9
BAP1(8)	95	40	14	20	16	5
BAP1(5)	77	30	10	22	12	3
BAP1(3)	50	14	5	24	4	3
BAP2(13)	60	20	14	14	10	2
BASF	55	23	9	10	11	2
TMRF	83	44	8	12	14	5

In BAP1 (3), BAP1 (5), BAP1 (8), and BAP1 (13), the total species richness increased from 50, to 77, 95, and 109 species, respectively. Among these, numbers of tree, shrub, vine, and fern species showed increasing trends, while only the number of herb species decreased with age. Thus, *B. alnoides* stand age had a strong effect on the species composition of the understory vegetation.

The results of this study showed that 54% of regenerated species in BAP1 (13) were also found in the adjacent primary forest (TMRF) and 73% of regenerated species in BAP2 (13) were found in the BASF, indicating that BAPs could be effective tools for restoring native species diversity.

Comparisons of species diversity in different layers within the communities

The Shannon-Wiener Index (H´), Simpson Index (λ), and Pielou Evenness Index (J_{sw}) in different layers within the communities are calculated and summarized as follows:

1. Diversity of the tree layer
   In BAP1 (13), BAP1 (8), BAP1 (5), BAP1 (3), and BAP2 (13), *B. alnoides* was the single dominant species. The diversity indices of the tree layer of these five communities were therefore the lowest. The ranking of the communities in terms of diversity of the tree layer was: TMRF > BASF > BAP.

2. Diversity of the shrub layer
   The ranking of the diversity index and evenness index of the shrub layers for the seven communities was: BAP1 (13) > BAP1 (8) > BAP1 (5) > TMRF > BASF > BAP2 (13) > BAP1 (3).

3. Diversity of the herbaceous layer
   The ranking of the diversity index and evenness index of the herbaceous layers of the seven communities was: BAP1 (13) > BAP1 (3) > BAP1 (8) > BAP1 (5) > TMRF > BAP2 (13) > BASF.

Similarity of plant species in the seven communities

Based on the field investigation, the Jaccard Similarity Coefficient of plant species between each pair of communities was calculated (Table 2).

The highest similarity coefficient (53.33%) was between BAP2 (13) and BASF, which had similar previous vegetation. Four BAP1 plots also had relatively high similarity coefficients with TMRF. High Jaccard similarity coefficients of plant species appeared among the four *B. alnoides* plantation plots established on clear-cut areas of a TMRF as well. The results showed that under the same climatic conditions, the progress and direction of secondary succession are significantly related to the previous native vegetative conditions. The results also showed that the closer the ages of the two forest communities, the greater the similarity coefficient.

For the other pairs of communities, similar previous environmental conditions did not exist, which led to a relatively low number of common species and low similarity coefficients.

Table 2. Jaccard Similarity Coefficients of plant species among the seven communities

Community	BAP1(13)	BAP1(8)	BAP1(5)	BAP1(3)	BAP2(13)	BASF	TMRF
BAP1(13)	–	39.19	36.76	33.61	17.36	17.99	30.61
BAP1(8)	–	–	38.10	34.86	15.67	15.38	29.93
BAP1(5)	–	–	–	36.56	14.17	17.86	25.98
BAP1(3)	–	–	–	–	15.79	15.38	23.15
BAP2(13)	–	–	–	–	–	53.33	10.85
BASF	–	–	–	–	–	–	13.11
TMRF	–	–	–	–	–	–	–

Conclusions

Higher species diversity in *B. alnoides* plantations than native forests indicates that *B. alnoides* plantations can facilitate the development of plant species under their canopy in terms of species composition, diversity, and restoring native species diversity. The species could thus be an effective tree species for restoring tree diversity in tropical southwestern China.

The basic characteristics of the previous community before plantation can be partly retained or transferred to the newly established *B. alnoides* community. Therefore, regenerating plant species in the new *B. alnoides* community had a close relationship with the previous community.

In the *B. alnoides* plantation, species richness significantly increased with increase in plantation age. In addition, the *B. alnoides* stand age had a strong effect on the species composition of the understory vegetation, which changed from pioneer species to shade-tolerant plants and sciophytes. Moreover, the understory composition of the older community had considerable similarities with that of indigenous forests.

References

Burton, P.J., Balisky, A.C., Coward, L.P., Cumming, S.G. and Kneeshaw, D.D. 1992. The value of managing for biodiversity. *For Chron* 68(2):225–37.

Chen, H.W., Liu, Y.G. and Feng, X. 1999. Discussion on sampling area of *Betula alnoides* artificial forest community. *Yunnan For Sci and Technol* 88(3):25–27.

Wang, W.B. and Zhang, J.F. 2004. *The manual of Betula alnoides plantation establishment technology.* Kunming, China: Yunnan Technology Press. 6 p.

Yunnan Academy of Forestry. 1996. *The proceedings on tropical reforestation tree species*. Kunming, China: Yunnan Science and Technology Press. 99 p.

Zeng, J., Zheng, H.S. and Wang, B.G. 1998. *Betula alnoides*-the fast-growing and valuable timber tree species in tropical and southern Sub-tropical area. *Yunnan For Sci Technol* 98(4):18–20.

Acknowledgments

We are grateful to the Puwen Tropical Forest Research Institute of the Yunnan Academy of Forestry for the use of their facilities, and to Prof. Z.L. Wu and Prof. H. Zhou for their constructive comments and valuable suggestions. This work was supported by the Yunnan Provincial Science and Technology Research and High-tech Development Project (2006NG28).

Schleichera oleosa – A Case for Transboundary Conservation

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Schleichera oleosa (Lour.) Oken (Syn. *S. trijuga* Willd) belonging to the family Sapindaceae is a commercially important tree species particularly in South and Southeast Asia. *S. oleosa* is found widely distributed in the sub-Himalayan region, throughout central and southern part of India. It is also available in the forests of Bangladesh, Myanmar, China, Thailand, Sri Lanka, Indonesia and Malaysia. It is commonly known as Kusum in Hindi language. This tree produces the best quality lac. Lac is a natural resin secreted by an insect *Kerria lacca* (Kerr.), which thrives on the tender twigs of specific host trees. Lac from Kusum is lighter in colour and it gives higher yield per tree basis than other host trees like Palas (*Butea monosperma*) and Ber (*Ziziphus mauritiana*). The raw lac is the source of three valuable, natural and renewable products: resin, dye and wax. Lac provides sustained high economic returns, generates employment opportunities and has potential to pave a strong foundation for lac-based rural cottage industries. With increasing demand for natural products for various uses e.g. fruits and vegetable coating, and as food colouring, the time is ripe to integrate lac culture in the farming system with plantation of lac host plants.

India is the largest producer of lac in the world and fetches approximately USD 25 million of foreign exchange through export of lac every year. However, the area of lac cultivation as well as the production of quality lac had been eroded due to several reasons: fluctuating prices of lac, over dependence on foreign buyers, and loss of biodiversity of lac insects as well as their host plants. So far, very limited research activities on improvement of lac host plants particularly *S. oleosa* have been carried out. Its natural, as well as artificial regeneration is markedly impaired by seed-insect infestation, poor germination and slow initial growth rates. It is therefore, expedient to explore an alternative means of propagation as well as improvement in seed germination for ensuring the regular supply of quality planting stocks of this species. A decade ago, Institute of Forest Productivity, Ranchi, under the umbrella of Indian Council of Forestry Research and Education, Dehradun, started to work on the selection, tree improvement, reproductive biology and propagation techniques of *S. oleosa.* Most of the studies were conducted at the campus of Forest Research Centre of the Institute located at Mandar, Ranchi with average annual rainfall of 1400 mm. Generally, monthly average rainfall exceeds 200 mm during June to September and maximum temperature crosses the bar of 35°C during mid March to mid June.

Selection and macropropagation

Selection criteria of this species as a lac host plant have been developed for the first time (Sinha 2006). Trees having vigorous growth, expanded crown, dense foliage and branches, good health and higher lac productivity were chosen (Figure 1). The extensive exploration was carried out for the collection of superior trees of *S. oleosa* from the whole lac producing region in eastern part of the country, represented by three states: West Bengal, Jharkhand and Orissa (Figure 2). As many as 30 trees were selected. Techniques were standardized for plant establishment from stem cuttings, grafting and air-layering. Stem cutting studies were carried out on source plants of different ages, different sizes of branches, and collection seasons. Different auxins (IBA, IAA, NAA) and synergist were applied individually and in combination. IBA at 2000 ppm with 5% sucrose supported the best cutting establishment than any other hormonal combinations tried (Figure 3). Maximum rooting success (> 60%) was observed in cuttings from seedlings of 2–5 years of age (Figure 4).

Grafting of Kusum tree was not reported earlier. In other members of the Sapindaceae family, such as litchi (*Litchi chinensis*) longan (*Dimocarpus longan*) and rambutan (*Nephelium lappaceum*), success in grafting has been reported (Cobin 1948, Tabora and Atienza 2006). Maximum success (56.7%) in grafting of Kusum has been achieved by cleft grafting (Figure 5) when all leaves were cut off at the base of the blade, leaving the petioles intact on the scion and the scion was covered with polyethylene sheet (Sinha 2011). This polyethylene cover was tied below the graft union to prevent desiccation. The age of scion was a deciding factor for success of grafting union. No grafting success was observed when scion was taken from trees more than 40 years old. Rainy season (June to August) was found to be the best time for grafting as well as air-layering of this species in eastern part of India. Patel *et al.* (2010) also observed best grafting success and minimum days for sprouting in Mandarin when the grafting was performed in rainy season. In this study, combined application of IBA along with NAA, IAA and thiamine induced good success in air-layering of Kusum trees (Figure 6). Twig diameter smaller than 2 cm was found to be unsuitable for successful plant establishment. The genotypes suitable for more rooting success are being screened for further multiplication to supply quality planting stocks for large scale plantation.

Figure 1. A selected tree of *Schleichera oleosa*

Figure 2. Prominent lac growing region in eastern part of India

Figure 3. Rooted stem cutting

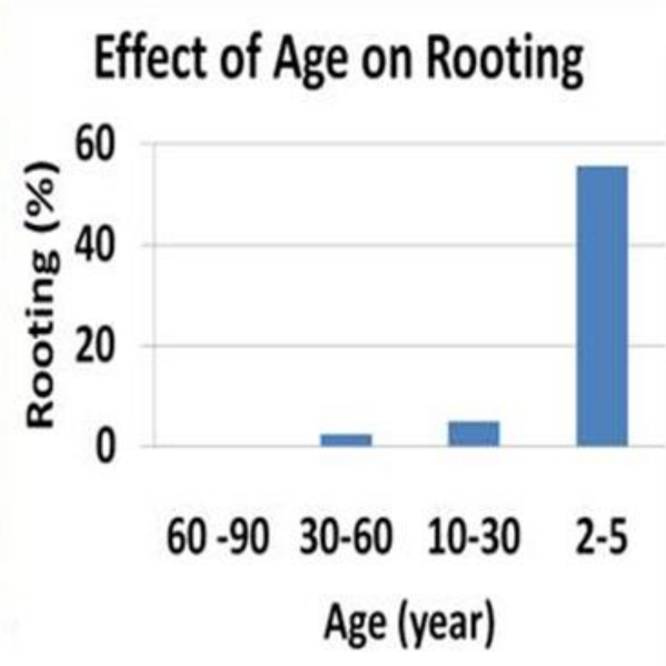

Figure 4. Variation in rooting of stem cuttings

Figure 5. Cleft grafting **Figure 6.** Rooted air layer

Micropropagation

Efforts were made to develop a protocol for *in vitro* propagation of this species. For the first time *in vitro* shoot proliferation of this species was reported by the Institute. The effect of source of explants, media formulations and plant growth regulator concentrations on shoot generation of juvenile and mature selected trees were examined. Apical shoot tips and axillary buds taken from seedlings and fresh shoots emerged after pruning or pollarding of trees were taken as explants. Media formulations included Murashige and Skoog (MS) medium and McCown's Woody Plant Medium (WPM). Treatments included growth regulators BA, KN, TDZ, 2, 4-D, IAA, IBA, NAA, Bavistin or Phloroglusinol in different concentrations singly or in combination. Shoot initiation was observed in MS medium with BAP and kinetin (Figure 7). Addition of $AdSO_4$ in this treatment showed better result with respect to initiation and development of shoots. Addition of $AdSO_4$ promoting higher shoot length has also been observed in *Bombax ceiba* (Vaidya and Bansal 2004) and *Oroxylum indicum* (Parveen *et al*. 2006). *In vitro* shoot cultures were capable of axillary and adventitious shoot proliferation up to 6 months. Later when growth ceased, leaflets dropped, shoot tip necrosis appeared and shoot cultures died. Durkovic (2008) also reported shoot tip necrosis and death of cultures of *Cornus mas* after one year of establishment of cultures and shoot proliferation. Different approaches are being followed to solve the problem.

Figure 7. *In vitro* shoot proliferation

The exudation of phenolic substances from cut ends of explants is a common problem in woody plant tissue culture (Quraishi *et al.* 1997, Aliyu 2005, Shirin *et al*. 2005). Several approaches were followed for controlling the browning of explants in culture vessels. The exudation was checked by suspending explants in a chilled solution of 2.8 mM ascorbic acid for 1 h and by the addition of 1.25 µM PVP, 56.8 µM ascorbic acid and 52 µM citric acid in establishment medium (Sinha and Akhtar 2008a and b). Experimentation on *in vitro* seed germination of Kusum was also carried out with the aim to get cotyledonary nodes for their uses as explants for micropropagation of this species.

Seed germination

Different methods: soaking of seed in cold water/ hot water, sulphuric acid treatment, soaking of seed in GA_3/ PVP/ KNO_3, were applied for enhancement of seed germination percentage *in vivo*. Pre-treatment of seeds with KNO_3 for one hour showed higher germination in fresh seeds. Variation in seed germination of different seed lots was observed.

Recommendations

Traditionally, lac is cultivated in existing trees of Kusum which are 40–100 years old. Pollarding trial has been initiated recently (Figure 8). Success in producing more number of shoots through pollarding and lac cultivation on them would be a great help in increasing lac production and sustenance of lac cultivation, which may ultimately motivate farmers to go for lac farming by planting Kusum plants.

Figure 8. Emergence of shoots after pollarding

Due to over exploitation, over maturation of trees, destruction of trees for other purposes, and non establishment of fresh plantation, the population of Kusum is declining day by day. The rapid economic development in other countries have also reduced the overall natural habitats of this species and threatened its existence in these countries. Efforts are needed to conserve and protect this species. Bilateral or multilateral collaborations on conservation and efficient utilization of this species should be initiated among countries having good natural resources of the species in the region.

References

Aliyu, O.M. 2005. Application of tissue culture to cashew (*Anacardium occidentale* L.) breeding: An appraisal*. Afr. J. Biotechnol.* 4 (13): 1485–1489.

Cobin, M. 1948. Notes on the grafting of *Litchi chinensis* Sonn. Fla. *State Hort. Soc. Proc.* pp. 265–268.

Durkovic, J. 2008. Micropropagation of mature *Cornus mas* 'Macrocarpa'. *Trees* 22: 597–602.

Parveen, Sharma, V.K.and Mandal, A.K. 2006. A comparative study of stomata of tissue culture raised plants and seedlings of *Oroxylum indicum* Vent. *Ind. For.* 132(1): 127–129.

Patel, R.K., Babu, K.D., Singh, A., Yadav, D.S. and De, L.C. 2010. Softwood grafting in Mandarin (*C. reticulata* Blanco): A novel vegetative propagation technique. *International Journal of Fruit Science* 10(1): 54–84.

Quraishi, A., Koche, V. and Mishra, S.K. 1997. Micropropagation of *Lagerstroemia parviflora* through axillary bud culture. *Silvae Genetica* 46(4): 242–245.

Shirin, F., Rana, P.K. and Mandal, A.K., 2005. *In vitro* clonal propagation of mature *Tectona grandis* through axillary bud proliferation. *J. For. Res.* 10 (6): 465–469.

Sinha, A. 2006. Selection of plus trees of *Schleichera oleosa* (Lour.) Oken – a multipurpose tree. In: Tewari, V.P., Srivastava, R.L. (Eds.), *Multipurpose Trees in the Tropics: Management and Improvement Strategies.* Scientific Pub, Jodhpur, pp 719–721.

Sinha, A. 2011. Clonal propagation of *Schleichera oleosa* by cleft grafting. Indian Forester (in press).

Sinha, A. and Akhtar, S. 2008a. Nodal bud culture in *Schleichera oleosa*: aseptic culture establishment, explant survival and influence of plant growth regulators. *Indian J Genet.* 68(2): 219–221.

Sinha, A. and Akhtar, S. 2008b. *In vitro* shoot proliferation from nodal explants of mature trees of Kusum (*Schleichera oleosa*). In: Ansari, S.A., Narayanan, C., Mandal, A.K. (Eds.), *Forest Biotechnology in India.* Satish Serial Publishing House, Delhi, pp. 205–213.

Tabora, P.C. and Atienza, L. 2006. Highly successful wedge grafting for Rambutan, Lychee, Longan, Mangosteen and other fruit trees. *Proc. Fla. State Hort. Soc.* 119: 4–6.

Vaidya, K. and Bansal, Y.K. 2004. Multiple shoot induction from apical buds of mature Semul (*Bombax ceiba* L.). *Ind. J. For.* 27(2): 175–178.

Acknowledgements

The first author is thankful to Department of Biotechnology, Govt. of India, New Delhi and Indian Council of Forestry Research and Education, Dehradun for providing research grant and Director, Institute of Forest Productivity, Ranchi for providing necessary facilities.

Conservation of Valuable and Endangered Forest Tree Species in Protected Area in the Philippines

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The Philippines is one of the traditional log exporters to developed countries like those in Europe, Japan and Korea. Leipzig (1996) reported that among the Philippine hardwoods imported by other countries are *Dipterocarpus grandiflorus*, *Shorea polysperma*, *Shorea negrosensis*, *Shorea contorta*, *Shorea palosapis*, *Shorea guiso*, *Shorea astylosa*, *Shorea hopeifolia*, *Parashorea malaanonan*, *Anisoptera thurifera* and *Hopea acuminata*. Because of the long history of huge exportation of these species and the concomitant destruction of their habitat, they have become endangered, many even critically endangered.

Korea has initiated multilateral collaboration with several ASEAN countries to address the need for biodiversity conservation and environmental restoration in the region (ASEAN-Korea Environmental Unit Project 2001) especially of threatened species. This paper discusses the conservation of endangered forest tree species and their natural habitats in the protected area in the Philippines under this project.

Methodology

The conservation of valuable and endangered forest tree species among other forest species in the Philippines and Korea has been the object of research by three teams composed of Filipino and Korean researchers under the ASEAN-Korea Environmental Unit Project. In the Philippines, the protected area studied was the Mt. Makiling Forest Reserve (MFR). In the MFR, biodiversity and habitat surveys were conducted in its four sub watersheds (Figure 1). The dominant creek in the area served as the transect line during the survey. Primary data on biodiversity, natural features and other information that affect the status of the natural resources (e.g. importance value, regeneration, socio-economic importance, threats and problems) were gathered and used in identifying strategies for the conservation and management of the species and their habitats. Specific areas and species for conservation were prioritized based on diversity index of the area/habitat, conservation status of the plants and the gravity of threats to which the species are exposed to. Mitigation measures and recommendations for the protection and enhanced regeneration of the species in the MFR were identified.

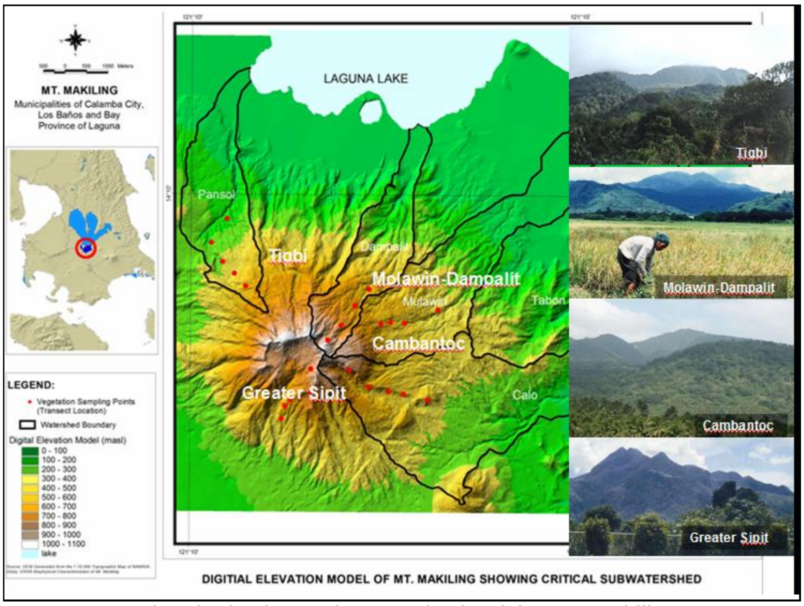

Figure 1. Survey plots in the four sub watersheds of the Mt. Makiling Forest Reserve

Results and discussions

Threatened species in the MFR

The research showed that the forest reserve supports a total of 48 threatened plant species of economic and ecological importance. Twenty-three are in the high threat category, 15 of which are critically endangered (Table 1). All the 15 critically endangered species are timber species heavily extracted from other forests. Of these 15, *Pterocarpus indicus* was found in all the 4 sub watersheds while *Diospyros blancoi, Toona calantas* and *Shorea guiso* were found in 3 of the 4 sub watersheds of the MFR. *Shorea contorta* is also in the top ten list of species dominating the MFR. Molawin-Dampalit sub watershed has the highest number of vulnerable and critically endangered species (42 of 48) with *Parashorea malaanonan* and *Diospyros blancoi* dominating.

Table 1. Family of forest species in the MFR in the high threat category

Family	Endangered	Critically endangered
EBENACEAE	2	1
DIPTEROCARPACEAE	-	10
LEGUMINOSAE	3	2
MELASTOMATACEAE	2	-
MELIACEAE	-	1
MYRTACEAE	-	1
SAPINDACEAE	1	-

Threats to critically endangered species in the MFR

In the MFR, the threats are natural (climate change, pest and diseases) and anthropogenic in nature. Timber harvesting is prohibited. Many of the forest violations occur in the periphery of the MFR. The most common violations are construction of structures, camping and the attendant putting up of campfire, hunting and collection of forest products, timber poaching and collection of physical resources (mud and white earth) which directly affect the species or indirectly through habitat damage or change.

The *El Nino* of 2010 and the landslides in 2006 have threatened many species including the critically endangered *Hopea foxworthyi*, *Parashorea malaanonan*, *Shorea contorta*. Lapitan (2010) cited the study of Lambio on altitudinal diversity in Mt. Makiling which revealed the lowest altitude showed significant loss in diversity index from 0.92 to 0.80 while the highest altitude registered little loss. The low altitude area is predisposed to more exploitation and disturbance.

Management, protection and conservation of critically endangered species in the MFR

The conservation in protected areas like the MFR, as advocated by the 10th Conference of the Parties of the Convention on Biological Diversity in October 2010, is logical and the most practical. The protected status lessens the threat to species and makes conservation strategies easier to implement. The MFR's ecological functioning as indicated by the high species diversity in its four sub watersheds (Table 2) supports species' survival. The high species diversity indicates the plurality of roles and functions of species in the MFR. Lapitan *et al.* (2010) reported that diversity in other groups of organisms (fungi, vertebrates and invertebrates) exists as well in the MFR.

The management, protection and conservation of Molawin-Dampalit area should be prioritized as more biodiversity is threatened in this area being the most accessible to intrusion compared to the other three sub watersheds. The *in situ* conservation of the critically endangered timber species *Diospyros blancoi, Parashorea malaanonan, Pterocarpus indicus, Shorea polysperma, Shorea guiso, Syzygium nitidum* and *Toona calantas* including *Diospyros pilosanthera* (EN) in the MFR should be focused. Most of these species belong to "climax species" which are shade-tolerant and favoured by gaps, the seedlings growing and surviving to adulthood better in these openings in the forest floor. Most are outcrossing and therefore produce more heterogeneous seedlings or progenies/offsprings. The seeds are mostly recalcitrant, and dispersal occurs in short distances owing to the heavy weight of the seeds. These seeds have very short viability and cannot be stored for long.

Table 2. Diversity indices of tree and undergrowth species in different sub watersheds in MFR (UPLB –KNIER 2011)

Shannon- Wiener Diversity Index for MFR						
Sub watershed	**Tree species**			**Undergrowth species**		
	No. of species	**No. of family**	**Diversity Index**	**No. of species**	**No. of family**	**Diversity Index**
Tigbi	57	29	**1.771**	49	34	1.553
Cambantoc	46	25	1.643	54	37	1.638
Mo law in-Dampalit	45	26	1.396	68	40	1.763
Greater Sipit	44	25	1.301	56	40	**1.722**
These diversity index values are moderately high						

These species should be protected and managed for sustained growth and development. While the species' regeneration is not a problem, there has to be an effort to monitor and periodically assess population growth and genetic diversity changes of these species. Gap formation should be managed for seedling survival and species perpetuation. Habitat fragmentation or abnormal or man-induced opening of canopies should be prevented. Considering most produce recalcitrant seeds which are dispersed in short distances, the immediate germination and thereafter the protection of reproductive niches of the species should be undertaken. Reproduction should be monitored to insure that regenerants are able to successfully give rise to a new generation. Protecting the habitat, protecting MFR is the best strategy for conserving these species.

References

Lapitan, P.G. 2010. *Managing Mt. Makiling Forest Reserve for UPLB's Academic Advancement, Resource Generation and Service to the Nation.* UPLB Centennial Professorial Lecture. College, Laguna, Philippines.

Lapitan, P.G., Fernando, E.S., Suh, M.H., Fuentes, R.U., Shin, Y.K., Pampolina, N.M., Castillo, M.L., Cereno, R.P., Lee, J.H., Han, S., Choi, T., and Lee, D.K. 2010. *Biodiversity and Natural Resources Conservation in Protected Areas of Korea and the Philippines*. Geobook Publishing Co. Korea. 248pp.

Leipzig.1996. *Philippines: Country Report to the FAO International Technical Conference on Plant Genetic Resources.* Prepared by: Department of Agriculture of the Philippines, Quezon City.

Acknowledgements

The authors acknowledge the involvement of the followings in the project cited in this paper: N.M. Pampolina of UPLB, JaeHo Lee, Saerom Han and Taebong Choi of KNIER.

Conservation of *Melia dubia* Cav. and *Santalum album* Linn. by Extension and Development: Trials in Tobacco Farms in South India

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Tobacco farmers can reap many benefits by growing tree species such as *Melia dubia* and *Santalum album* along with silvi-horticultural crops. Besides the economic benefits, there is potential for improvement of environment and eco-restoration. Such silvi-horticultural practices can also involve large numbers of people in forestry-related works. This promises to be an efficient way to conserve important species such as *Melia* and *Santalum*. India's strength in *in situ* conservation lies in its impressive network of 661 protected areas (which include 99 national parks and 515 wildlife sanctuaries).India has special flagship programmes for tiger and elephant conservation. Even these impressive programmes have some limitations and have not succeeded in giving the expected results. In this background these trials conducted in tobacco fields in Karnataka state in South India gain importance.

Silvi-horticultural experiments were conducted in Bangalore by planting suitable tree species in a coconut garden. Of many species tried, *Melia dubia* was found to be promising. It attained a height of 5 m in the first year and girth of 1 m in three years. A journalist friend was excited after visiting the farm and published an illustrated article in a popular local magazine in September 2005. This was perhaps the first catalytic call to farmers of Karnataka for growing of *Melia dubia*.

Unstable market for agricultural produce, and growing demand and increasing prices for timber have induced farmers to pay attention to tree farming. *Melia*'s fast growth, its straight bole, coppicing capacity, anti-termite quality, usefulness as fodder for goats and sheep, and attractive financial returns, make it a favoured tree species.

In Hunsur Forest Division (Karnataka state, South India) between 1977 and 1980 when tobacco cultivation was at its peak, the Government, in its eagerness to uplift the socio-economic conditions of the farmers, had encouraged extension of tobacco cultivation and in the process sacrificed tree vegetation by way of supplying firewood from the Forest Department. Farmers used to clandestinely remove *Kydia calycina* from the forest for curing tobacco leaves, causing serious negative impact on forests and wildlife. With support of the local political leaders, a workshop on "alternative cash crops to tobacco" was conducted in late 2007, which was attended by farmers and officers from the Forest, Horticulture and Agriculture Departments. The outcomes of this workshop encouraged more tobacco farmers to diversify to silvi-horticulture.

Involvement of diverse key players

A beginning was made during the rainy season of 2010. The Environment Department of the Government of Karnataka supported this programme. The Bangalore software company I-Gate agreed to fund the project for a period of two years. The Indian Plywood Research and Training Institute, Bangalore, assisted in involving the Plywood Industries Association which supplied 100,000 *Melia dubia* seedlings free to the farmers and agreed to pay a good price for the timber that could be harvested later.

The Indian Tobacco Company assured supply of quality seedlings of *Casuarina equisetifolia* and *Eucalyptus* species. They promptly supplied half of the assured quantity during 2011 and the balance will be supplied shortly.

The Saw Mill Association members of Hunsur and X-treme, Bangalore, provided superior quality grafted *Artocarpus integrifolia* seedlings. Supply of selected bamboos, like *Guadua angustifolia*, *Bamboosa tulda* and *Dendrocalamus brandisii*, along with rattan cane *Calamus* species, are personal contributions. The Horticulture Department is supporting by supplying grafted saplings of sapota, mango, etc.

Sandal can be grown in tobacco farms

Sandalwood is the world's most expensive timber. The present price of high-grade sandal heartwood is Rs.6,500,000 (US$125,000) per tonne. This species, which was once well distributed in the Indian subcontinent, is now restricted mostly to South India. Sandalwood and sandal oil are used for making handicrafts, incense sticks and perfumes, and sandal oil is an important ingredient in some pharmaceutical products. The supply is not sufficient to meet the increasing demand. The huge demand supported by high prices has led to smuggling of sandal trees.

In the past growers were getting a fixed amount as sandal bonus, and damaging or smuggling sandal trees met with heavy punishments. Attempts to modify some outdated laws in favour of the cultivators of sandal were unsuccessful until 2010. With the liberalization of sandal laws, everyone is interested in growing this highly lucrative tree nowadays.

The Karnataka State Handicrafts Development Corporation, which is reputed for its elegant sandalwood carvings, has since earmarked funds for free distribution of seedlings to farmers. The Institute of Wood Science and Technology in Bangalore has taken the initiative to grow quality sandal seedlings and supply them to the farmers. So far about 10,000 seedlings have reached the farmers. On reaching maturity in 40 years, a sandal tree produces half a tonne of sandalwood, fetching over Rs.3,000,000 (USD -60000). Each mature tree brings an income of around Rs.75,000 (USD-1300) to the farmer annually. Farmers are eager to grow sandal on ambitious scale. When this trend picks up, sandalwood farming can become a highly profitable activity.

Forest tree species typically need long period to reach maturity and hence are not very popular for commercial planting. Farmers are however convinced by the experience gained from silvi-horticulture, and want to raise sandal plantations. After a few years natural regeneration should take over and conservation and development of *Santalum album* and also *Melia dubia* should be successful.

Benefits of forestry species

The area under tobacco cultivation in the administrative divisions of Hunsur and Periyapatna in Karnataka state in South India is 62,000 hectares. With a productivity of half a tonne of tobacco leaves per hectare, the total production will be around 31,000 tonnes (personal communication, Indian Tobacco Company, Hyderabad).

About 10 tonnes of firewood is required to cure every tonne of tobacco leaves. Farmers are planting forest species for firewood and timber along the boundary. At a spacing of 3 m x 3 m, a farmer can plant about 375 seedlings per hectare. On this basis roughly about 4000 hectares of planting have been covered this year. Apart from this, the Forest and Horticulture Departments are encouraging planting of other tree species (personal communication, Deputy Conservator of Forests, Hunsur).

The benefits gained will be innumerable: trees provide shade, lower temperature, reduced wind speed, and have many other environmental gains. With silvi-horticulture farmers can stagger their work load evenly during the year. This will bring income security to the farmers and reduce incidence of suicide. It will improve eco-restoration and ultimately forestry itself. The villainous tobacco crop, which used to take the life of six million people annually and cause sickness to four times this number, can slowly be reduced.

It is evident from these field trials and work with farmers and government and private agencies that eco-restoration and conservation of selected tree species are achievable. The practice provides tobacco farmers reliable and profitable alternatives to tobacco. It will help the farmers financially and will act as an insurance against recurring drought.

Recommendations

Taking advantage of wide distribution and utility (including the recent carbon sequestration and climate change applications) of these two species, they can be extended to non-conventional areas.

Workshops should be held every two years or so to disseminate the knowledge and experience gained by inviting all important stakeholders like perfume, plywood and pharmaceutical industries.
Some international organizations should be selected as nodal agencies to monitor progress in different countries/regions. An integrated approach should be developed by involving forest, agriculture, horticulture and irrigation/watershed development departments and also connected industries. Favourable rules, regulations, financial support and guidance should be liberally extended to support the growers.

References

ICFRE. 1992. *Sandal* – Santalum album Linn. Indian Council of Forestry Research and Education. P.O. New Forest, Dehra Dun-248 006.

G.O.I. 2009. *India's Fourth National Report to the Convention of Biological Diversity*. Ministry of Environment and Forest,

Conservation of Genetic Resources of Sandalwood *(Santalum album L.* var. *album)* in Timor Islands

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Sandalwood belongs to the family Santalale, subfamily Santalineae, order *Santalaceae* and genus *Santalum*. There are several species of sandalwood, but the species *S. album* is believed to have originated from the Timor region. Two varieties of *S. album* are found in the Timor region, *S. album L.* var. *album*, which is characterised by small leaves, and *S. album* var. *largifolium*, which has larger leaves (Harisetjono and Suriamihardja 1993). Like most species of the genus *Santalum* it is a root parasite, tapping the roots of other species for water and inorganic nutrients (the mistletoe, *Viscum album*, a branch parasite, is a relative).

In Indonesia, sandalwood (*Santalum album* Linn) is primarily found in eastern Nusa Tenggara (NTT)/west Timor (Figure 1). The three main islands of NTT are Timor, Flores and Sumba (formerly known as "sandalwood islands"). The name reflects the long history of sandalwood trees in Sumba Island. The island of Timor is the largest and easternmost of the Lesser Sunda Islands, part of the Nusa Tenggara archipelago. The long narrow island is 34,200 sq. km with parallel mountain ranges spanning its length. Average rainfall is about 1,250 mm per year and most of it falls during the monsoon season from December to March. Timor has little natural vegetation due to its poor soil, although it does contribute valuable timber such as eucalyptus, teak, rosewood and sandalwood, as well as bamboo.

The oil extracted from the heartwood of sandalwood is of high economic value. It is used in cosmetics, scent for soap, aromatherapy oil, perfumery and medicines (Rahayu *et al.* 2002, Doran *et al.* 2002, CABI 2000, Weiss 1997, Coppen 1995). The fragrant wood is the raw material for a range of products such as sculptures, fans, carvings, rosaries and furniture, while the powdered wood is used for incense sticks (Doran *et al.* 2002, Rahayu *et al.* 2002).

This paper outlines the strategy for conservation of sandalwood based on the existing conditions of the genetic resources and biological/genetic characteristic of the species.

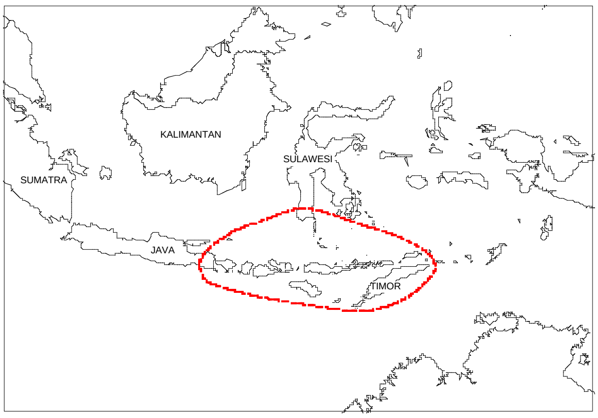

Figure 1. Generalized distribution of sandalwood in Indonesia

Methodology

a. Sandalwood resources

As much of the initial stands of sandalwood have been exploited, there is concern now for its survival and the habitat in which it grows. The natural regeneration or artificial establishment is dependent on suitable host plants as well as a suitable forest and agricultural environment. *Santalum* is generally vulnerable to fire and grazing animals, both of which are common in its habitats.

Recent data on the current status of sandalwood stands in NTT is not available, but the rapid decline of sandalwood resources in Timor Islands is reflected from the inventory carried out by the Provincial Forestry Service in which during the 10 years period from 1987 to 1997 (Dinas Kehutanan 2006), the number of sandal trees dropped almost 50% from 544,952 trees to only 250,940 trees. Worst situation was found in east Sumba, where in 1990 over 27,900 trees were reported still exist; recent inventory in 2001 found only 3,253 trees left.

b. Major threats

Sandalwood genetic resources have been under threat for decades, partly due to unfavourable legislation that discourage farmers/villagers to plant and look after the tress. According to Red List category of IUCN 1994, sandalwood in Timor is classified as EN (endangered) (P3HT 2005). In the past sandalwood trees and trade had been tightly controlled by the Government to the extent that famers who illegally cut or mistreated sandalwood trees could face criminal charges. The regulations provided little incentives for the local people to get involved in sandalwood resource management.

Another major threat is of course over-exploitation of this species in natural stands. Unsustainable harvesting is the main threats to sandalwood in Timor Islands. In addition, most people in Timor are subsistence farmers who have been practicing shifting agriculture for centuries. Fire is the main tool in subsistence agricultural land clearing and development. Uncontrolled fires have reduced the regeneration of sandalwood in natural stands because they change the structure of the stands (UNEP-WCMC 2007). Extreme climatic condition in west Timor with long interval of dry season has added to the difficulties in the rehabilitation of sandalwood resources resulted in low success rate of planting.

c. Genetic diversity

Study on *S. album* was carried out to examine genetic diversity and genetic relationship from 17 populations (Rimbawanto *et al.* 2006). The study examined 16 populations from Timor Islands namely Polen, Bu'at, Oenlasi, Aen Ut, Kuma', Haumeni, Snok, Noemuti, Amanuba Selatan, Amanuba Tengah (Timor Island); Omtel, Pailelang, Waisika (Alor Island); Katikutana, Hambala, Mondu (Sumba Island), and 1 landrace from Karangmojo (Java). Each population was represented by 12 individuals. Using 17 RAPD primers, the study found that the average genetic diversity within population was 0.391, while diversity between populations was 0.038. These data also showed that around 96% of genetic diversity resides within population. For genetic conservation purposes, this situation is even more critical because depletion of natural stand has gone unchecked. When trees in a natural stand are gone, the whole genetic diversity of the stand is also disappeared.

Cluster analyses based on population data revealed that the 17 populations were divided into 2 big groups. In general the clustering of the populations did not reveal clear relationship with geographic distribution; however geographically-closed populations were clustered into small group (Rimbawanto *et al.* 2006). Lack of association between geographic location and genetic cluster suggests that the remaining trees might have come from narrow genetic base and was brought into the area in recent times.

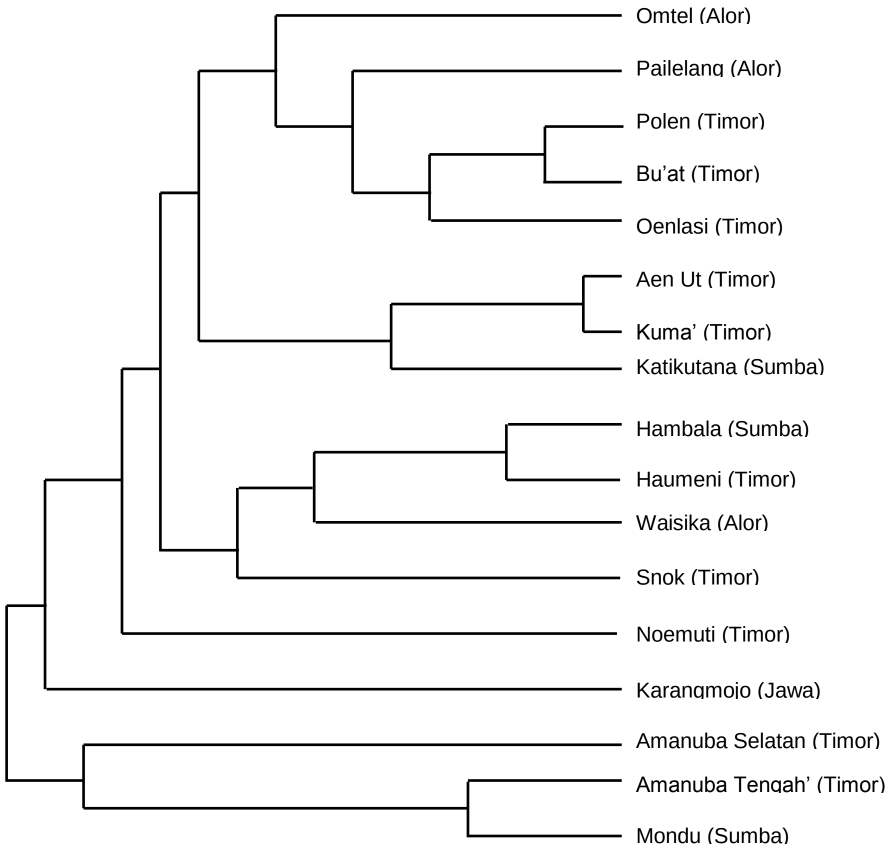

Figure 2. Grouping of sandalwood from different population/geographical locations

Results and discussions

Conservation strategy

The conservation strategy is developed based on relevant known information of the sandalwood such as biology, distribution, utilization and threats. The overall objective of the strategy is to better manage sandalwood genetic resources in Timor Islands for conservation and utilization. It should be emphasized that this conservation strategy will have any impact only if all the stakeholders are actively participating accordingly. Without active participation from all stakeholders, sandalwood in Timor Islands will never return to its glorious time. Loss of sandalwood genetic resources in Timor Islands will not only affect the islands but in the long run would have significant effect on the sustainability of sandalwood in general.

Conservation of sandalwood genetic resources in Timor Islands aims at maintaining the available genetic variation that exists both within and among the remaining sandalwood stands/populations. It puts emphasize on maintaining intra-specific genetic diversity. This conservation effort shall involve preventing extinction of genetic resources and ensuring their availability for future use.

Details of the proposed strategy are as follows.

Step 1

Conduct an inventory of the remaining sandalwood trees in Timor Islands:

Such an inventory will provide critical data and information of the current status of sandalwood natural stand and identify suitable seed stands. For resource management purposes such information will be useful to set limits for harvesting so that management of the resources can be planned with a focus on sustainability.

Step 2

Maintain existing remaining sandalwood trees to protect the remaining genetic resources and to prevent further loss of genetic diversity: Sandalwood trees found in Timor Islands are mostly scattered individually, or in small groups; trees grown in a stand are no longer existed. Furthermore, sometimes it is not possible to assure the origin of the tree.

Step 3
Collect seeds from the existing trees found across Timor Islands and establish *ex-situ* conservation plots in several locations as well as for operational plantations: Seed collection is an important part and should be done annually to provide sufficient seedlings for the programme. Coordinated attempt to explore and collect seeds from all the remaining natural trees/stands should be instigated and implemented.

Step 4
Planting programme for rehabilitation of natural stands, as well as for commercial production of sandalwood, should be continued. More effort should be done to ensure better success rate. This planting programme will ensure that sandalwood trees will one day return to the Timor Islands.

Step 5
Continuing research on sandalwood necessary for the development of a scientifically based conservation strategy, including:

- improve knowledge of the distribution of sandalwood in Timor Islands, especially identifying the remaining natural stands/trees, when necessary use DNA method to assert the origin of the tree (parental analysis);
- identify factors involved in successful regeneration; and
- determine genetic structure of the species.

Research institution should take a leading role in the conservation efforts collaborating with other government agencies such as the Provincial Forest Service of NTT, Watershed Management Centre, and Centre for Conservation of Natural Resources, the universities, as well as NGOs or community groups.

References

CABI (CAB International). 2000. *Santalum album, Forestry Compendium: Global Module*, CAB International, UK.
Coppen, J.J.W. 1995. *Flavours and Fragrances of Plant Origin*. Non-wood Forest Products 1. Food and Agriculture Organisation of the United Nations, Rome.
Doran, J.C., Thomson, L.A.J. and Brophy, J.J. 2002. Sandalwood, *In:* L. Thomson, S. Bulai and L. Sovea (Eds), *Proceedings of the Regional Workshop on Sandalwood Research, Development and Extension in the Pacific Islands and Asia, 7–11 October 2002*, Noumea, New Caledonia, SPC Forest and Trees Programme, Suva, Fiji.
Dinas Kehutanan Propinsi, N.T.T. 2006. *Rencana Pengembangan Cendana di Nusa Tenggara Timur/ Sandalwood Development Plan in East Nusa Tenggara* (in Indonesian), Dinas Kehutanan Propinsi NTT, Kupang.
Harisetijono and Suriamihardja, S. 1993. Sandalwood in Nusa Tenggara Timur, In F. H. McKinnell (ed.), 1990, *Proceedings of a Symposium held on 2 June 1991 at the XVII Pacific Science Congress, Honolulu, Hawaii*, ACIAR Proceedings No. 49, 39–43. Canberra.
P3HT (Pusat Penelitian dan Pengembangan Hutan Tanaman). 2005. *Data base jenis-jenis prioritas untuk konservasi dan pemuliaan/Database of priority species for conservation and breeding* (in Indonesian). Pusat Penelitian dan Pengembangan Hutan Tanaman. Yogyakarta.
Rahayu, S., Wawo, A.H., van Noordwijk, M. and Hairiah, K. 2002. *Cendana: deregulasi dan strategi pengembangannya* (Sandalwood: deregulation and strategy of development), World Agroforestry Centre-ICRAF, Bogor.
Rimbawanto, A., Widyatmoko, A.Y.P.B.C. and Sulistyowati, P. 2006. *Distribusi Keragaman Genetik Populasi Santalum album berdasarkan Penanda RAPD/Genetic diversity of S. album revelaed by RAPDs markers* (in Indonesian with Englsih abstract). *Jurnal Penelitian Hutan Tanaman* 3(3) 2006. ISSN 1829-6327.
UNEP-WCMC (United Nations Environmental Programmes–World Conservation Monitoring Centre), 2007. *Tree Conservation Information Service: Santalum album*, United Nations Environmental Programmes–World Conservation Monitoring Centre, Available at: http://www.unep-wcmc.org/trees/trade/san_alb.htm (Accessed 26 July 2011).

Seed Characteristics of *Xanthoceras sorbifolia* in Several Areas of China

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Xanthoceras Sorbifolia Bunge, only one species in this genus, belongs to the family Sapindaceae. The seeds of this species, originated from China, contain a lot of unsaturated fatty acids, which are edible and medicinally usable (Li *et al.* 2010, Zhang *et al*. 2010). Recently much attention has been paid to this tree because of its high potential as a resource of biodiesel and horticulture.

In 1970s it was planted on a large scale in Inner Mongolia, Liaoning, Gansu, etc. in China. However, as it is known as “a tree of thousand flowers but one fruit", its seed productivity is so variable year by year, and very hard to predict (Ding and Ao 2008). To increase the production of seed it is highly recommendable to raise fertile individual and/or family. Thus the understanding of seed traits is indispensable before selecting the trees or families excellent in seed production. However, seed characteristics were not reported much so far.

In this study, seeds from six areas in Inner Mongolia and Liaoning in China were collected and evaluated. The characteristics recorded were seed length(mm), width(mm), and weight(g); weight and volume of 1,000 seeds; and weight and number of 1L seeds.

The seeds were collected in late August 2011 from four origins in Chifeng, Inner Mongolia; and two in Choyang, Liaoning, China. The information on locations is as given in Table 1.

Table 1. Locations of trees and plantations for seed collection

Name	Location	Latitude	Longitude	Altitude
Jingjilinchang	Ongniud Banner, Chifeng, Inner Mongolia	N42°57'50.7"	E119°00'31.7"	633m
Lindonglinchang	Baarin Left Banner, Chifeng, Inner Mongolia	N43°58'17.1"	E119°22'45.3"	485m
Tree No. 38	Ar Khorqin Banner, Chifeng, Inner Mongolia	N44°13'55.3"	E119°56'20.4"	451m
Tree No. 160	Ar Khorqin Banner, Chifeng, Inner Mongolia	N44°13'55.3"	E119°56'20.4"	451m
Jianping Agri. Res. Station	Jianping County, Chaoyang, Liaoning	N41°21'34.0"	E119°34'06.5"	499m
Qingsonglingxiang No. 1	Jianping County, Chaoyang, Liaoning	N41°46'15.7"	E119°56'51.7"	547m

The seeds were stored at room temperature. Ten seeds were selected from each seedlot at random to measure length, width and weight. In addition, seeds were classified into three groups: large, medium and small, and 10 seeds were measured in each class for the traits above. The moisture content was measured with HB43-S Moisture Analyzer, Mettler Toledo, Switzerland. Weight and volume of 1,000 seeds are helpful for understanding seed traits of each seedlot. However, some of the sources could not supply 1,000 seeds. For these sources, the weight and volume of 100 seeds were measured five times per seedlot and the data on 1,000 seeds were estimated. Weight and number of one-litre seeds were estimated based on the data of 200ml seeds repeated five times.

The seeds of Qingsonglingxiang No. 1, growing alone in an open space, showed the highest values in seed length(16.08mm), width(14.48mm) and weight(1.40g). Those of Tree No. 160 in Arhorqin County have the lowest measurements: 11.48mm for length, 11.81mm for width, and 0.73g for weight, respectively (Table 2). The similar trends were found for every trait in the categorized seeds (Table 3). Traits of seeds varied quite a lot between trees and among areas. For example, Trees No. 38 and No. 160 produced quite different seeds in several traits, although they are adjacent to each other in the same farm.

Table 2. Several seed traits of each seedlot

Seedlot name	Length(mm)*	Width(mm)	Fresh weight(g)	Water content (%)
Jingjilinchang	$14.33^{c}\pm0.35$	$13.65^{c}\pm0.27$	$1.08^{b}\pm0.06$	$25.20^{a}\pm3.46$
Lindonglinchang	$14.08^{bc}\pm0.33$	$13.38^{bc}\pm0.36$	$1.04^{b}\pm0.07$	$26.40^{a}\pm2.70$
No. 38	$13.28^{b}\pm0.23$	$13.08^{bc}\pm0.24$	$0.93^{b}\pm0.05$	$24.13^{a}\pm3.18$
No. 160	$11.48^{a}\pm0.23$	$11.81^{a}\pm0.23$	$0.73^{a}\pm0.04$	$23.53^{a}\pm3.26$
Jianping Agri. Res. Station	$13.80^{bc}\pm0.27$	$12.61^{b}\pm0.29$	$0.75^{a}\pm0.04$	$26.67^{a}\pm2.27$
Qingsonglingxiang No. 1	$16.08^{d}\pm0.21$	$14.48^{d}\pm0.20$	$1.40^{c}\pm0.06$	$37.53^{b}\pm4.43$
Average	13.64±0.76	13.00±0.46	0.95±0.13	27.97±2.66

*The same alphabet means that there is no significant difference at 5% level by Duncan's Multiple Range Test.

Table 3. Length, width and fresh weight of each seedlot when divided into three categories

No.*	Length(mm)**			Width(mm)			Fresh weight(g)		
	Small	Medium	Large	Small	Medium	Large	Small	Medium	Large
1	$12.60^{b}\pm0.46$	$14.26^{bc}\pm0.27$	$16.10^{c}\pm0.48$	$12.58^{cd}\pm0.40$	$13.20^{b}\pm0.25$	$15.17^{b}\pm0.28$	$0.76^{c}\pm0.76$	$0.98^{b}\pm0.03$	$1.49^{c}\pm0.05$
2	$10.43^{a}\pm0.33$	$14.87^{b}\pm0.55$	$15.10^{b}\pm0.30$	$11.32^{b}\pm0.36$	$13.70^{b}\pm0.30$	$15.10^{b}\pm0.54$	$0.63^{b}\pm0.07$	$1.10^{c}\pm0.05$	$1.39^{c}\pm0.06$
3	$11.93^{b}\pm0.31$	$13.64^{b}\pm0.19$	$14.26^{b}\pm0.25$	$11.77^{bc}\pm0.10$	$13.24^{b}\pm0.26$	$14.23^{b}\pm0.37$	$0.62^{b}\pm0.03$	$0.98^{b}\pm0.03$	$1.19^{b}\pm0.02$
4	$10.44^{a}\pm0.30$	$11.41^{a}\pm0.24$	$12.58^{a}\pm0.31$	$10.51^{a}\pm0.29$	$11.81^{a}\pm0.12$	$13.12^{a}\pm0.20$	$0.47^{a}\pm0.04$	$0.74^{a}\pm0.01$	$0.97^{a}\pm0.03$
5	$12.56^{b}\pm0.36$	$13.90^{b}\pm0.32$	$14.94^{b}\pm0.43$	$11.83^{bc}\pm0.25$	$11.71^{a}\pm0.43$	$14.29^{b}\pm0.34$	$0.55^{ab}\pm0.03$	$0.66^{a}\pm0.03$	$1.03^{a}\pm0.03$
6	$14.88^{c}\pm0.22$	$16.51^{d}\pm0.25$	$16.85^{c}\pm0.23$	$13,28^{d}\pm0.24$	$14.94^{c}\pm0.14$	$15.22^{b}\pm0.27$	$1.01^{d}\pm1.01$	$1.52^{d}\pm0.04$	$1.65^{d}\pm0.05$
Avg.	12.14±0.68	14.10±0.68	14.97±0.61	12.22±0.50	13.64±0.50	14.68±0.35	0.75±0.09	1.14±0.13	1.39±0.11

*1 – Jinjilinchang; 2 – Lindonglinchang; 3 – Tree No. 38; 4 – Tree No. 160; 5 – Jianping Agri. Res. Station; and 6 – Qingsonglingxiang No. 1.
**The same alphabet means that there is no significant difference at 5% level by Duncan's Multiple Range Test.

Weight of 1,000 seeds varied from 718.0g to 1,010.1g, and volume from 0.76 L to 1.52 L (Table 4). Weight of 1-liter seeds were 522.3g to 688.2g, while the number of seeds were 603 to 935. It is necessary to understand seed traits to select a superior clone or provenance in the increased, successful production of seed.

Table 4. Weight and volume of 1,000 seeds; and weight and number of 1-L seeds*

Name	Weight of 1,000 seeds(g)	Volume of 1,000 seeds(L)	Weight of 1-L seeds(g)	Number of 1-L seeds
Jingjilinchang	805.00	0.96	597.00	714
Lindonglinchang	735.00	0.76	615.90	830
Tree No. 38	950.50	1.05	570.60	603
Tree No. 160	727.60	0.80	673.00	935
Jianping Agri. Res. Station	718.00	0.86	522.30	695
Qingsonglingxiang No. 1	1,010.10	1.52	688.20	689
Average	824.37±51.46	0.99±0.11	611.17±25.51	743.33±48.33

*Only means are shown without standard deviation because every mean is estimated from the measurements of 100 seeds and 200ml seeds, separately.

Acknowledgements

This research was supported by the Agricultural Development Agency of the Republic of Korea (Project No. PJ008229) to the corresponding author.

References

Ding, M.X. and Ao, Y. 2008. Research progress on the flowering and fruit set of *Xanthoceras sorbifolia* Bge. *Chinese Agric. Sci. Bull*. 24(10):381–385. (In Chinese with English Abstract)

Li, J., Zu, Y.G., Fu, Y.J., Yang, Y.C., Li, S.M., Li, Z.N. and Wink, M. 2010. Optimization of microwave-assisted extraction of triterpene saponins from defatted residue of yellow horn (*Xanthoceras sorbifolia* Bunge.) kernel and evaluation of its antioxidant activity. *Innovative Food Science and Emerging Technologies* 11:637–643.

Zhang, S., Zu, Y.G., Fu, Y.J., Luo, M., Liu, W., Li, J. and Efferth, T. 2010. Supercritical carbon dioxide extraction of seed oil seed oil from yellow horn(*Xanthoceras sorbifolia* Bunge.) and its anti-oxidant activity. *Bioresource Technology*. 101:2537–2544.

Conservation of *Aquilaria* (Thymelaeaceae) in Peninsular Malaysia

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Gaharu, a valuable resin, is mainly sourced from the genus *Aquilaria* (Thymelaeaceae). Driven by lucrative trade demand, the unsustainable harvesting of *Aquilaria* trees in the wild is dangerously decimating the populations and this has become a global concern. While efforts have been taken to establish *Aquilaria* plantations worldwide, trees are still being harvested from the wild, both legally and illegally. To regulate its trade, *Aquilaria* was listed in the Appendix II of CITES (CITES 2011). There are five species of *Aquilaria* in the rainforests of Peninsular Malaysia (Turner 1995) and these are *A. beccariana* Tiegh., *A. hirta* Ridl., *A. malaccensis* Lam., *A. microcarpa* Baill. and *A. rostrata* Ridl..

Before a sustainable source of gaharu can be established, one needs to understand the reproductive and regeneration patterns of indigenous *Aquilaria*. In this respect, a project was initiated recently to study the reproductive ecology of the most sought-after species, *A. malaccensis*. The research data will be used to develop both *in situ* and *ex situ* conservation measures. In addition, conservation assessment based on IUCN will be conducted on all *Aquilaria* species from Peninsular Malaysia.

Methodology

Four field surveys had been conducted since the study began in March 2011. The main purpose of these surveys was to identify study sites. All individuals 5 cm diameter at breast height (DBH) and above were tagged. The coordinate reading for each tree was obtained using Garmin GPSMAP 60CSx. Trips were made periodically to monitor flowering and fruiting activities as well as to trace new individuals of *Aquilaria* tree, if any. Other aspects investigated include phenology, pollination, germination and population viability.

Conservation assessment based on the IUCN Red List Categories and Criteria version 3.1 (IUCN 2001) was carried out on the five species. Data on each species was obtained from the herbarium specimen notes and if possible through ground truthing. These data were then transferred into the Botanical Research and Herbarium Management System (BRAHMS) and maps were subsequently generated from ArcView GIS 3.2a. Assessments were made by filling the Taxon Data Information Sheet (TDIS) which is now available from http://www.chm.frim.gov.my. In the TDIS, there are five sections pertaining to the taxon which need to be filled. These are Taxon Attributes, Geographical Range and Demographic Details of Population(s), Red List Category and Criteria Assessment, Current Conservation Measures for the Taxon, and Utilisation (Chua and Saw 2006).

Results and discussions

Several locations with healthy populations were identified. These populations reside in the fragmented forest areas of Universiti Teknologi Petronas (UTP), Perak; and several locations on the island of Penang. The total number of trees in the UTP population is 15 with DBH ranging from 10 to 70 cm, while in Penang, there are 154 trees recorded with DBH between 5 and 90 cm (Figures 1 and 2). The Penang populations occur in Penang Botanic Gardens (PBG), Government Hill, Teluk Bahang Recreational Forest and Penang National Park. Between March and October, several trees from the populations in Penang Botanic Gardens and Teluk Bahang Recreational Forest had flowered and fruited. Preliminary result showed that the species requires almost four months from flower initiation to complete mature fruit fall. Flowering may last about one month. Fruits begin to set even before the flowering phase ends and a fruit may take about one and a half months to mature before splitting which signals maturity. The duration from budding to first flowering inflorescence is not known.

The 15 trees from UTP occupy an area of approximately 38 ha of fragmented forest. During the study period, one tree was observed barely fruiting and another has several young seedlings, believed to be from the previous fruiting season. Some larger seedlings measuring between 20 cm and 2 m of height were also recorded but further away from the mother trees. A giant black squirrel was spotted on the tree and is believed to consume *Aquilaria* fruits. In PBG, there are clear indications that the fruits are eaten by small mammals such as macaques and tree squirrels. The regeneration of the trees in the Gardens is often prevented by general hygiene work where young seedlings are frequently swept away.

Fruits suspected to be viable were collected at the last phase of the fruiting period, in the fourth month of the flowering-fruiting period. The germination rate ranged between 10 and 80%.

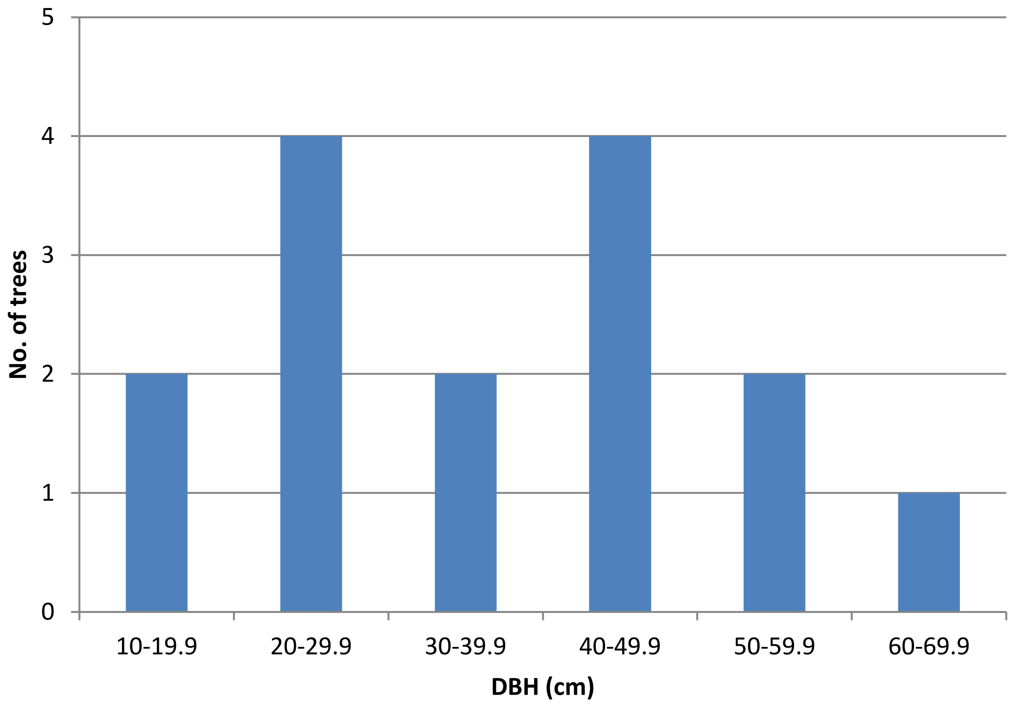

Figure 1. Number of trees according to DBH classes in UTP as of December 2011

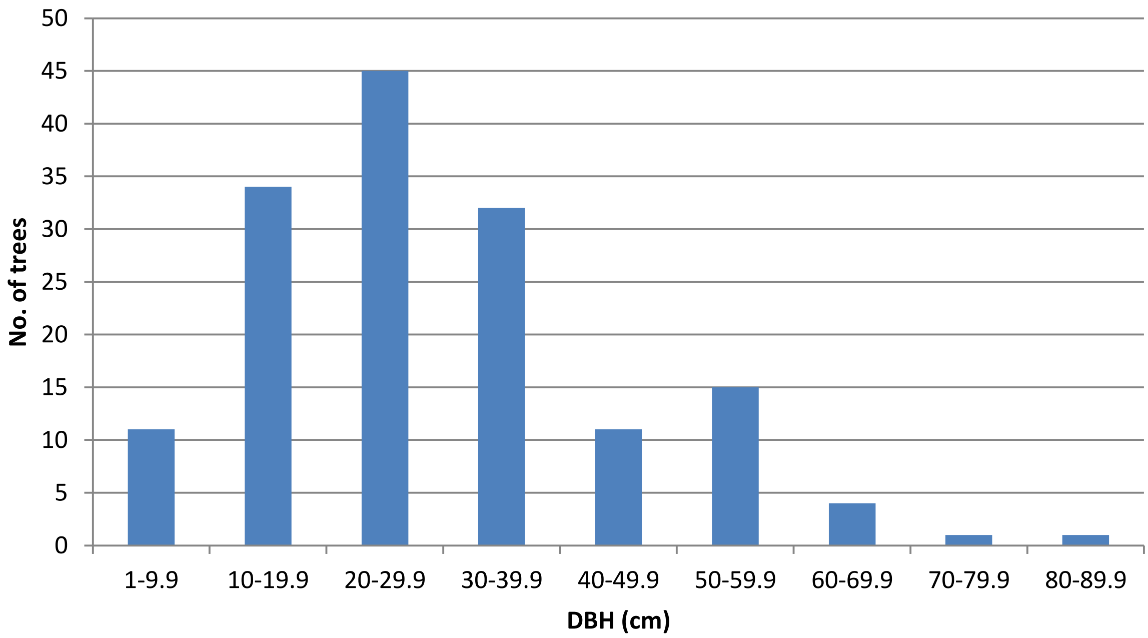

Figure 2. Number of trees according to DBH classes in Penang as of December 2011

In terms of conservation status, two species are considered Vulnerable (VU), while the remaining three are Data Deficient (DD). *Aquilaria hirta* and *A. malaccensis* are vulnerable to habitat loss and over-exploitation. For *A. beccariana, A. microcarpa* and *A. rostrata*, there is insufficient information to verify its status and existence as they are either known only from a single herbarium specimen or from literature. As expected, there are differences between the Peninsular Malaysia's assessment and the IUCN global assessment (Table 1). The conservation assessments made for Peninsular Malaysia are based on current sources. For example, *Aquilaria beccariana* is widely distributed in Sumatra and Borneo but poorly known in Peninsular Malaysia. Therefore, it is rated DD.

Table 1. Comparison between Peninsular Malaysia's and the global conservation status of five *Aquilaria* species

Species	Peninsular Malaysia status	Global status (ARW 1998, WCMC, 1998a, b, c and d)
Aquilaria beccariana	DD	VU (A1d)
Aquilaria hirta	VU (A4cd)	VU (A1d)
Aquilaria malaccensis	VU (A4cd)	VU (A1cd)
Aquilaria microcarpa	DD	VU (A1d)
Aquilaria rostrata	DD	DD

References

Asian Regional Workshop (Conservation & Sustainable Management of Trees, Vietnam) 1998. *Aquilaria malaccensis*. In: IUCN 2010. IUCN Red List of Threatened Species. Version 2010.4. <www.iucnredlist.org>. Downloaded on 22 February 2011.
World Conservation Monitoring Centre, 1998a. *Aquilaria beccariana*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. <www.iucnredlist.org>. Downloaded on 24 October 2011.
World Conservation Monitoring Centre, 1998b. *Aquilaria hirta*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. <www.iucnredlist.org>. Downloaded on 24 October 2011.
World Conservation Monitoring Centre, 1998c. *Aquilaria microcarpa*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. <www.iucnredlist.org>. Downloaded on 24 October 2011.
World Conservation Monitoring Centre, 1998d. *Aquilaria rostrata*. In: IUCN 2011. IUCN Red List of Threatened Species. Version 2011.1. <www.iucnredlist.org>. Downloaded on 24 October 2011.
CITES, 2011. Appendices I, II & III. http://www.cites.org. Accessed in 27 October 2011.
Chua, L.S.L. & Saw, L.G. 2006. *Malaysia Plant Red List. .Guide for Contributors.* Forest Research Institute Malaysia. 28 pp.
IUCN, 2001. IUCN Red List Categories and Criteria: version 3.1. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge.
Turner, I.M. 1995. A catalogue of the vascular plants of Malaya. *Gard. Bull. Sing*. 47:1–757.

Acknowledgements

This project is funded by the Ministry of Natural Resources and Environment. The authors would like to thank Forestry Department Peninsular Malaysia, Department of Wildlife and National Parks Peninsular Malaysia, Universiti Teknologi Petronas and Public Works Department of Penang for granting permission to enter the forest sites. We also thank the staff from the Penang Botanic Gardens for their assistance.

Conservation and Protection of Songga Tree (*Strychnos lucida R Brown*) as Rare and Valuable Tree Species – A Case Study in Sumbawa Island, Indonesia

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Songga tree *(Strychnos lucida R Brown),*is from the Loganiaceae family. This species is native to Australia, Thailand (*Phayaa Muun Lek)*, and Indonesia. In Indonesia, it is called Bidara laut or Songga on Sumbawa Island. Habitat of this species is in dry and windy coastal areas, mostly found in primary forest (Roemantyo 1994). Distribution of this species almost all in the forest area in Dompu District of Sumbawa Island, East Java Province, Roti Island, Timor Island, and South East Maluku Province. Habitat of this species is from 0–500 m above sea level. Local people on Sumbawa Island use this plant for many medicinal purposes such as aphrodisiac, anti hypertension, anti fertility, anti diabetes, anti malaria, anti inflammation, anti cancer, antidote for snake bite, anti rheumatism, and for healing bone fracture. Infusion 10% of songga wood with 400 mg/kg bw dose had antipyretic, diuretic and hypoglycemic effect (Yoyoh *et al*. 1978). Lethal dose fifty (LD50) of infusion songga wood treated to mice was 27.11 g/kg bw (Gery 1986).

It has high and competitive price in international trade, so this species is very valuable for local people. Unfortunately, the existence of this species in nature is being threatened because of over exploitation. Moreover people around the forest have exploited this species in the nature without any effort to cultivate them.

Methodology

This study was conducted on Sumbawa Island, Nusa Tenggara Barat Province, Indonesia, in October 2009. The methods were: direct observation in the field, and survey of home industry of songga cup, literature reviews, and interviews of local people and key informants in the study area.

Results and discussions

Utilization of Songga tree (Strychnos lucida R. Brown) in Sumbawa Province
Songga tree contains secondary metabolite such as: alkaloid, strychnine, brucine, tetra hydro strychnine, brucidine, tetra hydro brucine, pseudostrychnine, α-β-culubrine, vomicine, loganin, chlorogenic acid, mannosan and galactan. Nearly all parts of the Songga tree (roots, fruits, and stem) could be used as traditional medicine. Stem and roots are used as medicine to treat fever, snake bite, wound, and eczema. The roots are used for anti diabetes, while leaves and fruits are applied as antidote (Rahayu and Walujo 1996, de Padua *et al.* 1999). Nowadays, there is a simple way to use this species as traditional medicine. Cups made from songga wood have being sold as souvenir has medicinal effect. Just pour hot water into the cup not more than five minutes. The waste of songga cup processing made into tea bag.

Economical value of Songga tree (Strychnos lucida R Brown)
Songga tree is an important source of traditional medicine on Sumbawa Island. It has been made into songga cups in Dompu District, about four home workshops still exist and producing songga cups. Each workshop could produce 420 cups per day. It has high value as an export commodity. The price in the local market is about USD1.50–2.00 per cup, but the export price can be as high as USD25 per cup. The demand in international trade is quite stable, mostly exporting to Malaysia, Hong Kong and Singapore. Unfortunately, these workshops cannot meet the increasing demand due to shortage of raw materials.

Problems
1. Over exploitation of raw material;
2. People have exploited this species from the forest without putting any effort to cultivate them;

3. The existence of this species is threatened in nature, but local government has not taken action to plant this species as one of the priority commodities;
4. Distribution chain and market of songga cup are not clearly understood;
5. Even though this species has been used by many people on Sumbawa Island for years, but research about this species as medicinal plant is very limited

Figure 1. Process of making Songga cup

Recommendations

Songga tree not only has the potential as an important source of traditional medicine, but it also has high economical value. Shortage of raw material could not fulfill the increasing demand from many countries. Thus, it is very urgent that local communities are encouraged to develop forest plantation. Development of songga plantation not only will increase the local people's income, but will also improve the environment. Local government should collaborate with research centre and university research programme to develop this species.

References

Annon. 1985. *Tanaman Obat Indonesia Jilid II*. Direktoral Jendral Pengawasan Obat dan Makanan RI:Jakarta.

De Padua, L.S., Bunyapraphatsara, N.. and Lemmens, R.H.M.J. (Eds.). 1999. *Plant Resources of South East Asia No. 12(1): Medicinal and Poisonous Plants I.* PROSEA foundation, Bogor, Indonesia. Pp.185–190.

Geri, C.K. 1986. LD5O of Boiled Songga Tree *(Strychnos ligustrina* BI) on Rat. JF FMIPA UNHAS.

Sangat-Roemantyo, H. 1994. Hydrocotyle sibthorpioides Lamk. *In*: Siemonsma, J.S and Piluek, K. (Eds.). *Plant Resources of South-East Asia Vol.8: Vegetables.* Bogor: Prosea Foundation.

Supriadi**.** 1986. Hipoglichemic Effect of Boiled Songga Tree *(Strychnos ligustrina* BI.) on Rabbit. JF FMIPA UNHAS**.**

Sukandar, E.Y. Ny., Soegiarso, N.C. and Payayuani, I. 1979. *Anti Inflamation And Analgesic Effect of Songga Tree (Strychnos ligustrina Bl).* Pharmacy Bandung Technology Institute.

Yoyoh, K., Padmawinata, K. and Andreanus, A.S. 1978. *Test of Farmacology Effect of Songga Tree (Strychnos ligustrina) BI on Animal Model*. School of Pharmacy ITB.

Acknowledgements

This study could not have been possible without considerable support from the Ministry of Industry in Bima District, and the home workshops of Songga tree in Bima. Deepest appreciation goes to Forest Research Development Agency, Ministry of Forestry, Republic of Indonesia for funding this study. Last but not least, I wish to thank the staff of Industrial Departement, and the producers of songga cup who deserve special gratitude for their contribution in various ways

Community Participation in Conservation and Protection of Rare and Valuable Tree Species Sandal Wood (*Santalum Album*)

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Sandal (*Santalum album*) naturally grows in some dry scrub forests mainly located in two administrative districts: Badulla and Rathnapura. Due to large domestic and international demand, sandal trees in most of the forests in Sri Lanka are indiscriminately exploited. In addition to the organized illegal fellings, the natural regeneration of this valuable species has been badly hampered due to fire, grazing and browsing mainly by the nearby communities. Various law enforcement efforts such as boundary demarcation, declaration as conservation forests, and increase the physical protection capacity by attaching more field staff for patrolling duties, were implemented by the Forest Department to protect and conserve these valuable sandal-bearing forests. These protection efforts were able to control illegal fellings up to some extent but failed to control the fire and grazing problems which are the main causes for destruction of the natural regeneration. However, natural regeneration is very important for the substance of the sandal-bearing forests as top revenue earner and also to conserve its genetic diversity (Radomiljac *et al.* 1998)

Methodology

Recognizing that the "Participatory Management" is one of the best approaches in some Asian countries for sustainable forest management, the Sri Lanka Forest Department decided to use that for a pilot learning exercise for conservation and protection of a few selected sandal-growing natural forests. The three selected forest areas were bordering to villages and having substantial numbers of forest offences such as illegal felling, forest fires and illegal grazing during last three years. The details of the three forest areas selected for this pilot exercise during early part of 2003 are given in Table 1.

Table 1. Details of the sandal growing forests selected for the pilot exercises

Districts	Name of the forest	Extent (ha)	Average rainfall (mm)	Legal status
Badulla	Uva-Paranagama	82	1000–1200	Conservation Forest
Badulla	Soranatota	55	550–600	Conservation Forest
Ratnapura	Rajawaka	110	450–550	Conservation Forest

All three forest areas are categorized as dry monsoon scrub forests located in sloppy lands with moderate elevations and with dry climate conditions, where Sandal (*Santalum album*) is naturally growing. Three villages adjacent to the selected forest areas were earmarked by the Forestry Extension Officers to participate in this pilot level protection and conservation exercise. These three villages were selected based on the criteria such as dependency on forest use of the community members, the level of threats on natural regenerations caused by fire and grazing, and willingness of community members to engage in a participatory forest management programme. The main income source for the villagers living in Uva-Paranagama and Soranatota was vegetable cultivation. The villagers in Rajawaka were mainly depended on shifting cultivation. Basic infrastructure facilities such as roads were very poor for all three cases. Even thought they engaged in commercial scale agriculture, they have not received systematic extension services and market assistance. Forest Department Planning Team decided to use this ground situation as a suitable platform to mobilize the community members for participatory conservation exercise. ***The aim was to develop some actions jointly in order to improve this situation of the villages which will lead to the livelihood improvement of the community members. Accordingly, the participatory model based on the "livelihood theory" was used for this pilot exercises. This livelihood theory assumes that improving livelihoods of the forest adjacent communities lead to sustainable forest***

management (Forest Department 2007). Systematically trained field officers and Extension Staff on participatory approach, community mobilization and resources management are keys for any successful community management exercise. Therefore, such well-trained staff with friendly attitude towards communities was hand-picked and deployed for this study. Based on the theoretical aspects the process given in Figure 1 has been adopted for this pilot learning exercise.

During the initial community meeting, the objective of the exercise, expectations of the Forest Department, responsibilities of both parties, and benefits for the participating communities and limitations of the programme, were clearly explained to the communities. Thereafter, informal community organizations for all three forest sites were formed. The objective was that formal Community Based Organizations (CBOs) will be finally established. The finalization of the management areas for this participatory management exercise was also very much important for smooth implementation of this exercise. Generally the unit for management use for this participatory management programme is one that contains the inhabitants of the selected village, the agriculture land resources, associated water/irrigation systems, and the forest area adjacent to the village where they are used or depended.

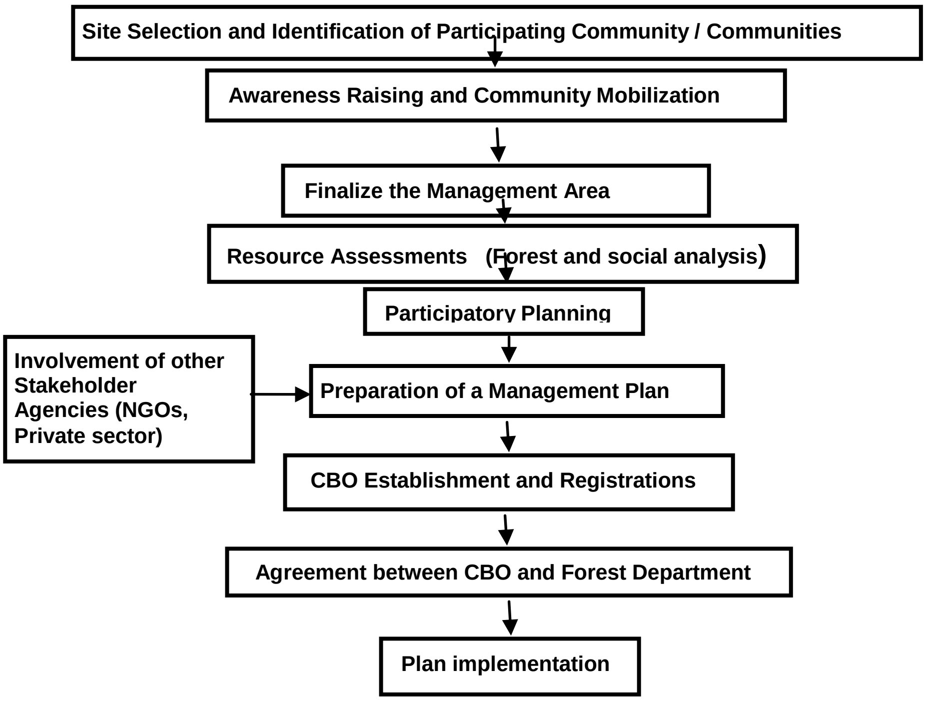

Figure 1. Participatory process

To mobilize poor community members for a task which does not provide immediate tangible benefits is always hard (Koselela *et al.* 2002). At the initial meetings, the community members were informed that the revenue out of the mature *Sandal Wood* harvesting will be shared by the government and the community but these benefits are long-term. Expected environment benefits of the conservation exercise will not provide sufficient encouragement for the community members to participate in this exercise. Therefore, various ***non-forest benefits*** were used to encourage the participation of the communities (Forest Department 2009)

For this exercises, a facilitation team lead by the Forest Department Extension Officers decided to have formal participatory planning exercise. The resource data, both social and natural resources data were collected. In order to assess the success of the exercise, the base line data on number of sandal tree/ha and present status of natural regeneration is very much important. In this regarded, a low intensity sampling inventory was conducted and with the aim of the revisit the same sample plots, GPS readings were also recorded.

Development of long- and short-term objectives of forest management and resource development are very crucial. Objectives were developed based on the needs and conditions of communities and forest as well as other resources. Specially, to improve the income level of the people, possible options to upgrade the present agricultural practices were discussed in details. All possible options to protect the sandal-growing forest from fire and grazing, and the improvement of the natural regeneration, were also discussed. While participatory planning process is in progress, the formation of the formal CBO was also initiated by the planning team. Within a CBO, several sub-committees based on various tasks were formed. The final plan was prepared as a five-year plan with detailed activities further elaborated and included as annual action plans. In summary two types of major activities were identified by the five-year plan: forestry activities and non-forestry activities. The details of the type of activities identified are given in Table 2.

Table 2. Forestry activities and non-forestry activities of the Plans

Forestry activities	Non-forestry activities
Enrichment planting and Gap planting with Sandal seedlings Dibbling of pelletised Sandal seeds in and around bushes and advance work areas.	**Category1 Livelihood Development** • Providing extension services for agriculture activities • Linkages with the private sector (to provide seeds and marketing support) • Income generation activities • Rural micro-finance support
Fire protection activities and protection against cattle. Regulating use of NTFPs specially fire wood	**Category 2 Rural Development** • Rural infrastructure developments (Roads, small irrigation schemes, community halls, etc.) • Linkages with other stakeholders who are dealing with rural development activities
Soil conservation and water harvesting (conservation of gully plugs and percolation ponds)	**Category Social Development** • Health Camps • Religious and cultural activities • Improvement for pre-schools
Home garden development by including planting of Sandal seedlings	

For those activities identified in the Plans which are beyond the mandate of the Forest Department, the planning process identified potential providers, and Forest Department assisted to establish necessary linkages.

Results and discussions

A participatory assessment carried out towards the end of 2010 has concluded that the approach used was effective in terms of reducing deforestation and forest degradation in all three selected forests, and the damage cause by fire and grazing were minimized. The natural regeneration status of sandal has been improved drastically. Apart from that, the community members have planted large number of sandal seedlings within their home gardens which are growing well. As results of the implementation of non-forestry activities of the plan, the livelihood of the participating communities has improved. In particular, productivity of the agricultural land has improved. The project has facilitated better markets for their agricultural products. The assessment also found that the ability of the CBO has improved up to the level that they are capable of sourcing external assistance for village development, and exploring some new economic activities. Most importantly, the programme has contributed to community cohesion and unity. However, In order to replicate this successful exercise in other areas, the challenges and limitations too would need to be examined. Systematically trained staff with friendly altitude towards communities is the key for any successfully community management exercise. Being a pilot exercise, the Forest Department has the luxury to hand-pick and deploy such capable staff for this project. However, expansion of participatory forest management programmes throughout the island will be a challenge to the Department due to the limitation of such trained extension staff. Therefore, an urgent capacity building programme for field staff on participatory forestry concepts and approaches, improved extension capacity to work with the community and more importantly develop their skills on coordination to work with other stakeholder agencies are critical for promoting this participatory forest management approach.

References

Forest Department. 2007. *Operational Guideline for Community Forest Management*.

Forest Department. 2009. *Sri Lanka – Australia Natural Resource Management Project & Forest Resource Management Project*, Workshop Proceeding of Participatory Management of Forest and Other Natural Resource in Sri Lanka

Koselela, J., Appanah, S. and Pedersen, A.P. (Eds). 2002. *Proceeding of the Southeast Asia Moving Workshop on Conservation, Management, and Utilization of Forest Genetic Resources*.

Radomiljac, A.M., Ananthapadamnobho, H.S. and Welbourn, R M. (Eds). 1998. *Sandal and Its Products*, Proceeding of an International Seminar organized by the Institute of Wood Science and Technology(ICFRE) and Karnataka State Forest Department, Bangalore, India.

Germplasm and Conservation of Rare and Endangered Tree Species Endemic to East China

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East China is a geographical region that covers the southeastern coastal zone of China, including Provinces of Zhejiang, Jiangsu, Shandong, Fujiang, Jiangxi, Anhui and Shanghai (Liu *et al.* 1995). The area of this region is 65.86 sq km. Most of the east China region locates in the northern and mid-subtropical monsoon region with superior natural condition, with annual rainfall of about 1100mm and moderate climate. So east China is one of the key biodiversity regions in the world (Gao *et al.* 2004, Ma *et al.* 2010). The main reasons for this are the ancient geological history and abundance various kinds of plants. With the global industrial expansion and the increase in urban population, the biodiversity of the world is decreasing rapidly. In east China region where there is rich biodiversity, ecological system is severely damaged and a large number of plant species have become extinct or endangered (Hao *et al*. 2000, Hu *et al*. 2002, Zheng *et al*.2008). It is critical to take necessary measures to protect endangered species endemic to the region in adaptation to global climate change.

Germplasm of rare and endangered tree species endemic to east China

There are 16 rare and endangered tree species endemic to east China belonging to 11 genera in 10 families (Table 1). Two of them, *Abies beshanzuensis* and *Carpinus putoensis,* are national first class protected wild plants (Fu *et al.*1992, Wang *et al.* 2004). Number of national secondary and third class protected endangered tree species is seven and five in east China, accounting for 43.8% and 31.3%, respectively. The last two tree species, *Carpinus tientaiensis* and *Tilia miqueliana*, are not listed in the China Red List of threatened plants. These two species are worthwhile to study for their endangered status (Tang and Tang,2007,Tang *et al.* 2008, Chen *et al.*2010), so they are included in this paper.

Reasons why the tree species become endangered

Reasons for rare and endangered tree species becoming endangered are many: narrow natural distribution area, low level of genetic diversity, habit change, poor natural regeneration and weak population competitiveness, and are often integrated rather than isolated (Oldfield *et al.* 1998). When efforts are made on their conservation and recovery, it is important to assess the main factors that result in the decline of their populations.

Conservation status of these rare and endangered tree species

The conservation situation is serious for the threatened level of endangered tree species endemic to east China. With the rapid economic development in east China, the local governments have realized the importance of protecting biodiversity. Fourteen of these endangered tree species have been listed in China Red List of threatened plants (Fu *et al.* 1992). The first law for protecting wild plants was published by the state council officially in 1996 (Wu *et al.* 2004). Everyone has made aware of the significance of protecting the wild species, and nobody dare to destroy the endangered species. Studies on conservation biology and genetics were carried out by the main research centres in east China. The research contents cover genetic diversity assessment, population structure, flowering and fruit characters, artificial propagation, and conservation strategies and so on.

Conclusion and future prospects

The germplasm of endangered tree species endemic to east China is an important part of biodiversity. Protection of these threatened germplasms is the main component of plant conservation strategies. Endangered tree species endemic to east China are worth studying for a better understanding of their ancient origin, and high threatened and conservation level. But severe conservation situation exists because the size of these tree species' population is getting smaller and smaller.

Table 1. Number and distribution of endangered tree species endemic to east China

Species	Protection grade	Wild individual number	Distribution area /ha	Distribution and habitats
Abies beshanzuensis	1	4	0.1	Zhejiang Province, Alt.(altitude) 1700m in beach forest
Carpinus putoensis	1	1	0.05	Zhejiang Province, Alt.240m,on Zhoushan Island
Torreya jackii	2	7000	56	Zhejiang and Fujian Provinces, Alt. 200–800m in steep shady slope or evergreen forest along both sides of valley
Sinojackia xylocarpa	2	0	0	Jiangsu Province, Alt.300–800m in forest edge
Ostrya rehderiana	2	5	0.4	Zhejiang Province, Alt.160m along both sides of valley
Neolitsea sericea	2	130	10	Zhejiang, Shanghai and Jiangsu Provinces, Alt.150–350m in evergreen forest of gully
Sinocalycanthus chinensis	2	60000	500	Zhejiang Province, Alt. 600–1000m understory along both sides of valley
Ulmus elongata	2	300	20	Zhejiang and Fujian Provinces, Alt.400–800m in open forest
Phoebe chekiangensis	2	3000	200	Zhejiang, Jiangxi and Fujian Provinces, Alt.150–1000m in open forest of gully
Magnolia cylindrica	3	8600	600	Zhejiang, Anhui, Jiangxi and Fujian Provinces, Alt.600–1700m in open forest of gully
Magnolia amoena	3	12000	900	Zhejiang, Anhui, Jiangxi and Jiangsu Provinces, lt.200–1000m in evergreen or mixed forest
Ulmus gaussenii	3	30	10	Anhui Province, Alt.60–100m along both sides of brook
Magnolia zenii	3	18	5	Jiangsu Province, Alt.180–230m in north slope of Baohua Mountain
Acer yangjuechi	3	1	1	Zhejiang Province,Alt.240–500m, in mixed forest of Tianmu Mountain
Carpinus tientaiensis	None	21	0.3	Zhejiang Province, Alt.800–1000m,in forest of Tiantai Mountain
Tilia miqueliana	None	500	10	Jiangsu, Zhejiang and Anhui Provinces, Alt.180–300m in broadleaf forests

References

Chen, M.S., Ke, S.S., Yang, Y.Y. and Yan, Q.Q. 2010. Anatomical Study on Vegetative Organs of *Carpinus tientaiensis*. *Journal of Zhejiang Forestry Science and Technology* 30(5):14–19.

Fu, L.G. 1992. *China plant red data book – threatened plants (Vol.1).* Beijing: Science Publishing House.

Gao, X.M., Wang, C., Hou, S.Q. and Ma, K.P. 2002. *Study progress on conservation ecology in China– The 5th national Symposium of protection conservation*. Beijing: Science Publishing House. pp. 37–45

Hao, R.M., Huang, Z.Y., Liu, X.J., Wang, Z.L., Xu, H.Q. and Yao, Z.G. 2000. *Chinese biodiversity* 8(2):153–162.

Hu, S.Q., Ding, B.Y. and Chen, Z.H. 2002. The critical regions for conservation of rare and endangered plant species diversity in Zhejiang Province. *Biodiversity science* 10(1):15–23.

Liu, F.X., Liu, S.H., Yang, Z.B., Hao, R.M., Yao, J., Huang, Z.Y. and Li, N. 1995. A floristic study on the seed plants from the region of east China. *Acta botanica Yunnanica* pp. 93–110

Ma, Q.X., Tian, Q. and Hu, Y.H. 2010. Rare and endangered plants and their protection in east China. *Journal of Hubei University for Nationalities* 28(3):310–313.

Oldfield, S.F., Lusty, C. and MacKinven, A. 1998. *The world list of threatened trees*. Cambridge: World Conservation Press

Tang, S.J. and Tang, G.G. 2007. Analysis on structure of *Tilia miqueliana* population in Huangcangyu Nature Reserve of Anhui Province. *Journal of plant resources and environment* 16(3):58–63

Tang, S.J., Peng, Z. and Tang, G.G. 2008. A community characteristics analysis on *Tilia miqueliana* in Baohua Mt. *Journal of Yangzhou University (agricultural and life science edition)* 29(1):90–94.

Wang, S. and Xie, Y. 2004. *China Species Red List (Vol.1).* Beijing: Higher education publishing house.

Wu, X.Q., Huang, B.L. and Ding, Y.L. 2004. The Advance on the Study of Protection of Rare and Endangered Plants in China. *Journal of Nanjing Forestry University* 28(2):72–76.

Zheng, Z.Z. and Jin, X.F.. 2008. Study on the Chinese endemic genera of seed plants distributed in the region of east China. *Journal of Zhejiang University (Science edition)* 35(6):668–673

The Traditional Knowledge Survey of Plants in Gangwon Province, The Republic of Korea

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Traditional knowledge is referred to as the knowledge conveyed from the previous generations to the present one about using materials originated from plants or animals in food, medicine, household goods, etc. They are typically not established yet scientifically and/or technologically. It used to be known as local knowledge, traditional ethnobotanical knowledge (TEK), indigenous knowledge (IK), sustainable knowledge, folk knowledge, cultural knowledge, etc. (Gervais 2003). It was ignored sometimes from the aspect of science but it is much valuable because it can be the source of valuable information for various fields including medicine and food.

Traditional knowledge has been recognized by the Convention on Biological Diversity (Article8:j) from the aspect that it may preserve biodiversity and respect native people's existence. Rio Declaration also suggested that settled villages and people must be protected for managing environment and to control development.

Fifty-eight percent of patents obtained were discovered from the chemical contents of oriental plants which were used to make oriental medicines (Barsh 2001). Thus protecting native people and preservation of their traditional knowledge will secure the supply of valuable plant materials. Otherwise, these resources may be used by other people rather than indigenous people. From the aspects of ABS (Access to Genetic Resources and Benefit-Sharing), it is important to protect plant resources and improve resource information documentation.

This study was aimed at surveying and documenting traditional knowledge on mountain-grown plants through the interviews of local people in Gangwon Province, the Republic of Korea.

Methodology

Survey was conducted in Gangwon Province, which is located in the mid-eastern part on Korean Peninsula. The Province was divided into five survey areas, for the sake of convenience, along the Baedudaegan Mountain Range. However, this paper will report information gathered from three regions only. People who are more than sixty years have been interviewed, and the same person had been visited at least twice to verify the mentioned knowledge.

Results and discussions

All the results of the interviews are shown in Figure 1.

It was found that men have more traditional knowledge than women. It is presumed that men usually work in the field and have more chances to harvest plants in mountain and field than women. Persons who are 80 to 85 years old knew more than persons of other ages. More than half of the plants surveyed were used as medicines to cure cold, fever, stomach ailments, joint pains, injury, woman's diseases, etc. The secondary usage was for food and instruments. Some of the plants were used differently both in purpose and method by different communities. Medicinal and edible plants were important during the last decades because medicines and even food were not easily available due to colonization and internal conflicts. Some plants used have toxic materials, but interviewees knew well how to remove them, although the process was not supported scientifically and technologically. Thus it needs a lot of caution if one takes these plants as food or medicine. The most popular part of a plant is leaf, whole plant, wood, fruit and bark, in that order. It was believed that herbs are used more frequently than trees because they are easily accessible and not necessarily divided. The collection season was from spring to autumn, widely distributed throughout the year.

As a lot of people did not like to be interviewed, more surveys are necessary to get valuable, useful traditional knowledge.

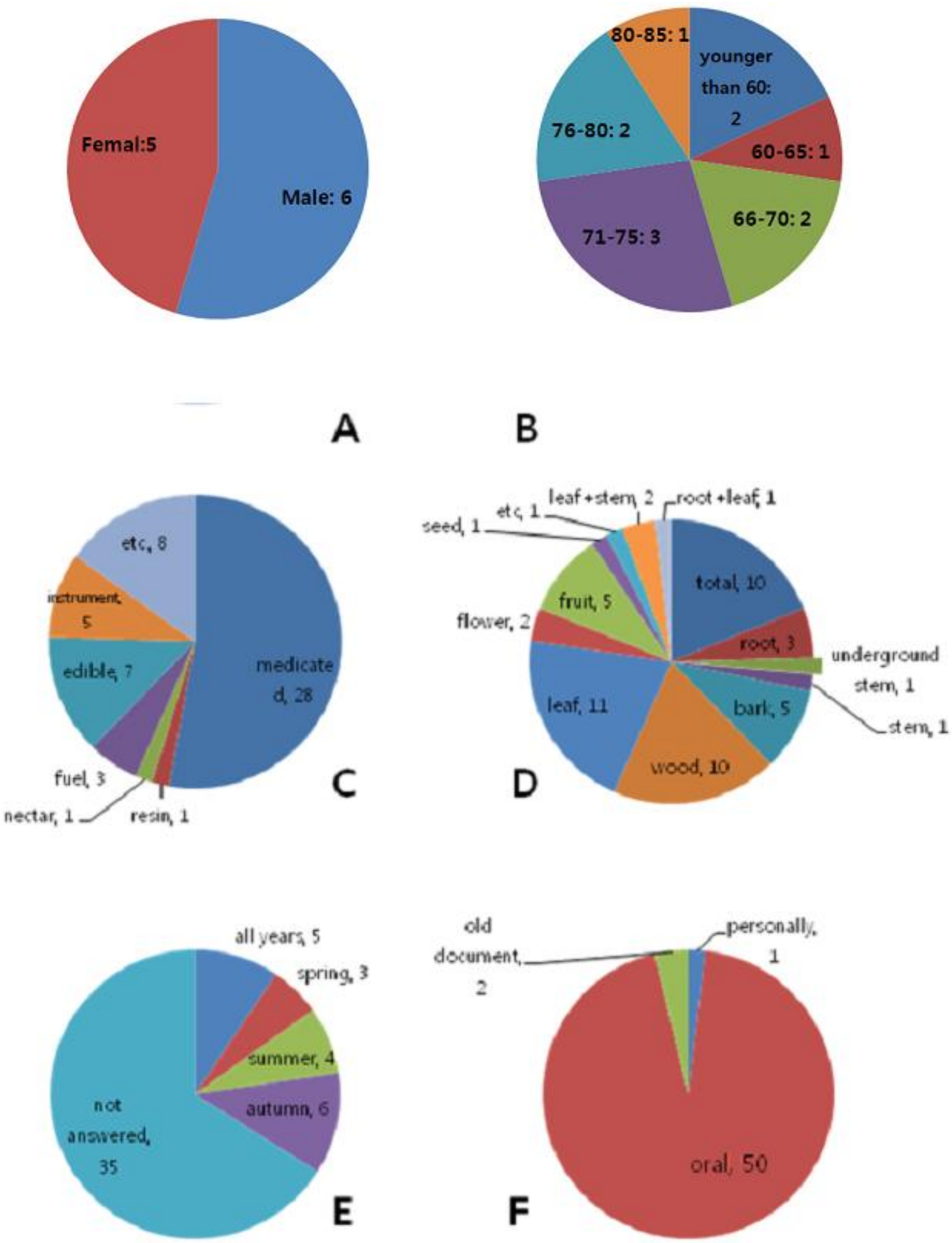

Figure 1. The diagrams show the results of interviews. A: gender distribution, B: age distribution, C: utilization, D: part of plant used, E: collection season, and F: source of information

Acknowledgements

This study was carried out with the support of Forest Science & Technology Project (Project No. S211010L020110) provided by Korea Forest Service.

References

Gervais, D. J. 2003. Spiritual but not Intellectual? The Protection of Sacred Intangible Traditional Knowledge. *Cardozo Journal of International and Comparative Law* 11: 467–495.

Barsh, R.L. 2001. Who Steals Indigenous Knowledge? *Proceedings of the Annual Meeting American Society of International Law* 95:153–161.

Camphor Tree Resources and Utilization

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Camphor tree is a large evergreen tree that grows up to 50 m tall. It is cultivated for camphor and timber production in south China, and has always been considered a valuable native tree species with high reputation (Liu 1990, Dai 1993).

Distribution and habitat

Camphor tree is intolerant and thermophilous, thus making it widely distributed between 88°–122°east longitude and 10–30°north latitude. As a native to China, camphor tree has been discovered in provinces of Guangdong, Jiangxi, Guangxi, Fujian, Taiwan, Yunnan, Zhejiang, Hunan, Sichuan, Guizhou, Hubei, Jiangsu, Anhui and Hainan. This species has been regarded as a representative tree species in tropical and sub-tropical regions (Li *et al*. 2007, Editorial Committee of China's Tree Species 2003). Its main producing regions are in Taiwan, Fujian, Jiujiang of Jiangxi, west of Hunan, southeast of Guizhou, Vietnam and Japan. Recently, camphor tree is also discovered in East Asia, Oceania, and Pacific Islands (Liu 1990).

Camphor tree usually grows in low mountains and plains at an altitude between 500 and 600 m. It is also discovered on borders of Hunan and Guizhou Provinces at an altitude of 1000 m and in north central Taiwan at 1800 m above sea level. Camphor tree is acclimated to regions with annual average temperature higher than 16 °C, average temperature in January higher than 5 °C, absolute minimum temperature higher than -7 °C, and annual precipitation higher than 1000 mm. This tree has a relatively faster height growth between 10 and 30 years, diameter-at-breast-height growth between 10 and 40 years, and individual-volume growth between 50 and 60 years. Camphor has a dense leafy crown, short and large trunk, and flourishing roots. Its lifespan can be as long as 1000 years (Liu 1990, Dai 1993).

Camphor tree resources utilization

There is a long history of exploitation and utilization of camphor trees in China. The first record of cultivation was as early as 2000 years ago. Camphor tree was cultivated for valuable hardwood, camphor production, and landscaping. Currently, it is mainly used for ecological improvement, timber production and by-product generation.

Ecological service function
Camphor tree has a dense leafy crown that makes it able to absorb smoke and dust in the air and also noise. Therefore this tree is highly resistant to environmental pollution and considered environmental-friendly. Currently this tree species has been broadly used for landscaping cities, residential areas and streets. Camphor tree has large biomass, rich fallen leaves, and flourishing root system, which makes it highly suitable for soil and water conservation. A statistic analysis reported that camphor trees have an average 92.52 tons of biomass per ha, of which 47% (43.48 tons) was carbon (Lee and Feng 2008). The annual carbon growth was 6%. A prediction from Yao (2003) suggested that 18-year-old camphor trees have 111.08 tons of biomass per ha. Another report from Lei *et al*. (2004) revealed that annual net productivity of camphor trees was 9.55 tons per ha, and its annual net amount of organic carbon sequestration was 4.98 tons per ha.

Wood Utilization
Camphor tree produces highly valuable timber with distinct heartwood and sapwood. Heartwood is yellowish-brown and sapwood is light-colour. The timber has shining surface and pleasant aromatic odour. It is resistant to damage by moths and perennially durable. Therefore camphor tree timber is high-quality and widely used for production of furniture, ship and artwork, and also in building architecture.

By-product development
Camphor tree has plenty of camphor oil in roots, stems, branches and leaves. Further processing of camphor oil can produce cineole, safrole, linalool, terpineol, and citral. These chemicals are widely used for production of medicine, perfume and food. Therefore camphor tree is closely associated with daily lives of human beings.

New variety development

Many research institutes in China have been carrying out genetic improvement on camphor trees. Based on breeding goals, genetic improvement can be divided into three research directions: the first is to select and breed superior varieties for establishment of fast-growing and high-yielding timber forests. The second is to enhance the yield and quality of camphor oil. And the third is to improve landscape characteristics (such as crown size, canopy form and stem form, etc.) for the purpose of greening cities, residential areas and streets.

Improvement of growth rate and wood quality
Two Chinese research institutes (Research Institute of Sub-tropical Forestry of Chinese Academy of Forestry and Guangdong Academy of Forestry) have engaged in genetically improving growth rate and wood quality of camphor trees since 1990s (Yao *et al.* 1999, 2002). The scientists have collected many germplasm resources, and made considerable progresses in selection and breeding of superior provenances and families. Recently they have developed the key technology for tissue-culturing camphor trees. By using the improved varieties, they have generated many high-quality seedlings for reforestations (personal communication).

Improvement of biochemical content and quality
It was as early as 1980s that provinces like Fujian, Jiangxi, Hunan, Guangxi and Zhejiang started genetic improvement of contents and properties of key biochemical compositions in camphor oil (Zhao 2005, Wang *et al*. 2010, Wu *et al*. 2011, Duan 2006). Many studies have been conducted on selecting and breeding superior varieties with higher content of linalool and camphol. Currently, many clones of linalool-type and camphora-type camphor trees have been obtained, and widely utilized with help of vegetative reproduction and management of coppice forests. Camphora-type trees have facilitated the establishment of camphol-processing industry in the provinces of Hunan and Jiangxi. This industry has become a new and stable economic growth point, enhancing the economic development of local areas (Gua *et al*. 2003, Chen and Sun 2006, Liao 2008, Xu *et al.* 2001).

Improvement of landscape characteristics
There are few studies reporting the genetic improvement of landscape characteristics of camphor trees so far. However personal communications suggested that many private companies and enterprises have made considerable efforts to improve the crown size, crown form, stem form, growth-rate, and resistance of camphor trees to pest and diseases by using cultivation technology and management.

In general, camphor tree has high economic value and plays a significant role in environmental protection. Because of its wide distribution across China, camphor tree is regarded as a regionally representative tree species native to south China. Unfortunately, this tree species suffered from over-exploitation during past decades, the natural forests degraded gradually. With the large-scale development of reforestation activities, plantations of camphor trees are increasing rapidly during recent years (Long 2000, Song 1998). However, the majority of seedlings used for reforestation were derived from low-yield and poor-quality secondary forests, thus leading to the plantations remaining low-yield and poor-quality. Therefore, it is of significance and urgency to select and breed new camphor tree varieties with improved quality. The improved varieties are able to significantly improve the productivity and economic benefits, and further enhance forestry industry sustainability.

References

Chen, H.M. and Sun, L.F. 2006. The exploitation and utilization prospects of borneol *Cinnamomum camphora* Resources in Ji'an. Jiangxi Province. *Scientia Silvae Sinicae* 42(3):94–98. (In Chinese)

Dai, B.H. 1993. *Studies of Wild Plant Resources*. Beijing Agricultural Publishing House, Beijing, pp. 25–236. (In Chinese)

Duan, B.L. *2006. Study on genetic variation of leaf-oil and its main ingredients of Cinnamomum camphora (L.) Presl*. Dissertation. (in Chinese)

Editorial Committee of China's Tree Species. 1983. *Afforestation Techniques of Main Tree Species in China.* China Forestry Publishing House, Beijing, pp. 124–132. (In Chinese)

Feng, F.L. and Li, X.D. 2009. The status and perspectives of camphor Tree in Taiwan. *Biological Sciences* 51:37–51. (In Chinese)

Gua, Z.G., Sun, X.Q. and Zhou, X.Q. 2003. Research and application of high speed breeding technology of *Cirmamonun camphora* (I) presl. *Hunan Forestry Science and Technology* 30(3):44–46. (In Chinese)

Lei, P.P., Xiang, W.H. and Tian, D.L. 2004. Carbon storage and distribution in *Cinnamomum camphor* plantation. *Chinese Journal of Ecology* 23(4):25–30. (In Chinese)

Li, Z.H, Wen, Q. and Dai, X.Y. 2007. Resource utilization presentation and expectation in *Cinnamomum camphora*. *Jiangxi Forestry Science and Technology* 6:30–36. (In Chinese)

Liao, H.B. 2008. Analysis and thinking of problem of developing borneol camphor. *Jiangxi Forestry Science and Technology* 3:1–6. (In Chinese)

Liu, Y.G. 1990. The Investigation report of the type resources of *Cinnamomum camphora* in Ji'an. *Jiangxi Forestry Science and Technology* 3:13–16. (In Chinese)

Lee, H.T. and Feng, F.L. 2008. A forest carbon sequestration inventory system: An Example of Camphor Trees in Taiwan. *Taiwan Journal of Forest Science* 23(Supplement):S11–22. (In Chinese)

Long, G.Y., Peng, Z.L. and Guo, D.X. 2000. The coppicing techniques and efficiency analysis of *Cinnamomum camphora*. *China Forestry Science and Technology* 14(6):30–31. (In Chinese)

Song, Y.F., Sun, X.Q. and Luo, J.L. 1998. The development and application of natural camphol. *Flavour Fragrance Cosmetics* (3):33–36. (In Chinese)

Wang, Y.H, Qin, Z.H. and Wu, Y.M. 2010. Plus tree selection of *Cinnamomum camphora* and character evaluation of camphor Oil. *Journal of West China Forestry Science* 39(2):18–21. (In Chinese)

Wu, M.L., Chen, X.L. and Liao, Z.X. 2011. Research utilization and prospect of borneol Camphor. *Jiangxi Forestry Science and Technology* 2:30–36. (In Chinese)

Xu, Y.M., Jiang, Z.H. and Bao, C.H. 2001. Comparative studies on differences of oil contents and wood properties among five clones of camphor trees. *Journal of Huazhong Agricultural University* 20(5):484–488. (In Chinese)

Yao, X.H., Ren, H.D. and Sun, Y.X. 1999. The analysis on genetic variance for provenance/families test at seedling stage of *Cinnamomum camphora*. *Forest Research* 12(3):283–290. (In Chinese)

Yao, X.H., Ren, H.D. and Sun, Y.X. 2002. A study on *Cinnamomum camphora*'s genetic variance & dominant selection for provenance/families. *Acta Agriculturae Universitiatis Jiangxiensis* 24(3):321–328. (In Chinese)

Yao, Y.J. 2003. *The biomass productivity and nutrient contents and accumulation in Cinnamomum camphora plantation*. Dissertation. (In Chinese)

Zhao, G. 2005. *A study on biochemical types and selection of excellent camphor trees of camphor trees in Fujian*. Dissertation. (In Chinese)

Conservation Status of Threatened Dipterocarps in Peninsular Malaysia

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Dipterocarpaceae is a family of 17 genera and approximately 500 species (Ashton 1982) of mainly tropical lowland rainforest trees. The family achieves its greatest diversity, dominance and majesty in the tropical lowland moist evergreen rain forests of the Indo-Malayan region and southwest Sri Lanka. Dipterocarpaceae is a family of significant socio-economic importance and is listed as one of the most threatened plant families in Malaysia. Many populations of Dipterocarps in Peninsular Malaysia are on the decline mainly as a result of land use changes and harvesting.

This decline has raised the importance of conserving threatened species. In view of Malaysia's vast diversity and the need to identify and prioritize conservation efforts, a Malaysia Plant Red List Project entitled "Conservation Monitoring of Rare and Threatened Plants in Peninsular Malaysia", funded by the Federal Government, was initiated in 2005. Conservation assessment on families, namely Dipterocarpaceae, Begoniaceae and Gesneriaceae, and long term monitoring work are currently being undertaken on selected hyper-endemics and threatened species from these families. For the Dipterocarpaceae in Peninsular Malaysia, a total of 164 taxa comprising 155 species were assessed (Chua *et al*. 2010).

Methodology

The conservation assessment follows the IUCN Red List Categories and Criteria version 3.1 (2001). There are nine categories: Extinct (EX), Extinct in the Wild (EW), Critically Endangered (CR), Endangered (EN), Vulnerable (VU), Near Threatened (NT), Least Concern (LC), Data Deficient (DD) and Not Evaluated (NE). To assign a category for a threatened taxon objectively, five criteria are used: population decline, geographic range in the form of extent of occurrence or area of occupancy, small population size and decline, very small or restricted population, and quantitative analysis.

Basic information for the taxon are placed in Taxon Data Information Sheet (TDIS) (Chua and Saw 2006) which comprises five parts, i.e., Taxon Attributes, Geographic Range and Demograhic Details on Population, Red List Category and Criteria Assessment, Current Conservation Measures for the Taxon, and Utilisation. This set of information provides the rationale to support the Red List category given to the taxon concerned and maintained in the form of a database by the Forest Research Institute Malaysia (FRIM). TDIS is available from http://www.chm.frim.gov.my/.

The taxon's geographical information is obtained from geo-referenced herbarium and voucher specimens. Taxonomic and nomenclature information of each taxon were checked by experts while its habitats, current threats and conservation measures were ground-truthed. The assessments were evaluated by a panel of reviewers comprising Dipterocarp specialists and experts.

Conservation status of threatened Dipterocarps

Taxa that are CR, EN and VU are collectively referred to as threatened. Ninety two taxa of Dipterocarps (56.1%) occurring in the peninsula have a threatened category nationwide; of these, 22 are endemic to the peninsula. Of the 92 taxa, fifteen taxa are Critically Endangered (CR), 35 taxa are Endangered (EN) while 42 taxa are Vulnerable (VU). *Shorea kuantanensis* is the only taxon in this family thought to be extinct in the peninsula. Compared to other states in Peninsular Malaysia, Pahang has the highest number of threatened taxa (59 taxa; 35.9%). It also has the peninsula's only extinct taxon. This paper discusses the conservation status of threatened Dipterocarps and provides some insight into conservation initiatives undertaken by respective stakeholders.

Species	Distribution	Conservation status	Current status as a result of awareness
Dipterocarpus sarawakensis	Sarawak, Brunei and Central Kalimantan. In Peninsular Malaysia known only from Sg. Dadong and Jerangau FR in Terengganu	CR A4c	Terengganu Forestry Department has gazetted Compartment 31 of Jerangau Forest Reserve and its 63 ha as Genetic Resource Area (GRA) and protected under High Conservation Value Forest (HCVF).
Vatica yeechongii	Selangor (Sungai Tekala Recreation Park) and Negeri Sembilan (Setul FR)	CR A4c, D2	Populations in Setul Forest Reserve are now protected under High Conservation Value Forest (HCVF).
Hopea subalata	Endemic to Kanching FR, Selangor.	CR B2ab(iii)	Compartment 2 of Kanching Forest Reserve, is now protected under High Conservation Value Forest (HCVF). Public Work Department of Malaysia had agreed to divert the proposed road away from the population.
Shorea peltata	Sumatra, Borneo (Sabah) and Johor (Gunung Arong FR, Tenggaroh FR and Jemaluang FR)	CR B2ab(iii)	This species is highlighted in the Johor Forest Management Plan (FMP) for a period 2006–2015 and being proposed as High Conservation Value Forest (HCVF).
Cotylelobium melanoxylon	Sumatra, Borneo and Johor (Gunung Arong FR, Tenggaroh FR and Jemaluang FR)	EN B2ab(iii)	Compartment 14 of Gunung Arong Forest Reserve, are now protected under High Conservation Value Forest (HCVF).
Dryobalanops beccarii	Johor (Panti FR, Kluang FR and Labis FR) and Borneo.	EN B2ab(iii)	Compartment 6A & 6B of Panti Forest Reserve, are now protected under High Conservation Value Forest (HCVF).
Shorea inappendiculata	Sumatra, Borneo and Johor (Gunung Arong FR, Tenggaroh FR and Jemaluang FR)	EN B1b(iii)+c(iii)	This species is highlighted in the Johor Forest Management Plan (FMP) for a period 2006–2015 and being proposed as High Conservation Value Forest (HCVF).

Discussions

As a result of the Dipterocarpaceae assessment, more than half of the taxa are in the threatened category. Many threatened taxa have little form of protection in the habitat they occupy and occur within the production forests. The Forest Department Peninsular Malaysia, for example, has taken positive actions towards protecting highly threatened species by giving protection status to the affected forest compartments. Several populations of the threatened species that occur in the compartment of Forest Reserve (FR) are now protected under High Conservation Value Forest (HCVF). The commitment and efforts of various stakeholders to support the maintenance of *ex situ* collection is crucial, especially for species that occur on private land. Through information sharing, close communication and cooperation between stakeholders, successful conservation for the threatened Dipterocarp species is now becoming a reality.

References

Ashton, P.S.1982. Dipterocarpaceae. *Flora Malesiana, Ser. 1*, 9: 237–552

Chua, L. S. L., Suhaida, M., Hamidah, M. and Saw, L. G. 2010. Malaysia Plant Red List. Peninsular Malaysian Dipterocarpaceae. *Research Pamphlet* No. 129. Forest Research Institute Malaysia.

IUCN. 2001. *IUCN Red List Categories and Criteria: Version 3.1*. IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge.

Chua, L. S. L. and Saw, L. G. 2006. *Malaysian Plant Red Data Book. Guide to Contributions*. Forest Research Institute Malaysia.

Acknowledgements

This project is funded by the Ministry of Science, Technology and Innovation (MOSTI) of Malaysia through the National Council for Scientific Research and Development (MPKSN) under a special science fund (Project No. 01-04-01-0000 Khas). We wish to thank the Forestry Department Peninsular Malaysia for the sharing of GIS data on forest cover. Special thanks are due to Johor, Selangor, Negeri Sembilan and Terengganu State Forest Departments for their cooperation and permission granted. We also wish to acknowledge the contributions made by the team members of the Conservation Unit, Forest Research Institute Malaysia.

Legal Settings to Conserve Valuable and Endangered Trees Using Village Common Forest and Forest Tree Tenure in Bangladesh

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The Constitution of the People's Republic of Bangladesh, 1972 (amended 2011), provides that all citizens shall have the right to hold, acquire, transfer and dispose of property. The total area of Bangladesh is about 147 570 km^2. The country consists of low, flat and fertile land with a network of rivers flowing to the Bay of Bengal, except for the hilly regions in the northeast and the southeast. The total forest area in Bangladesh, according to Forest Department, is estimated to be 2.52 million ha corresponding to 17.4% of the land of the country. This includes 1.52 million ha Forest Department controlled land, 0.73 million ha Unclassified State Forests (USF) (Figure 1) under the control of District Administration and 0.27 million ha village forest land (mostly homesteads). However, National Forest and Tree Resources Assessment 2005–2007 found forest cover of the country as 9.8% as per definition of FAO.

There are three major natural forest types in Bangladesh: semi-evergreen forest occurring the eastern hills, deciduous Sal forest on the central and northwestern terraces, and the mangroves littoral forest facing the Bay of Bengal. Besides, fresh water swamp forest occurs in low-lying areas of Sylhet and also in depressions within semi-evergreen forest. Additionally, there are human raised village forests all over the country which are highly productive. Major paradigm shifts in forest land and tree tenure came into force during 1989, when government ban (moratorium) on harvesting of trees (because 3.3% deforestation rate prevailed in that year) from the public and private forests and introduce community and social forestry activities. Furthermore, the government had taken initiative to involve people in some protected areas in reserve forests of Bangladesh.

Village Common Forest (VCF) is a natural forest other than the government forest around the households of the ethnic communities, and is being managed to fulfill their daily needs. The community-managed VCF in the Chittagong Hill Tracts (CHT) may be a forest repository to combat constraints generated by deforestation and protect people's valuable plant species not only for regular livelihood (food, fodder and medicinal) but also restore their spiritual thoughts of ethnic minorities, as well as facilitating conservation of valuable tree species for communities.

However, VCF is yet to be recognized in legal settings of forest land tenure. Therefore, a need may exist to unfold the capabilities of VCF to conserve economically valuable and ecologically suitable forest tree species in a fragmented homestead forest not restricted to CHT but expend the protocol throughout Bangladesh. This study will focus on how paradigm shift of forest tree tenure through village common forests (VCF) in hilly regions of Bangladesh may facilitate conservation of economically, socially valuable and endangered forest tree species in Bangladesh. This study also correlate how the VCFs may be incorporated with country's legal settings particularly key forest related legislations: Forest Act 1927 (amended in 1989) and the Private Forest Ordinance of 1959.

Methodology

This study focused on different forest land tenures in present legal settings. However, a theoretical framework was drawn to elucidate capabilities of VCF using available literatures and field visits. In addition, this study also reviewed different forest resource assessment reports conducted by FAO, World Bank, Bangladesh Forest Department (BFD); and relevant forest laws and policies to accommodate VCF in a legal frame.

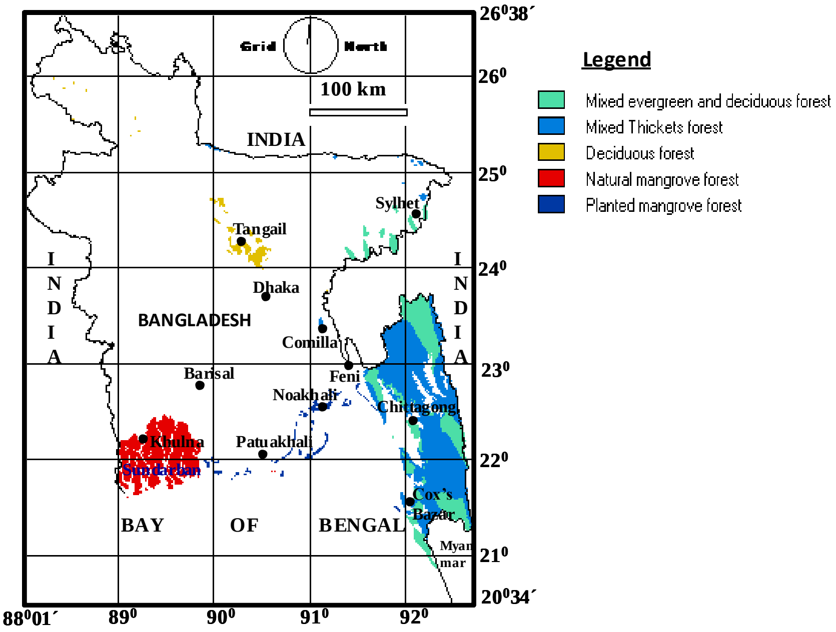
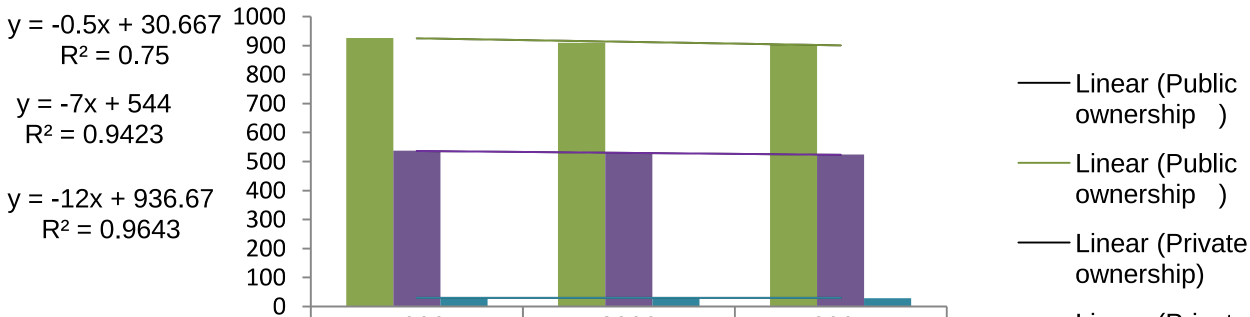


Figure 1. Forest distribution in Bangladesh (Al Amin 2011)

Results and discussions

VCF as a means to conserve plant diversity

Plant biodiversity is decreasing day by day in forests of government managed forests with alarming rate of deforestation (0.3% per year). However, VCFs are enriched with high biodiversity. Most of the VCFs are heterogeneous in floral composition, are more in number than government managed reserve forests in CHT. Many socially and economically valuable and endangered tree species like *Swintonia floribunda*, *Aphanamixis polystachya, Artocarpus chaplasha, Albizia procera, Alstonia scholaris, Anisoptera scaphula, Pterospermum*, *Quercus* are being protected and conserved in VCFs. Baten *et.al*. (2010) reported that 173 floral species are found in VCFs which indicates rich in diversity compared to government managed forest. The natural forests all over the country have depleted alarmingly (Figure 2). The National Biodiversity Strategy and Action Plan for Bangladesh has pointed out that the forest cover has come down to 6% from 10% of the area of the country (Choudhury and Hossain 2011).



	1990	2000	2005
Public ownership	926	910	902
Private ownership	538	528	524
Other types of ownership	30	30	29

Figure 2. Trends of Forest Land Tenure change of Bangladesh in 1990, 2000 and 2005 (‘000’ ha)

However, Forest Resource Assessment Report 2010 illustrated that forest area of Mouza Circle or un-classed state forest remains unchanged due to cultural, traditional and ancestral beliefs of indigenous communities (Figure 3).

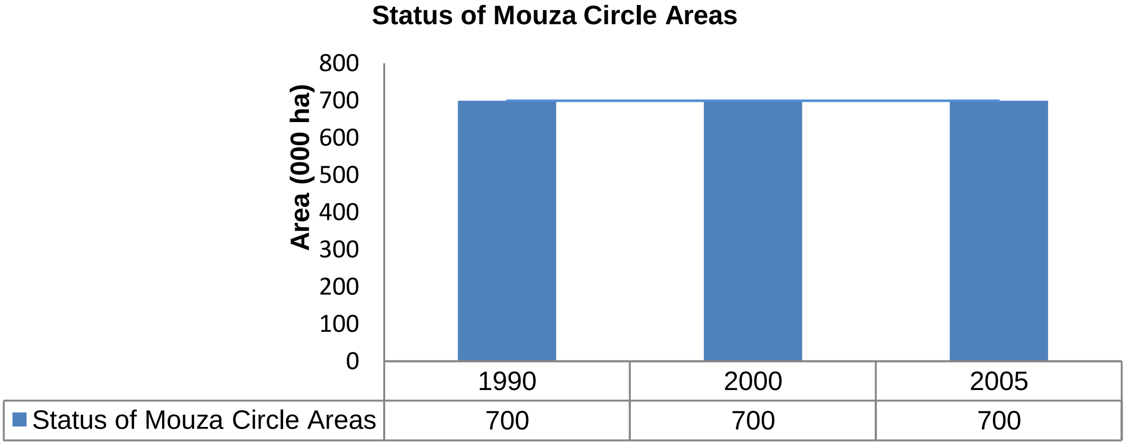


Figure 3. Status of Mouza Circle Areas

Legal settings

Forest Act 1927 (Amendment, 1989)
The Forest Act of 1927 as amended in 1989 has its roots in the Indian Forest Act, 1878. The Forest Act grants the government several basic powers, largely for conservation and protection of government forests, and limited powers for private forests. The act was amended in 1989 for extending authority over "any [Government-owned] land suitable for afforestation". The areas in Bangladesh that are referred to as "village forests" are actually privately owned land covering about 270,000 ha. Under the Forest Act the government may establish village forests by assigning parts of reserved forest to particular villages for their use. However, this provision has never been used in Bangladesh. Under current social conditions and existing institutional structure, the Forest Department finds it difficult to enforce many of the rules and regulations issued under the Forest Act. For example, forged claims and encroachment are common due to rough and incomplete records of land; and moving people from encroached forest land is socially and politically sensitive. Bangladesh is seriously considering improvements to enforceability of the legal provisions through changes in acts, rules, regulations, and institutional structures of the forest department. The efficiency of change will however be defined by the development of local institutions and human resources for conservation of natural resources.

The Bangladesh Private Forest Act (PFA), 1959
The Private Forest Act of 1959 allows the Government to take over management of improperly managed private forest lands, any private lands that can be afforested, and any land lying fallow for more than three years. The Private Forest Ordinance was originally enacted in 1945, as the Bengal Private Forest Act, and was re-enacted by the Bangladesh (then East Pakistan) in 1949 before being issued as an Act in 1959. PFA 1959 empowers the government to implement management plans for private forests and to assume control of private forests as vested forests. Government has broad powers to write rules regarding the use and protection of vested forests, and apply rules to "controlled forests," which include all private forests subject to any requirement of the Act. The Bangladesh (The East Pakistan) Private Forest Management Rules, 1959, provides a format for preparation of such management plans of private forests. The format follows outlines of the traditional forest timber management plans that do not deal with other forest produce, wildlife, or environmental amenities. After finalization and approval of the management plans by the government, the private owner becomes bound to implement the plan and in case of the default, the government may take over management of the land as a vested forest. Community perception of tenure security (using title deed) is very important. Tenure security has been difficult to attain, as governments continue to assert ownership of the forests, and traditional tenure is undocumented. This situation leaves indigenous people vulnerable to pressures from both government and communal interests.

Conclusion and recommendations

VCFs are of immense value for environmental, economic, medical and cultural reasons. These forests contribute to conserve valuable tree species considering changing climate and socio-political situation of Bangladesh. Although, VCFs are now only practiced in the hilly part of the country with its indigenous technology, however, may be an replicable forestry practice for the rest of the deltaic region (flat lands), particularly, in marginal, common or community possessed lands in villages of Bangladesh to conserve valuable tree species, Forest resource developments require moving from centralized to decentralized management system for paradigm shift. The Bangladesh government is yet to develop any legal framework that supports and recognizes VCFs officially. However, detailed study of the success of VCF in forest species conservation is yet to be done and need thorough (in depth) study in near future, which will help to recognize VCF legally.

References

Al-Amin, M. 2011. *The application of spatial data in Forest Ecology & Management; Windthrow, Carbon Sequestration, Climate Change.* Lap-Lampard Academic Publications. USA. 242 pp.

Baten, M. A., Khan, N. A., Ahammad, R. and Missbahuzzaman, K. 2010. *Village Common Forests In Chittagong Hill Tracts, Bangladesh: Balance Between Conservation And Exploitation, Unnayan Onneshan.*

Choudhury, J. K. and Hossain, M. A. A. 2011. *Bangladesh Forestry Outlook Study.* Food And Agriculture Organization Of The United Nations Regional Office For Asia And The Pacific.

FAO. 2010.*Global Forest Resource Assessment 2010, Country Report , Bangladesh*. Rome.

Strategies for Sustaining Sandalwood Resources in East Nusa Tenggara, Indonesia

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Sandalwood (*Santalum album* Linn.) is an important natural asset for the East Nusa Tenggara (ENT) Province, Indonesia, and has been used for various commercial products. Sandalwood had been commercially traded since the 10th century (Husain 1983) and contributing to about Rp 2.5 billion annually or about 40% of the total ENT provincial income during 1986 and 1992 (Suara Pembaharuan 1994). Since the last two decades, sandalwood population in the ENT Province has been decreasing with an alarming rate and had forced the provincial government to ban sandalwood harvesting during 1997 and 2003.

Over cutting, wild grazing and land conversion to support agriculture activities had caused sandalwood population in ENT Province continuously decreasing. Unsustainable wood harvesting, such as by digging up sandalwood stumps and roots, which otherwise play important roles for its natural regeneration, has accelerated sandalwood extinction (Rohadi *et al.* 2004). Previous studies (Rohadi *et al.* 2000, Rohadi *et al.* 2004, McWilliam 2001, Marks 2002) have identified root problems in sandalwood management. The studies concluded that low participation of local people on sustaining or cultivating sandalwood resources was caused by previous government policies that neglecting local people's rights. Efforts on sandalwood plantations are limited to government pilot projects with limited areas as well as their survival. In the mean time, demand of sandalwood by the handicraft and sandalwood oil industries remains high to fulfill both domestic and export markets. These conditions have been continuing for a long time and may lead to sandalwood extinction in the region.

Some revised policies have been taken to meet some local people needs, but people participation remains low. New approach is needed to create more conducive policies to increase people participation on sustaining sandalwood resources. This research is aiming at finding these new strategies by addressing three main aspects: reviewing the history and development process of policies and management practices that applied on sandalwood resources in the region, understanding local people perceptions regarding to the existing policies, and analyzing the economic incentives currently available for local people who involved in sandalwood management and or plantations.

Methodology

The study had been conducted during April and July 2010 in four districts within the ENT Province: Alor, East Flores, East Sumba and South Central Timor Districts. Rapid appraisal method was applied to collect data and information from relevant stakeholders that involved in sandalwood use and management in each district. The research team has visited 24 villages in total during the rapid appraisal. In addition, an inventory of sandalwood trees was completed in April 2010 in 23 villages in South Central Timor District. The inventory counted and measured stem circumferences of sandalwood trees greater than 20 cm in the villages which approximately represents 50% of the total sandalwood population grown in these villages.

The Oakerson's analytical framework (Oakerson 1992) was adopted in this study to analyze the impact of policies to people's behaviours and outcomes on sandalwood resources. A Strength, Weakness, Opportunity and Threat (SWOT) exercise was completed during the focus group discussion, participated by representative stakeholders in South Central Timor District to find alternative strategies for more effective participation of local people on sandalwood maintenance and cultivation.

Results and discussions

Sandalwood resources in the ENT Province had been tightly controlled under government authorities. Under the Regional Regulation (Peraturan Daerah/PERDA) No. 16/1986, all sandalwood resources in the province belong to the government regardless of their occurrence whether they are grown on the private or state lands. A major policy change took place in 1999 through the issuance of PERDA No. 2/1999 that started to acknowledge the right of community on sandalwood that grown on their private lands. The new regulation also handed over sandalwood resource management from the provincial government to district governments. An implementation guideline issued by the Provincial Governor regulated sandalwood management during the transition era, when the district governments have not yet issued their regional policies or regulations.

The study observed, however, that different policies over sandalwood resources are applied in the districts following that new regulation. Some districts have not issued any new regulation so far, leaving sandalwood resources remain administered under the Governor's guidelines. Some other districts have issued new policies, but leaving some ambiguities on the rights of local people on sandalwood use and trade. In most occasions, the new policies have not yet able to attract local people to actively invest on sandalwood cultivation.

The local people in the ENT Province have long experiences of low economical incentives on sandalwood cultivation. The history has shaped non cooperative behaviour of local people on sustaining the resources. In the past, the local people might only be benefited from the labour wages from sandalwood harvesting and some small proportions of sandalwood sales if the trees were grown on their private lands. In contrast, the real competitive market could actually provide much higher potential benefit for the locals. The international market price of sandalwood could reach up to AUS$ 40,000 per ton of wood or about Rp 280,000 per kg (Regina 2009). Assuming the price at local market could reach Rp 150,000 per kg, and a single sandal tree at 50 years old could produce 50 kg of heartwood, then an intensive sandalwood plantation with density of up to 250 trees per ha may yield up to Rp 1.875 billion, or it may contribute to an annual income of up to Rp 37.5 million. The demand for sandalwood is high and has reached 1,600 tons per year to fulfill the global sandalwood oil demand of 80 tons per year (Ministry of Forestry 2009).

Interview with many stakeholders at the study sites indicated that positive responses from local people on sandalwood cultivation could be expected when their rights on resources are secured and they can freely market their sandalwood as such is happening for other timber species. The interview underlines the importance of clear recognition from the government on the rights of ownerships of local people, and this in particular refers to the sandalwood that grows on lands under the private ownership. The rights of ownership should encompass rights to make decision on utilization, including cutting and selling the trees.

The inventory of sandalwood stands in the observed villages indicated that most of the sandalwood trees currently available were dominated by young trees with stem circumference less than 50 cm or approximately less than 16 cm in diameter. Apparently, almost all remaining sandalwood plantations were found on private lands, while information on sandalwood grows in state forest is very limited. Regardless of its population trend which is likely to decrease over time compared to the condition in the past or during the 90's, sandalwood germplasm in the form of young stands and seedlings remain widely distributed across the province. This condition may support efforts to develop sandalwood population in the future.

Based on the conclusion drawn from this study, the following strategies are recommended:

1 To develop new regulations on the management and utilization of sandalwood to accomodate needs of local communities through participatory process. Particular attention should be paid to guarantee local rights on the sandalwood resources and free market system for sandalwood trade.
2 To integrate government programmes on forest and land rehabilitation with sandalwood plantations and engage local people in the programmes by providing attractive benefits.
3 To support and facilitate initiatives on community based forest management, such as farm forest (HR), community forest (HKm) and Community Plantation Forest (HTR) and integrate sandalwood cultivation in these initiatives.

4 To strengthen institutional capacity on forestry extension for better facilitation to the local communities, in particular on their technical skills following a people-centered approach.
5 To develop database on sandalwood plantations through better coordination among relevant government agencies.
6 To develop techniques on conservation of natural regeneration and cultivation of sandalwood through research.
7 To support intensive cultivation of sandalwood through agroforestry system on the private lands.

References

Husain, A.M.M. 1983. *The rehabilitation of Sandalwood and the trade in Nusa Tenggara Timur, Indonesia.* Regional Planning and Preparation of Investment Oriented Projects in NTB – NTT. Direktorat Tata Kota dan Tata Daerah, Direktorat Jenderal Cipta Karya, Departemen Pekerjaan Umum. Jakarta.

Marks, S.V. 2002. NTT sandalwood: Roots of disaster. *Bulletin of Indonesian Economic Studies* 38(2): 223–240.

McWilliam, A. 2001. Haumeni, not many: renewed plunder and mismanagement in the Timorese Sandalwood Industry. *Resource Management in Asia-Pacific Working Paper* No. 29. Resource Management in Asia-Pacific Programme, Division of Pacific and Asian History, Research School for Pacific and Asian Studies, The Australian National University. Canberra.

Ministry of Forestry. 2009. Dunia Kekurangan Minyak Cendana 80 ton per tahun. Siaran Pers Departemen Kehutanan No: S.48/PIK-1/2009. http://114.4.5.222/index.php?q=id/ node/5086, [1 August 2010].

Oakerson, R.J. 1992. Analyzing the Commons: A Framework. In Bromley, D. W. (Ed.). *Making The Commons Work.* Institute for Contemporary Studies. San Francisco, California.

Regina, H. 2009. The outlook for non-wood forest products in Asia and the Pacific. *Working Paper No. APFSOS II/WP/2009/18.* Food and Agriculture Organization of the United Nations Regional Office for Asia and the Pacific. Bangkok.

Rohadi, D., Maryani, R., Belcher, B., Ruiz Perez, M. and Widyana, M, 2000. Can sandalwood in East Nusa Tenggara survive? Lessons from the policy impact on resource sustainability. *Sandalwood Research Newsletter* Issue 10. Department of Conservation and Land Management, West Australia.

Rohadi, D., Maryani, R., Widyana, M. and Azhar, I. 2004. A case study of production to consumption system of Sandalwood (*Sandalwood album*) in South Central Timor, Indonesia. *In:* Kusters, K. and Belcher, B. (Eds.). *Forest Products, Livelihoods and Conservation Volume 1-Asia*. Centre for International Forestry Research. Bogor. Pp. 187–205.

Suara Pembaruan, 13 Januari 1994. Tataniaga dan penggunaan kayu Cendana sebagai bahan baku menunggu kebijakan.

Acknowledgements

We would like to acknowledge the International Tropical Timber Organization (ITTO) who has funded this study through the project PD 459/07 (F) Rev. 1, "*Improving The Enabling Conditions For Sustainable Management of Sandalwood Forest Resources In East Nusa Tenggara (ENT) Indonesia*". The authors would also like to thanks the Asia Pacific Association of Forestry Research Institutes for the supports that makes this paper is presented in this workshop.

Landscape Management Approach as a Key to Transboundary Conservation of Valuable Forest Tree Species

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Transboundary conservation in recent years has acquired greater significance for meeting the goals of ecological regionalism. Transboundary conservation helps fill knowledge gaps to provide a better understanding of biodiversity resources and services, and their vulnerabilities in terms of climate change. It enhances capacities of collaborating partners and local communities to understand the status and importance of biodiversity and the impact of climate change on biodiversity and increase their knowledge base on ecosystem services and their values (ICIMOD 2011). Since natural systems transcend political borders, management approaches should also aim to transcend physical and cognitive barriers (Ali 2011). A transboundary conservation area (TBCA) is characterized as straddled international boundaries, managed for conservation purposes and inclusion of adjacent national parks or other protected areas (PAs). Recent data indicates that there are now 188 TBCAs involving 818 PAs in 112 countries, representing approximately 17% of the global extent of PAs (Mittermeier *et al.* 2011). Conservationists are continuing their advocacy for the establishment of ecological integrity across artificial frontiers and administrative boundaries (Wolmer 2003). This approach can have a better impact on the management of PAs and biodiversity conservation.

Landscape approach follows the landscape stability principle that emphasizes the importance of landscape structural heterogeneity for resistance to as well as recovery from fragmentation and disturbances thereby maintaining the total system stability. Therefore, the conservation activities should not have political boundary. At the landscape level, species richness has frequently been correlated with heterogeneity in the landscape (Bennett and Saunders 2011). Landscape level establishment of PAs between countries has now become a popular conservation movement. Such activities can be facilitated by conservation related INGO, multinational organization and semi governmental organization. The landscape level conservation approach has brought an inspiring understanding among the partners about the significance of conservation at the landscape level and has created considerable amount of interest among scientists, policy makers, and the general public (ICIMOD 2011).

Nepal has disproportionately large diversity of flora and fauna at genetic, species and ecosystem levels (MFSC 2002). With 0.1% of global land area, Nepal incorporates two bio-geographic realms and six floristic regions of the world. Nepal's rich biodiversity is a reflection of its unique geographic position and altitudinal and climatic variations. Considering the unique biodiversity and endemism in the Himalaya, it has been identified as one of the global biodiversity hotspots (Bhuju *et al*. 2007). Since past few years, Nepal, with support from different national and international organizations, has been involving in establishment and management of some transboundary landscapes which have been considered as important for biodiversity and other ecosystem services.

Methodology

The study sites selected for the research include the two landscape conservation areas of Nepal (Figure 1). Terai Arc Landscape (TAL) and Sacred Himalayan Landscape (SHL) are the two major transboundary conservation areas. The TAL is a part of the WWF Global 200 Ecoregion – Terai-Duar Savannah and Grassland, whereas SHL includes the Himalayan biological hotspot. The TAL in the south spreads from Bagmati River in Nepal to Yamuna River in India, covering an area of 49,500 km^2 of natural ecosystems. There are 11 transboundary protected areas (PAs) – seven from India and four from Nepal – within the TAL extending from Parsa Wildlife Reserve in Nepal to Rajaji National Park in India. On the other hand, the SHL in the north builds links with three major transboundary conservation areas in China, India and Bhutan, covering an area of 39,021 km^2 including four PAs of Nepal. The study is primarily based on review of literatures, and secondary data collection and analysis. Publications (paper or electronic or websites) of concerned organizations involved in managing the landscapes were consulted. Personal interviews with the key informants of these organizations were conducted during the visits to the organizations such as WWF, TAL Project, and SHL Project offices.

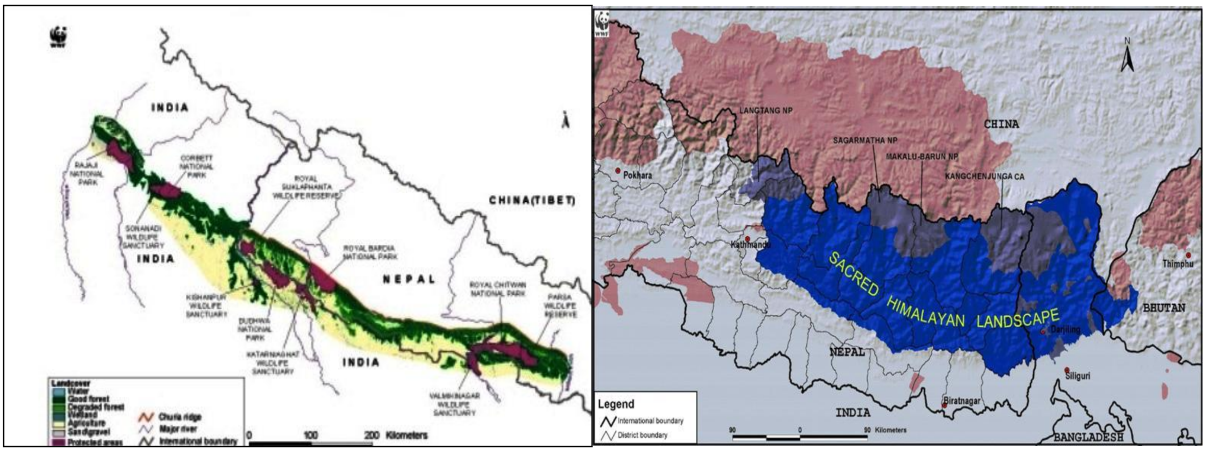

Figure 1. The study sites – Terai Arc Landscape (left) and Sacred Himalayan Landscape

Results and discussions

Concept of conservation has changed from species to ecosystem to landscape approach. The strategy papers of TAL (2004–2014) and SHL (2006–2016) have been prepared and approved for 10 years. The success of TAL has been applied in the SHL. With a network of 10 National Parks, 3 Wildlife Reserves, 6 Conservation Areas, 1 Hunting Reserve and 12 Buffer Zones in and around Parks/Reserves, the PAs system of Nepal covers an area of 34,185.62 km^2 (23.23% of the total area of the country). In 2010, Government of Nepal has declared two more National Parks and one Conservation Area (DNPWC 2010). Recent policy documents including Three Year Interim Plan of Nepal (2007–10) have given importance to landscape approach of conservation. The PAs in the landscapes have been found focused primarily on the conservation of charismatic and endangered wildlife species such as the Royal Bengal Tiger, One-horned Rhinoceros and Asian Elephant in TAL area, and also Snow Leopard, Red Panda, Musk Deer, Tibetan Wolf, Blue Sheep, and Clouded Leopard in SHL complex (DNPWC 2010). In addition, there are many other species of mammals and birds of this kind in both landscapes. In terms of species diversity, both TAL and SHL support remarkable assemblages of flora and fauna, which include several endemic species. However, these transboundary conservation areas have also explicitly or implicitly facilitated the conservation of valuable forest tree species across Nepal's borders with India and China. There are occasional transboundary meetings with India and China particularly at local level (personal communication).

The Terai forests of TAL have several high value forest tree species such as *Shorea robusta*, *Dalbergia latifolia*, *Terminalia tomentosa*, *Acacia catechu*, *Michelia champaca*, *Bombax ceiba* and *Pterocarpus marsupium* (Figure 2). Out of these, *S. robusta, D. latifolia* and *T. tomentosa,* are good timber species. *P. marsupium* is a medium to large, deciduous tree, and the heart wood of which is used as an astringent and in the treatment of inflammation and diabetes. *B. ceiba* is useful for cotton and also for making planks, ply and match sticks. Such high value timber species are good source of incomes for central as well as local governments. Similarly, the Himalayan forests of SHL also have valuable and endangered forest tree species such as *Taxus wallichiana* (Himalayan Yew) *Juglans regia* (Walnut) and *Larix* spp. across the landscape. Of these valuable species, most have been included in different categories of the IUCN Red List, for example, *S. robusta* as Least Concern, *D. latifolia* (Indian rosewood) as Vulnerable, *P. marsupium* (Indian Kino Tree or Bijaysal in Nepali) as Vulnerable, and *B. ceiba* as Threatened species. Similarly, *T. wallichiana* as Data Deficient (CITES appendix II), *J. regia* as Near Threatened, and *Larix* spp. as Least Concern species (IUCN 2011). Some of the biological hotspots are also located in these transboundary locations.

The landscapes have also helped address major forestry issues of common concern. For instance, they have provided forest tree species with extended area of habitat, permit genetic exchange with other populations, and enhance ecosystem services. Various corridors have helped maintain gene pool of the tree species (Mittermeier *et al.* 2011).

Figure 2. Some valuable and endangered forest tree species – (from left) *D. latifolia, P. marsupium, B. ceiba and T. wallichiana* found in the transboundary landscapes

In contrast, the transboundary conservation has also facilitated the spread of unwanted species, invasive alien species, pest and disease, and fire or other disturbances. Increased connectivity across borders can also lead to increased ecological threats. Invasive species can also act as vectors for pathogens, which could negatively affect conservation efforts (McCallum 2011). However, deforestation, forest degradation, fragmentation, population pressure, encroachment, and converting forest into agriculture are some challenges of landscape management (Wolmer 2003). Since conservation is not possible in isolated manner, landscape approach to conservation is the basis for sustainable management of endangered species of wild flora and fauna.

Recommendations

Conservation of forest tree species should also be given importance in the landscape conservation areas. A framework for regional strategy for biodiversity conservation and economic development should be developed and implemented. Supports can be sought from conservation-related INGOs, multinational organizations and semi-governmental organizations. Conservation and socioeconomic development should go together for effective conservation of valuable and endangered forest tree species beyond the borders.

References

Ali, S. H. 2011. *Transboundary Conservation and Peace-building: Lessons from Forest Biodiversity Conservation Projects*. United Nations University Institute of Advanced Studies, Tokyo, Japan.

Bennett, A. F. and Saunders, D. A. 2011. Habitat fragmentation and landscape change. *In* Sodhi, N. and Ehrlich, P. (Eds.). *Conservation Biology for All.* Available at http://ukcatalogue.oup.com/product/9780199554249.do

Bhuju, U.R., Shakya, P.R., Basnet, T.B. and Shrestha, S. 2007. *Nepal Biodiversity Resource Book: Protected Areas, Ramsar Sites, and World Heritage Sites.* International Centre for Integrated Mountain Development (ICIMOD), Kathmandu.

DNPWC. 2010. *Annual Report* (2066/67). Department of National Parks and Wildlife Conservation, Kathmandu, Nepal.

ICIMOD. 2011. *Transboundary Landscape Conservation Policy and Institutional Innovations in the Eastern Himalayas: Promoting landscape as a strategy to climate change adaptation and sustenance of ecosystem services*. International Centre for Integrated Mountain Development, Kathmandu, Nepal. Available at http://www.icimod.org/?q=282

IUCN. 2011. *IUCN Red List of Threatened Species.* Version 2011.1. Available at www.iucnredlist.org.

McCallum, J. 2011. *Ecological challenges and difficulty of gathering ecological data on Transboundary Conservation Areas (TBCA).* Global Transboundary Conservation Network. Available at http://www.tbpa.net/page.php?ndx=46

MFSC. 2002. *Nepal Biodiversity Strategy*. His Majesty's Government of Nepal. Ministry of Forest and Soil Conservation, Kathmandu, Nepal.

Mittermeier, R. A., Kormos, C. F., Mittermeier, C. G., Gil, P. R., Sandwith, T. and Besançon, C. 2011. *Transboundary Conservation: A New Vision for Protected Areas.* Conservational International. Available at www.conservation.org/publications/Pages/transboundary_conservation.aspx

Pradhan, N. M. B. 2007. A Landscape Approach in Conserving Large Mammals: A case Study from Western Terai, Nepal. *The Initiation* 1:44–55.

Wolmer, W. 2003. Transboundary Conservation: The Politics of Ecological Integrity in the Great Limpopo Transfrontier Park. *Journal of Southern African Studies* 29:261–278.

Almaciga (*Agathis philippinensis* Warb.): Valuable but Diminishing Tree Species in the Philippines

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Almaciga trees grow naturally in almost all of the Philippine forests and mountains. Since the government prohibits the felling of the tree, utilization is limited to its resin, known in the world trade as Manila copal. Although Manila copal is considered a minor forest product, it is one of the country's dollar earners. For a period of 10 years (2000–2009), annual average of 202,400 kg of Manila copal valued at USD 188,900 were exported to France, Germany, Japan, Spain, China and Switzerland. It is known for its superior quality as raw material for the manufacture of varnish, lacquer, reflector paint and sealing wax. Other important uses are for paper sizing, substitute for shellac, smudge for mosquitoes, incense, fire starter and torches. In the island province of Palawan, known to be the source of high quality almaciga resins in the country, many tapped almaciga trees are not expected to last for another 5 to 10 years because of unscrupulous harvesting methods used by resin tappers who are indigenous people. They deep tapped, over-tapped and frequently re-chipped, causing extensive wounds through which wood rotting organisms can enter and colonize the trees. Aggravating this condition is the open-pit mining operations in the province by different mining companies. The activities killed or disturb whatever regenerations are occurring in the almaciga-range mountains.

This resulted to decrease in the production of almaciga resins and eventually death of the trees. As more than 90% of the almaciga resins produced in the Philippines comes from Palawan, the rapidly decreasing production of the resin had resulted in decreased in export. The Philippines has since lost its status as the leading exporter of almaciga resins, and today, the country is poor second to Indonesia as far as volume and export of resin production is concerned.

Table 1. Production and export of Almaciga resin
(Quantity in thousand kilograms, value in thousand US$)

Year	Quantity	Value
2009	127	171
2008	121	172
2007	261	306
2006	163	136
2005	191	154
2004	230	222
2003	199	175
2002	209	150
2001	204	161
2000	319	242

Almacigas are dying
Known to be as one of the biggest Philippine tree species, almaciga attains a diameter at breast height (dbh) of up to 150 cm with a clear bole of 25–35 m. They have been tapped for decades in Palawan where overexploitation in certain areas has occurred even before the turn of the century. Along Palawan's west coast, the almaciga resources are very much in danger of exhaustion (Conelly 1985 as cited by Wakker (1993)). Unsustainable tapping methods cause deaths of almaciga trees while others no longer produce sufficient amounts of resin.

Although the cutting of almaciga for timber is banned or restricted, the over-mature trees, those which have a diameter of 160 cm dbh are dying one by one inexorably.

The dying starts with the rotting of the trunk, as the tree has been considerably weakened by overtapping by individuals concerned only with immediate volume and immediate income from sales of resins. Since the trees are over-mature, they disintegrate starting at the butt end, and the cavity going up the tree capable of reaching up to 10 m above ground. .

Chromite mining – Another worst thing that has happened in Palawan. There are open-pit mining areas where stands of almaciga are voluminously found. The habitat of almaciga is bulldozed to excavate the chromite stones. Thus, whatever regenerations found in these areas are destroyed and/or killed.

Traditional tapping damages

The most common damages caused by almaciga tapping in the Philippines are:

- *Deep tapping* – The cuts are deliberately extended to the sapwood portion, destroying the vascular cambium responsible for the tree's continuous radial growth, and healing of wounds;
- *Overtapping* – Oversized cuts or too many cuts are made around the tree circumference. The law requires that the distance between cuts around the girth should be twice the length of the tapping cut. Violations result in impaired growth and eventual death of the tree. Tappers cut around the trunk, sometimes making as many as 7 indiscriminate, improper, much-too-wide cuts, and these not with the tapper's knife but a big bolo. Often cutting into the wood itself and sometimes with the wounds appearing above earlier ones thereby cutting resin flow. With such a large number of wounds with those sizes, the tree is rendered vulnerable, and thus exposed to fungal and insect attacks; and
- *Frequent rechipping* – This introduces impurities into the exuded resin instead of increasing the flow rate. Chips of bark, wood and foreign materials lower the resin grade. Resin must be collected at least every two weeks to give ample time for the accumulation of large, easily-removed lumps of hardened resin.

Methodology

Various studies have been conducted by FPRDI, including:

- determining the influence of Ethrel application (0, 0.5, 1.5 and 2.5%); length of tapping cut (10, 20 and 30 cm); same width (2 cm) and same depth on the exudation of resin; and to establish whether the month of tapping, Ethrel treatment and tapping length affect almaciga resin yield;
- almaciga resin production and market opportunity for upland communities in Karagan Valley, Compostela Valley, Mindanao; and
- survey of faulty tapping practices of almaciga resin in the Philippines. The investigations were designed primarily to improve the traditional methods of tapping almaciga trees so as to sustain productivity and save the remaining almaciga trees in the country.

Results and discussions

Proper Tapping Methods

Owing to the detrimental effects of traditional tapping methods, FPRDI laid down the following guidelines for the proper tapping of almaciga trees. These are based on the results studies conducted by the Institute.

1. Tap only those trees with at least 40 cm diameter at breast height.
2. Remove loose barks, dirt and other foreign bodies; and lightly scrape the portion to be tapped. Start the first tapping at a point not less than 40 cm from the ground.
3. Make a horizontal cut about 2 cm wide and 30 cm long using a razor-sharp, broad-bladed bolo or a big knife. While cutting, take utmost care to avoid damaging the cambium. A wooden mallet may be used to hammer the bolo and control the depth of cut. Other cuts may be of the same dimension as the first cut at 30 cm but the distance between the tapped portions should be about 60 cm or twice the length of the cut. Apply 2.5% ethylene to the cut using a plastic sprayer. Use "Ethrel brand".
4. Since the resin exuded by the tree hardens slowly, a plastic receptacle should be tacked below the cut. The tapped trunk should be covered by a polyethylene sheet and sealed with plastic

roofing cement. This will prevent the entry of water, insects, and debris like dried barks, leaves or other foreign bodies into the cuts.

5. After a week when resin exudation stops, collect the hardened resin and put them in clean polyethylene plastic bags. Make a fresh cut (rechipping) of 4 to 10 mm wide immediately above the previous one and at the same length. Again, apply 2.5% Ethrel.
6. Tap vertically upward on the untapped portion of the trunk and use a ladder for convenience. Tapping tools should be razor-sharp at all times to ensure clean cuts. Also, care should be taken to obtain a clean product as much as possible.

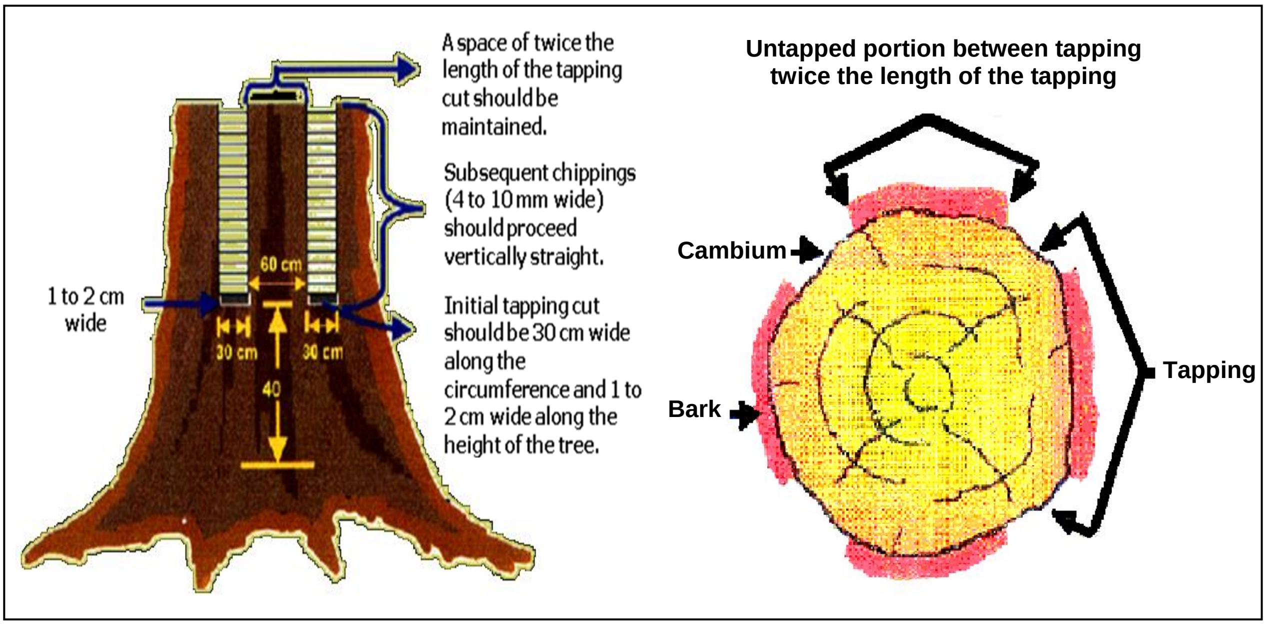

Figure 1. Diagram showing the proper methods of tapping almaciga trees

Advantages of the Technology

Tapping almaciga for resins is a veritable economic activity among farmers. Applying the proper or improved tapping techniques offer the following advantages:

1. prolong life of the tree;
2. increase production of quality resin;
3. increase income of tappers and the government;
4. is environment friendly and helps in the conservation programme of the government;
5. trees sequester CO_2 from the atmosphere and the longer the almaciga stands are preserved in the forest, the better they can contribute in the global effort to remedy climate change.

Recommendations to save Philippine almacigas from becoming another endangered species:

1. Improper tapping should be stopped immediately. People should be taught the proper methods of tapping resins under the close supervision of relevant government agencies. Further, the government should also work with other organizations both from public and private sectors.
2. Issuance of license or permit to extract almaciga resins for groups, organizations or individuals should be strictly regulated.
3. The ban on cutting almaciga trees for timber should be revised immediately. This will allow the harvesting of over-mature trees which are being lost to butt rot and heart rot fungi. The remaining good wood can be utilized properly into sounding boards for pianos and guitars where almaciga wood is known to have excellent acoustic properties.
4. The government should continue engaging in almaciga plantations which initially started in 1977 on the island of Samar with an area of about 300 ha. Further, almaciga should be included as a selected species for reforestation purposes.
5. The government should not allow open-pit mining operations in Palawan, especially in the vicinity of the natural habitat of almaciga.

References

Boer, E. and A.B. Ella (Eds). 2000. *Plant Resources of Southeast Asia. Vol. 18. Plants Producing Exudates*. Backhuys Publishers, Leiden, the Netherlands: 55–60.

Ella, A.B., M.L. Santander, Jr. and C.M.C. Garcia. 2009. Almaciga Resin Production for Upland Communities in Compostela Valley Province. Ecosystems and Development. *Journal on Tropical Forests and Natural Resources* 2(1):39–44.

Ella, A.B. 1999. The Resin Resource. *Tropical Forest Updates* 29: 6–7. Yokohama, Japan.

Ella, A.B., M. Ramos and R.E. Cortez, Jr. 1999. Inducement of Almaciga Resin Production Through Ethrel Application. *FPRDI Journal* 25 (1 & 2): 19–29.

Philippine Forestry Statistics. 2009. Forest Management Bureau (FMB), Department of Environment and Natural Resources (DENR), Diliman, Quezon City. 250 pp.

Quiniones, S.S. 1980. The diminishing almaciga in Palawan: A report. *Canopy International* 6(4): 1 & 13. ERDB-DENR, College, Laguna.

Wakker, E. 1993. *Towards Sustainable Production and Marketing of non-Timber Forest Products in Palawan.* Tropical Social Forestry Consultancies (TSP), The Netherlands.

Conservation and Restoration Strategy for Wild Forest Ginseng (*Panax ginseng* C. A. Meyer)

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Korean wild ginseng, *Panax ginseng* C. A. Meyer, is widely distributed from Korean Peninsula through Manchuria to Russia Far East.

It is generally believed that ginsenosides of ginseng, tetracyclic triterpenoids, are mainly responsible for the pharmacological activities of ginseng. Ginsenosides have been shown to exert many pharmacological effects, including immune system modulation, anti-stress activities, anti-hyperglycemic activities, anti-inflammatory, antioxidant, and anticancer effects.

Korean wild ginseng has long been accepted as having high medicinal values compared to nursery-cultivated ginseng. However, it is very rarely found in mountain region due to reckless harvesting. In Korea, it is believed to be seriously endangered and close to extinction these days. In contrast to Korean ginseng, American ginseng plant was listed in the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to protect the extinction of wild American ginseng. As a result, the international sale of wild and wild-simulated American ginseng plants is carefully controlled to conserve. Thus, some guidelines and strategies for conservation and propagation of Korean wild ginseng are urgently needed.

Principles

1. Wild forest ginsengs should be conserved and restored *ex situ* in the same municipal county (Do, Si or Gun in Korea) where they are found, under the responsibility of the municipal county through the advice of Forest Ginseng R&D Centre, Kangwon National University (KNU).
2. Autogametic fertilization system will be applied for the conservation and heterogametic fertilization system will be adopted for commercial seed production.
3. Funding will be supplied by municipal governments involved in the conservation/restoration project; Korea Forest Service; and Kangwon National University.
4. Wild ginseng seeds will be supplied to the Centre, stored in conservation facilities *in vitro* or *ex situ* and used as the restoration materials.

Strategy

Each municipal government is responsible for the collection of forest ginsengs and the establishment of primary conservation orchard. Financial support from every municipal government, which agrees to follow the principles mentioned above, is necessary for the Forest Ginseng R&D Centre to establish the secondary conservation orchard and propagate the genetic resources provided. The genetic resources given to the Centre by every provincial government will be used as the propagation materials, the final products of which will be used for the restoration and commercial purpose of the county. Korea Forest Service is responsible financially for the works of Forest Ginseng R&D Centre and will get a lot of information for formulating regulations and policy.

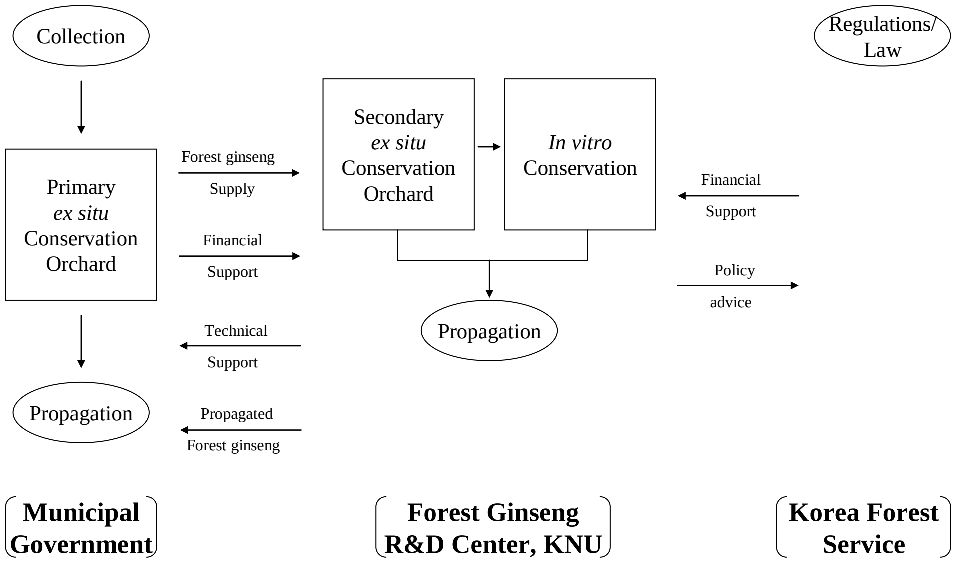

Figure 1. Schematic diagram of wild forest ginseng conservation and utilization by Forest Ginseng R&D Centre

Prospects

1. Within 10 years, natural genetic resources of Korean wild forest ginseng can be conserved and restored, following the principles mentioned above, in every county which agrees to take such conservation and restoration regime.
2. Commercial seeds originated from the resources of each county may be supplied to the customers in the same county.
3. The Centre will store the whole genetic resources of wild forest ginseng found.
4. Many ginseng gatherers will have good will to donate their invaluable, wild forest ginseng resource(s) to the Centre.

Recommendations

1. Regulations and systems should be established to conserve and restore ginseng genetic resources; and to control the unrevealed trade of wild ginseng. Those include the entry of Korean wild ginseng in CITES.
2. A collaborative network is necessary among countries in East Asia which have wild *Panax ginseng* resource.

Phylogeography and Refugia of the Peninsular Malaysian Endemic Timber Species, *Neobalanocarpus heimii* (Dipterocarpaceae)

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Southeast Asia covers the third largest block of tropical rain forests on Earth, and has been recognized as a major global biodiversity hotspot (Mittermeier *et al*. 2005). During the era of Cenozoic, Southeast Asia witnessed active tectonism (collisions between India and Eurasia about 50–65 Ma; Southeast Asia and Australia about 15 Ma) and dynamic climate changes (cooler and drier periods) (Hutchison 1989). Despite the importance of Southeast Asia as one the largest rain forest regions, the Asian tropics have been subjected to relatively few studies on phylogeography. By using *Neobalanocarpus heimii* as a model species, this study was initiated to reveal the evolutionary history of the species in Peninsular Malaysia, including the potential glacial refugia and their post-glacial recolonization routes. *Neobalanocarpus heimii*, or locally known as chengal, is endemic and widely distributed in Peninsular Malaysia. The species produces a naturally, highly durable wood and is among the strongest timbers in the world. Owing to the high demand for its valuable timber, this species is subjected to illegal logging and might become endangered in the near future.

Methodology

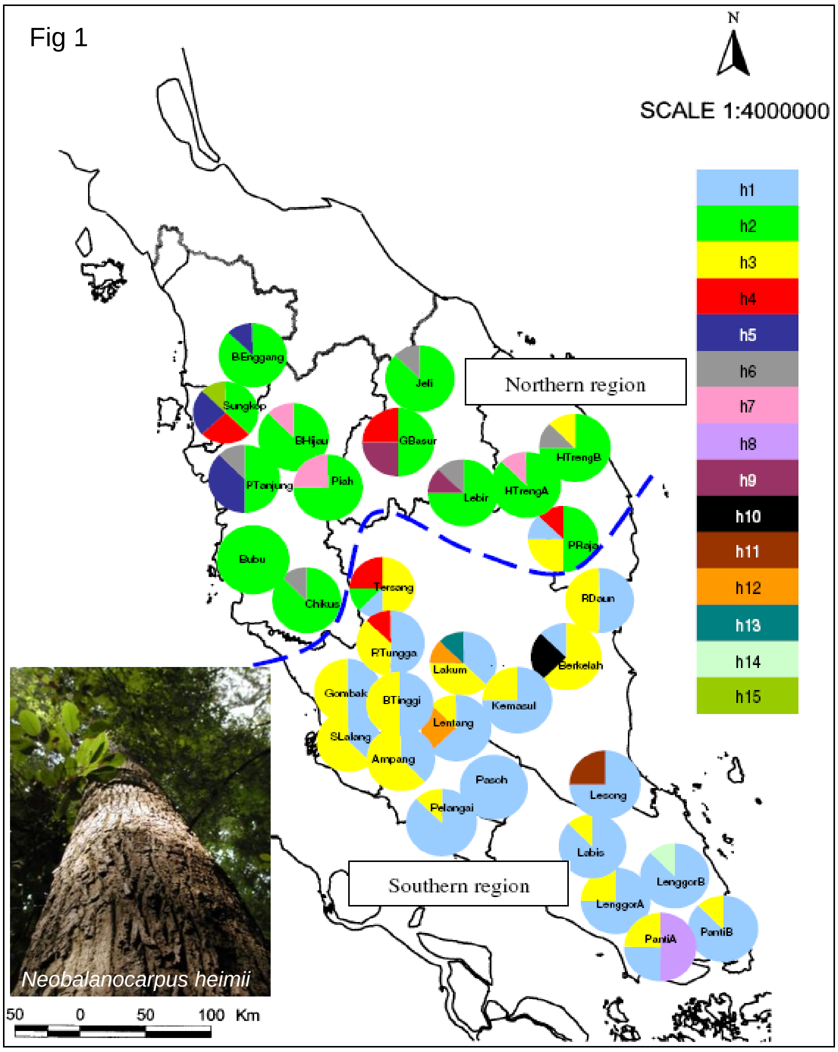
A total of 32 natural populations, with 8 samples from each population were sampled throughout the distribution range of *N. heimii* in Peninsular Malaysia (Figure 1). PCR amplifications and sequencing for five non-coding regions of cpDNA: *trn*L intron, *trn*S-*trn*G spacer, *trn*G intron, *trn*K intron and *psb*K-*trn*S spacer were carried out following procedures described in Tnah *et al*. (2009). Sequencing data were edited and assembled using CODONCODE ALIGNER. Haplotypes were determined based on substitution intraspecific variable sites. Haplotype and nucleotide diversity, associated with Tajima's D Neutrality Test were estimated using DNASP. Diversity and population differentiation were computed using PERMUTE and CPSSR, and contribution of populations to the total diversity was calculated using CONTRIB. Mantel test and hierarchical analysis of molecular variance (AMOVA) were performed using ARLEQUIN. Maximum parsimony network of haplotype was constructed using NETWORK.

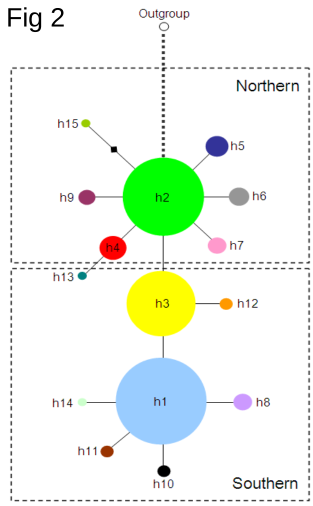
Results and discussions

Fifteen haplotypes were identified from 10 intraspecific variable sites of five non-coding cpDNA regions (Figure 2). Based on the coalescent theory, the interior haplotypes h2 can be inferred as the ancestral haplotypes. It was in the central part of a network with multiple connections, exhibited higher frequencies than tip haplotypes, and showed broader geographical distributions. Two major genealogical cpDNA lineages of *N. heimii* were elucidated in this study: a widespread southern region and a northern region (Figure 1). As all haplotypes within the northern region are genetically more similar to each other than the haplotypes that are found in the southern region, it is more likely that both regions have become reciprocal monophyly. Palaeoenvironmental phenomenon, for instance marine transgressions during Miocene or Pliocene, will possibly account for such divergence.

This study also revealed the persistence of *N. heimii*'s glacial refugia in Peninsular Malaysia during Pleistocence climatic oscillations. Although some reports suggested that rain forests might disappear almost entirely from Peninsular Malaysia (Morley 2000, Brandon-Jones 2001), small rain forest refugia are still believed to persist along the coastal regions (Corner 1978, Emmel and Curray 1982, Quek *et al.* 2007). Results from the present study clearly revealed that the species survives in multiple refugia throughout Peninsular Malaysia (Figure 3): the northwestern region (R1), the northeastern region (R2) and the southern region (R3). These putative glacial refugia exhibited a higher level of genetic diversity, while the post-glacial regions were found to have a reduced level of genetic diversity with large geographic areas dominated by a single haplotype.

The putative recolonization routes for *N. heimii* throughout Peninsular Malaysia were inferred based on the level of genetic diversity, distribution pattern of haplotypes and restricted dispersal of the species. Recolonization of refugia R1 and R2 could have first expanded into the northern region of Peninsular Malaysia during the interglacial retreat, and stopped at the central regions of Pahang, Terengganu and Perak (Figure 3). These stocks might have migrated both northeastwardly and northwestwardly after the climatic amelioration. Meanwhile, recolonization of *N. heimii* throughout the southern region of Peninsular Malaysia could have commenced from refugia R3, and migrated toward the northeast and northwest respectively. Though the existence of Titiwangsa Mountain Range could serve as a barrier between eastern and western populations of *N. heimii*, the haplotypes were distributed evenly on both sides of the mountain ridge. Hence, Peninsular Malaysia was seemed to partition in north-south rather than east-west orientation. Apparently, it is unlikely for these lowland dipterocarps with limited seed dispersal to have crossed over this mountain range. Therefore, it can be postulated that the species could have spread over a large part of the southeast and southwest regions of Peninsular Malaysia from refugia R3.





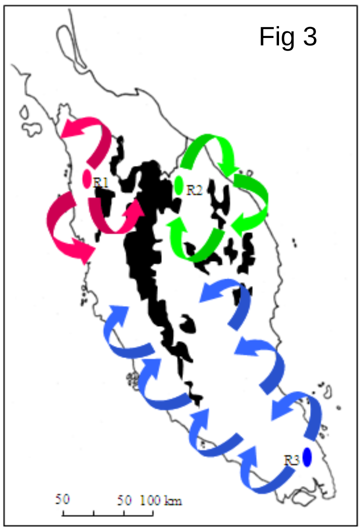


Figure 1. Locations of 32 populations of *Neobalanocarpus heimii* in 29 forest reserves of Peninsular Malaysia. The geographical distribution of cpDNA haplotypes (h1–h15) in each population is shown and haplotypes are colour coded and their frequencies are indicated by sectors of pies.

Figure 2. Maximum Parsimony Network of haplotypes of *Neobalanocarpus heimii* based on chloroplast DNA, with two major groups of haplotypes indicated by dashed lines. The relative sizes of the circles represent the frequency of these haplotypes and unsampled haplotypes are represented by square box. Each line connecting one haplotype to another indicates one mutational step.

Figure 3. Distribution of potential refugia sites (R1, R2 and R3) inferred for *Neobalanocarpus heimii* Hypothetical phylogeographical history of *N. heimii* in Peninsular Malaysia. Regions in black indicate mountain ranges and arrows indicate putative recolonization routes from R1, R2 and R3.

The populations of Tersang, Pasir Raja and Rotan Tunggal are shown to exhibit remarkably high haplotype diversity, which could be the contact zones of *N. heimii* in Peninsular Malaysia. These populations comprised both haplotypes that were endemic to the northern and also southern regions. Specifically, the contact zones with increased genetic diversity would be achieved mostly through the redistribution of the genetic information already present among populations in refugia (Petit *et al*. 2003).

An important conclusion which may be drawn from the above account, with reference to *N. heimii*, is to consider the putative glacial refugia sites, including the northwestern region (R1), the northeastern region (R2), and the southern region (R3), to be prioritized for long-term management. Besides, the contact zones of *N. heimii* are another key factor in conservation considerations, in which the maintenance of genetic diversity is critical for long-term survival of a species. In addition, further studies involving other tropical tree species are essential to provide a better understanding of the potential refugia and post-glacial recolonization routes in Peninsular Malaysia. Once the information is available for many tropical tree species, a consilience of the rain forest history will hopefully come to light. Thus, by understanding the role of long-term tectonic and climatic changes in the evolution of this tropical biota, as linked with all the potential glacial refugia between species, an assortment of recovery plans could be implemented to ensure protection and conservation of the refugia sites.

References

Brandon-Jones, D. 1998. Pre-glacial Bornean primate impoverishment and Wallace's line. In: Holloway, J.D., Hall, R. (Eds.), *Biogeography and Geological Evolution of SE Asia.* Backhuys, Lieden, pp. 393–404.

Corner, E.J.H. 1978. The freshwater swamp-forest of South Johore and Singapore. *Gardens Bulletin* Supplement 1: p. 266.

Emmel, F.J. and Curray, J.R. 1982. A submerged late Pleistocene delta and other features related to sea level changes in the Malacca Strait. *Mar. Geol*. 47: 197–216.

Hutchison, C.S. 1989. *Geological Evolution of South-East Asia*. Clarendon Press, Oxford.

Mittermeier, R.A., Gil, P.R., Hoffman, M., Pilgrim, J., Brooks, T., Mittermeier, C.G., Lamoreux, J. and da Fonseca, G.A.B. 2005. *Hotspots Revisited: Earth's Biologically Richest and Most Terrestrial Ecoregions.* Conservation International, Washington.

Morley, R.J. 2000. *Origin and Evolution of Tropical Rain Forests*. John Wiley, Chichester.

Petit, R.J., Aguinagalde, I., de Beaulieu, J.L., Bittkau, C., Brewer, S., Cheddadi, R., Ennos, R., Fineschi, S., Grivet, D., Lascoux, M., Mohanty, A., Muller-Starck, G., Demesure-Musch, B., Palme, A., Martin, J.P., Rendell, S. and Vendramin, G.G. 2003. Glacial refugia: hotspots but not melting pots of genetic diversity. *Science* 300 : 1563–1565.

Quek, S.P., Davies, S.J., Ashton, P.S., Itino, T. and Pierce, N.E. 2007. The geography of diversification in mutualistic ants: a gene's-eye view into the Neogene history of Sundaland rain forests. *Mol. Ecol*. 16: 2045–2062.

Tnah, L.H., Lee, S.L., Ng, K.K.S., Tani, N., Bhassu, S., Othman, R.Y., 2009. Geographical traceability of an important tropical timber (*Neobalanocarpus heimii*) inferred from chloroplast DNA *Forest Ecol. Manag.* 258: 1918–1923.

Chloroplast DNA Variation of *Dalbergia cochinchinensis* Pierre in Thailand and Laos

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The Siamese rosewood (*Dalbergia cochinchinensis* Pierre) is an economically important tree species throughout Laos, Cambodia, Vietnam, Myanmar and Thailand. Since *D. cochinchinensis* has the beautiful wood texture and its wood is durable, hence it is very highly demanded not only in Thailand but also in Asian region. This species has been illegally logged since the last few decades which may affect gene pool, genetic diversity and genetic structure. Chloroplast DNA (cpDNA) is uni-parentally inherited. Therefore, it can be used to develop markers for phylogeographic investigation in this species. Variation patterns of maternally inherited cpDNA haplotypes are often suitable for distinguishing the origin of trees (Schaal *et al*. 1998, Petit *et al*. 2005). Based on the study of Deguilloux *et al*. (2004) chloroplast DNA marker can be used to trace wood geographic origin in the context of the cooperage industry in France. In this study the cpDNA phylogeography of *D. cochinchinensis* was investigated by using cpDNA sequencing to characterize the spatial genetic variation and pattern of haplotypes of investigated populations in Thailand and Laos.

Methodology

D. cochinchinensis was sampled from nine populations of the central and northeastern part of Thailand and one population from Laos as shown in Table 1. Ten to twelve trees were randomly collected from each population. Leaves and/or bark from each sample tree were dried and stored in silica gel. Total DNA of each sample was extracted using a modified protocol described by Sharma *et al*. (2002). Chloroplast DNA in *D. cochinchinensis* was amplified by using three universal primer pairs from non-coding cpDNA *trn*S-*trn*G (Halmilton 1999), *trn*V-*trn*M (Demesure *et al*. 1995) and *trn*C-*pet*N1R (Kress *et al*. 2005) regions. Polymerase chain reactions (PCR) were performed in a 25 µl volume, containing 10–40 ng of genomic DNA, 1X PCR buffer with Mg^{2+} , 0.25 mM dNTPs, 0.4 pmol of each primer and 1 U of Taq DNA polymerase (RBC). PCR reactions were carried out using the following cycling profile: 94ºC for 3 min; 30 cycles of 94ºC for 1 min, 57ºC for 1 min, 72ºC for 1 min; followed by a final extension at 72ºC for 10 min. PCR products were purified using Exonuclease I and FastAP™ Thermosensitive Alkaline Phosphatase (Fermentas). Direct sequencing was performed by using ABI PRISM 3100-Avant Genetic Analyzer (Applied Biosystem USA). The combined data of the cpDNA sequences of this study was analysed. The obtained sequences were aligned and edited by using Bioedit 7.0.5.3 software (Hall 1999). The cpDNA haplotype diversity (h) and nucleotide diversity (π) were analysed and defined from the obtained sequences by using DnaSP 5.10.01 (Librado and Rozas 2009) software.

Table 1. Investigated population names and location of *Dalbergia cochinchinensis*

Population names and location	Sample size	Latitude-Longitude (N-E)
Muakleknai, Saraburi (MS)	10	14°41′19″ - 101°11′42″
Vientiane, Laos (VL)	10	17°58′00″ - 102°36′00″
Dongnatam, Ubon Ratchathani (DU)	10	15°37′04″ - 105°37′17″
Phu Pha Thoep, Mukdahan (PM)	11	16°42′36″ - 104°45′17″
Ponpisai, Nong Khai (PN)	10	18°01′19″ - 103°04′38″
Chuen Chom, Maha Sarakham (CM)	11	16°31′53″ - 103°10′18″
Na Dun, Maha Sarakam (NM)	12	15°42′35″ - 103°13′47″
Phu Pha Lek, Sakon Nakhon (PS)	11	17°16′28″ - 103°26′55″
Phu Laenkha, Chaiyaphum (PC)	12	16°00′27″ - 101°53′41″
Tapraya, Buriram (TB)	11	14°10′07″ - 102°34′56″
Total	108	

MS, PM, PS, PC and TB : National Park
CM, PN and VL : Conserved forest
NM : Community forest
DU : Community forest and part of National Park

Results and discussions

The obtained 1,841 bp nucleotide sequences from three cpDNA regions (*trn*S-*trn*G: 469 bp, *trn*V-*trn*M: 664 bp and *trn*C-*pet*N1R:708 bp) of 108 sampled trees of *D. cochinchinensis* were determined. A total of 11 haplotypes with 10 polymorphic sites, including 8 single nucleotide polymorphisms (SNPs) and 2 insertions/deletions were observed as shown in Table 2. So far, the obtained sequences have not been deposited in the GenBank (National Center for Biotechnology Information). The molecular diversity indexes are shown in Table 3. The haplotype diversity (h) for each population ranged from 0 to 0.697 and the nucleotide diversity (π) from 0 to 0.00056. It was found out that Na Dun population in Maha Sarakam Province (NM) had highest haplotype diversity and nucleotide diversity. This may be because this population is the forest community which has been reforested by the different sources of *D. cochinchinensis* materials*.* Figure 1 shows that the common haplotype (black) was widely found among populations. However, it is revealed that, Chuen Chom population in Maha Sarakham Province (CM), Phu Laenkha population in Chaiyaphum Province (PC), Tapraya population in Buriram Province (TB), Nadun population in Maha Sarakham Province (NM) and Muakleknai population in Saraburi Province (MS) have different unique haplotypes. Therefore, the unique haplotype information of the certain mentioned populations can be use as a tool to identify the origin of illegally logged wood in the future. Besides, it was found out that the Vientiane population in Laos (VL) shared the common haplotype with Thai populations. Therefore, more molecular markers, number of samples and populations of *D.cochinchinensis* in Thailand and Asian region should be collected and investigated for the indicative haplotype for specific populations, sub-regions and countries. Then it can be used to identify the origin of genetic resources of illegally logged wood, since Thailand is facing this problem due to high demand of illegally trade.

Table 2. Polymorphic sites and cpDNA haplotypes based on sequences of the *trn*S-*trn*G, *trn*V-*trn*M and *trn*C-*pet*N1R in *Dalbergia cochinchinensis*

Haplotype	***trn*S-*trn*G**			***trn*V-*trn*M**			***trn*C-*pet*N1R**				**Populations**										
	SNP136	**SNP387**	**SNP412**	**InDel[a] 128**	**InDel[b] 258**	**SNP621**	**SNP206**	**SNP390**	**SNP701**	**SNP702**	**MS**	**LL**	**DU**	**PM**	**PN**	**CM**	**NM**	**KS**	**TB**	**PC**	**T'tal**
H1	T	T	G	6 bp	5 bp	A	T	T	C	T		10	5	6	6	8	5	11	6	9	66
H2	G	·	·	6 bp	5 bp	·	·	·	·	·				5		1					6
H3	·	C	·	6 bp	5 bp	·	·	·	·	·	2										2
H4	·	C	A	6 bp	5 bp	·	·	·	·	·							1				1
H5	·	·	·	-	-	·	·	·	·	·	8										8
H6	·	·	·	-	5 bp	·	·	G	·	·							5		4		9
H7	·	·	·	-	5 bp	·	·	·	·	·									1		1
H8	·	·	·	6 bp	5 bp	·	G	·	·	·							1				1
H9	·	·	·	6 bp	5 bp	·	·	·	.	G			5		4						9
H10	·	·	·	6 bp	5 bp	C	·	·	·	·						2					2
H11	·	·	·	6 bp	5 bp	·	·	·	T	.										3	3
Total											10	10	10	11	10	11	12	11	11	12	108

[a] Deletion of ACAATC [b] Deletion of AGTAT

Table 3. Molecular diversity indexes of *Dalbergia cochinchinensis*

Population names and location	Number of haplotypes	Haplotype diversity (h)	Nucleotide diversity (π)
Muakleknai, Saraburi (MS)	2	0.356	0.00019
Vientiane, Laos (VL)	1	0.000	0.00000
Dongnatam, Ubon Ratchathani (DU)	2	0.556	0.00030
Phu Pha Thoep, Mukdahan (PM)	2	0.546	0.00030
Ponpisai, Nong Khai (PN)	2	0.533	0.00029
Chuen Chom, Maha Sarakham (CM)	3	0.473	0.00028
Na Dun, Maha Sarakam (NM)	4	0.697	0.00056
Phu Pha Lek, Sakon Nakhon (PS)	1	0.000	0.00000
Phu Laenkha, Chaiyaphum (PC)	2	0.409	0.00022
Tapraya, Buriram (TB)	3	0.618	0.00028
Total	11	0.608	0.00033

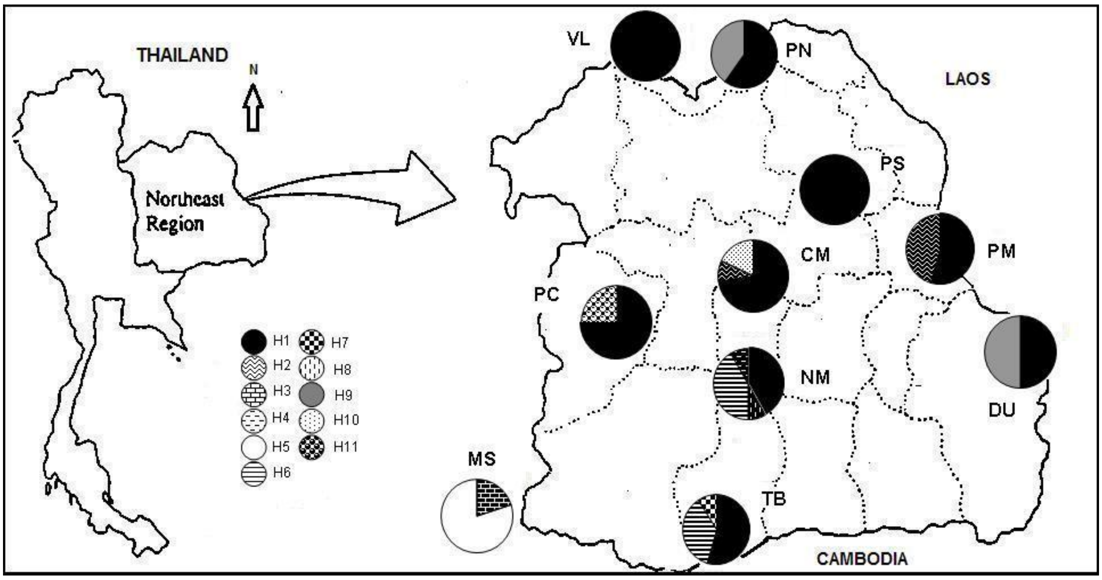

Figure 1. Geographic distribution of cpDNA haplotypes in *Dalbergia cochinchinensis* populations

Acknowledgements

We would like to express our thanks to the Department of National Park, Wildlife and Plant Conservation for providing financial support and DNA laboratory facility for this study as well as the Graduate School, Kasetsart University, to provide fund for research to publish in the international journal. We also thank Dr. Chadaporn Senakun, Mr. Sanguen Wongsa for helping on collecting samples; and Dr. Suwan Tangmitcharoen, for providing some of the material samples for this study. We would like to thank assistant researchers at Forest Genetics and Biotechnology Division, Forest and Plant Conservation Research office, Department of National Park, Wildlife and Plant Conservation for their technical assistance.

References

Deguilloux, M.F., Pemonge, M. H. and Petit, R.J. 2004. DNA-based control of oak wood geographic origin in the context of the cooperage industry. *Ann. For. Sci*. 61:97–104.

Demesure, B., Sodzi, N. and Petit, R.J. 1995. A set of universal primers for amplification of polymorphic non-coding regions of mitochondrial and chloroplast DNA in plants. *Mol*. *Ecol*. 4:129–131.

Hall, T.A. 1999. BioEdit: a user-friendly biological sequence alignment editor and analysis programme for Windows 95/98/NT. *Nucl. Acids. Symp. Ser*. 41:95–98.

Halmilton, M.B. 1999. Four primer pairs for the amplification of chloroplast intergenic regions with intraspecific variation. *Mol. Ecol*. 8, 513–525.

Librado, P. and Rozas J. 2009. DnaSP v5: A software for comprehensive analysis of DNA polymorphism data. *Bioinformatics* 25:1451–1452.

Kress, W.J., Wurdack, K.J., Zimmer, E.A., Weigt, L.A. and Janzen, D.H. 2005. Use of DNA barcodes to identify flowering plants. *Proc. Natl. Acad. Sci*. 102 (23):8369–8374.

Petit, R.J., Duminil, J., Fineschi, S., Hampe, A., Salvini, D. and Vendramin, G.G. 2005. Comparative organization of chloroplast, mitochondrial and nuclear diversity in plant populations. *Mol. Ecol.* 14: 689–701.

Schaal, B.A., Hayworth, D.A., Olsen, K.M., Rauscher, J.T. and Smith, W. 1998. Hylogeography studies in plants, problems and prospects*. Mol. Ecol.* 7:465–474.

Sharma, A.D., Gill, P.K. and Singh, P. 2002. DNA isolation from dry and fresh samples of polysaccharide-rich plants. *Plant Mol. Biol*. *Rep*. 20:415a–415f.

Introduction of *Quercus rubra* Tree and its *Ex Situ* Conservation in Guangdong of China

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Quercus rubra L. (Red Oak)，Quercus genus of Fagaceae family，is a highly valuable timber tree species in the United States. The quantity of red oak China has imported has been increasing steadily in recent years. It is expected that the introduction of *Quercus rubra* will diversify tree plantation species. The establishment of *Q. rubra* germplasm *ex situ* conservation will promote more research and development on *Q. rubra* in South China.

Methodology

Supported by the Georgia Botanic Garden, *Q. rubra* acorns were collected in the southeast of the United States. The quarantine nursery was established to raise the seedlings in Guangzhou, China. The cultivated seedlings were used to establish germplasm conservation plot and provenance test in Longdong Forest Farm and Beilingshan Forest Farm, Guangdong Province, China. The *Q. rubra* germplasm *ex situ* conservation plot is managed intensively.

Results and discussions

Introduction of Quercus rubra germplasm materials

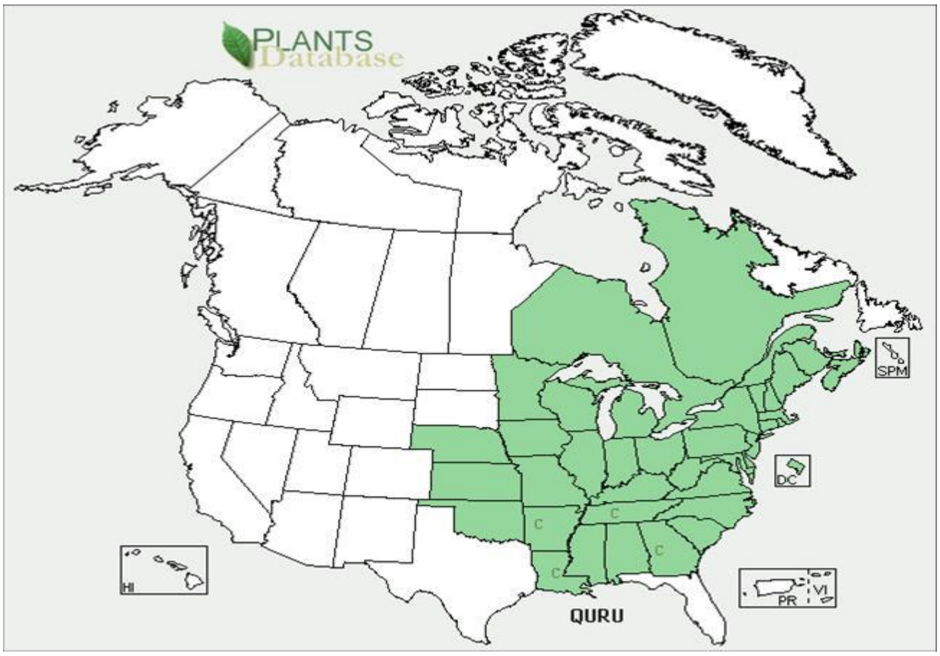

Figure 1. *Q. rubra* distribution and acorn collection states

Q. rubra is naturally distributed in east USA, grows on a variety of soils and topographies. Moderate to fast growing, this tree is one of the more important lumber species and is an easily transplanted, popular shade tree, with good form and dense foliage.

Learned from previous tree introduction experiences, Guangdong Academy of Forestry had introduced the acorns from Georgia, Tennessee, Arkansas, Louisiana and Mississippi of the southeast United States (Table 1).

Table 1. Detailed information of introduced *Q. rubra* germplasm materials

Introduction period	Acorns collection states	Provenance number	Uses	Number of cultivated seedlings
2009 and 2010	Georgia, Tennessee, Arkansas, Louisiana and Mississippi	10	Timber production and Landscaping	30,000

Establishment of Q. rubra germplasm ex situ conservation

The cultivated seedlings were used to establish *Q. rubra* germplasm *ex situ* conservation in central and west Guangdong Province of China. The basic information of conservation sites is as shown in Table 2.

Table 2. Basic information of *Q. rubra* conservation sites in Guangdong, China

Site	Location	Climate type	Elevation(m)	Soil	Vegetation
Longdong Forest Farm	23°7'N 113°15'E	subtropical monsoon climate	50	yellowish brown lateritic soil	Mixed forest
Beilingshan Forest Farm	23°10'N, 112°31'E	subtropical monsoon climate	350	Yellow soil	Pine forest

Assessment of Adaptability of Q. rubra in Guangdong

The one-year old *Q. rubra* growth performance is summarized in Table 3. Growth performance is good, and planting survival rate reached more than 90%.

Table 3. *Q. rubra* growth performance in seedling stage after one year

Height(cm)	Basal diameter(cm)	Tree crown(cm)	Growth season length(days)	Thermal burn	Pests and diseases	Wind chill damage
40	0.30	28	280	Slight occasionally	Leaf damage occasionally	None

Shown in Table 4, the climate factors between original and introduced locations are quite similar except winter temperature. Guangdong had successfully introduced Slash pine from southeast USA.

Table 4. Comparison on ecological and climate factors between original and introduced locations

	Mean annual temperature (°C)	Jan. mean temperature(°C)	July mean temperature	Rainfall (mm)	Jan. mean daily sunshine hours	July mean daily sunshine hours
Atlanta USA	17.3	-0.3	31.1	1600	5.3	8.8
Guangzhou China	21.3	9.8	32.7	1899	4.3	7.1

Recommendations

From the initial assessment, *Q. rubra* has good potential as tree plantation species in south China. Establishment and management of *Q. rubra* germplasm is necessary for large scale planting.

More *Q. rubra* germplasm from different ecological sites should be collected and introduced. This will improve the genetic base and produce better planting materials.
The investigation on long-term growth and development of *Q. rubra* is critical for the deployment of *Q. rubra* germplasm for large scale tree plantation.

Acknowledgements

Longdong Forest Farm and Beilingshan Forest Farm donated forestland for conservation sites. Zhang Qian, Lian Huiming, Zhou Lihua, Lan Yanqun, Wang Yan and Cai Hanxing assisted with field and laboratory work. Funding support was provided by the Science and Technology Department of State Forestry Administration, China.

References

Abrams, M.D. 1992. Fire and the development of oak forests, *BioScience* 42:353–364.

Bardon, R.E. and Countryman, D.W. 1993. Survival and growth for the first-growing season of northern red oak (Quercus rubra L.) seedlings underplanted in mixed upland hardwood stands in south central Iowa, Proc. of 9th central hardwood forest conf. *US For. Serv. Gen. Tech. Rep. NC-161,* pp. 195–209.

He Liping, Zeng Linghai, He Boxiang and Cai Yanling. 2011. Effect of Fertilization on the Growth of Quercus rubra L Seedlings, *Guangdong Forestry Science and Technology* 27:55–58.

Introduction Trials of *Chukrasia* Sp and *Manglietia glauca* in Southern China

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Chukrasia sp have a wide range of uses. The trees are popular ornamental trees, and the wood is used for furniture, buildings, and so on (Kalinganire and Pinyopusarerk 2000, Pinyopusarerk and Kalinganire 2003). Phragmalin from *Chukrasia* is used by pharmaceutical industry, as an ingredient for cancer medicine. Chukrasia timber is USD1000 per cu m, *and Manglietia* is around USD400 per cu m.

In 1996, a *Chukrasia* provenance trial was established in Zhangzhou, Fujian Province, with 10 seedlots. In 2008, *Chukrasia* provenance trials were also established in Chengmai, Hainan Province; and Xinxing, Guangdong Province, with 14 seedlots *Manglietia glauca* provenance/family trials were also established at two locations in Guangdong Province with 5 seedlots and 54–61 families. In 2010, another *Chukrasia* provenance trial with 27 seedlots was established at Xinxing, Guangdong Province; and a Provenance/Family Trial with 4 seedlots and 27 families at Xingxing and at Beilingshan State Forest Farm, Guangdong Province. Meanwhile, some related research activities have been carried out, such as primary selection of better genetic resources, propagation techniques and genetic variation analysis for the two species, endo-mycorrhizal fungus selection for *Chukrasia*, as well as the genetic diversity of *Chukrasia* in qualitative and quantitative traits.

Methodology

Genetic resources of introduction trails
Since 1996, 7 field trials were established. *Chukrasia* planting materials from Thailand, Vietnam, Malaysia, Lao, Myanmar, Sri Lank, Australia and China; and *Manglietia* from Vietnam only (Table1).

Experimental Design
Completely Randomized Block design was employed with 4–5 replicates and with 10 or 16 trees per plot (Table 1).

Table 1. Introduction trails in fields of Fujian, Hainan and Guangdong

No.	Year	Species	Provenance	Family	Location
Exp1	1996	*Chukrasia tabularis* and *C. velutina*	9		Yanxi Forest Farm, Changtai, Fujian
Exp2	2008	*Manglietia glauca*	5	61	Liangdongjing Forest Farm, Xinxing, Guangdong
Exp3	2008	*Manglietia glauca*	5	54	Longshan Forest Farm, Lechang, Guangdong
Exp4	2007	*Chukrasia tabularis* and *C. velutina*	13		Liangdongjing
Exp5	2007	*Chukrasia tabularis* and *C. velutina*	13		Chenmai, Hainan
Exp6	2010	*Chukrasia tabularis*	27	27	Liangdongjing, Xinxing, Guangdong
Exp7	2010	*Chukrasia tabularis*	4	27	Beilingshan Forest Farm

Note: some plant taxonomists suggested using *Manglietia conifera to* replace *Manglietia glauca* in Vietnam, but there are still augments between forestry researcher and taxonomists in China.
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Table 2. Tree height (m) and DBH (cm) of the total 5 provenances and 61 families at 2.5 years after planting in Guangdong (Duncan Multiple test, $p<0.01$)

Fam no.	Height (m)	Mean height (m/yr)	Fam no.	DBH(cm)	Mean DBH (cm/yr)
25	4.75 a	1.90	42	6.50 a	2.60
22	4.41 ab	1.76	48	6.48 a	2.59
42	4.18 abc	1.67	61	6.40 a	2.56
6	4.17 abc	1.67	67	6.38 a	2.55
34	4.14 bc	1.66	40	6.32 ab	2.53
44	4.12 bc	1.65	44	6.21 ab	2.48
21	4.12 bc	1.65	30	6.20 ab	2.48
15	4.11 bc	1.64	52	6.20 ab	2.48
68	4.10 bcd	1.64	21	6.16 abc	2.47
9	4.07 bcde	1.63	69	6.16 abc	2.47
69	4.04 bcde	1.62	25	6.15 abcd	2.46
8	4.04 bcde	1.62	32	6.10 abcd	2.44
66	4.01 bcde	1.6	55	6.07 abcd	2.43
48	4.00 bcde	1.6	8	6.06 abcd	2.43
38	3.99 bcde	1.6	34	6.01 abcd	2.41
67	3.97 bcde	1.59	66	6.01 abcd	2.4
37	3.96 bcde	1.58	6	6.00 abcd	2.4
64	3.93 bcde	1.57	59	5.97 abcd	2.39
52	3.92 bcde	1.57	65	5.95 abcd	2.38
17	3.89 bcde	1.56	22	5.88 abcde	2.35
50	3.88 bcde	1.55	38	5.86 abcde	2.34
55	3.88 bcde	1.55	50	5.84 abcdef	2.34
30	3.88 bcde	1.55	68	5.84 abcdef	2.34
49	3.87 bcde	1.55	49	5.79 abcdef	2.32
54	3.87 bcde	1.55	37	5.72 abcdef	2.29
63	3.86 bcde	1.54	43	5.67 abcdef	2.27
32	3.85 bcde	1.54	20	5.65 abcdef	2.26
40	3.85 bcde	1.54	5	5.64 abcdef	2.26
16	3.84 bcde	1.54	54	5.63 abcdef	2.25
61	3.82 bcde	1.53	57	5.58 abcdef	2.23
39	3.80 bcde	1.52	26	5.56 abcdef	2.22
59	3.80 bcde	1.52	41	5.55 abcdef	2.22
23	3.78 bcde	1.51	15	5.54 abcdef	2.22
56	3.78 bcde	1.51	64	5.53 abcdef	2.21
57	3.74 bcde	1.5	17	5.53 abcdef	2.21
41	3.74 bcde	1.5	63	5.52 abcdef	2.21
51	3.73 bcde	1.49	16	5.48 abcdef	2.19
20	3.72 bcde	1.49	58	5.46 abcdef	2.19
43	3.71 cde	1.48	23	5.46 abcdef	2.18
62	3.71 cde	1.48	46	5.43 abcdef	2.17
36	3.70 cde	1.48	62	5.42 abcdef	2.17
65	3.69 cde	1.48	39	5.41 abcdef	2.16
5	3.68 cde	1.47	9	5.38 abcdef	2.15
29	3.68 cde	1.47	11	5.37 abcdef	2.15
26	3.66 cde	1.46	56	5.36 abcdef	2.15
13	3.65 cde	1.46	33	5.29 abcdef	2.12
28	3.65 cde	1.46	51	5.28 abcdef	2.11
3	3.65 cde	1.46	29	5.28 abcdef	2.11
18	3.61 cde	1.44	18	5.25 abcdef	2.1
53	3.58 cde	1.43	3	5.22 abcdef	2.09
11	3.56 cde	1.42	28	5.18 abcdef	2.07
45	3.56 cde	1.42	31	5.18 abcdef	2.07
58	3.56 cde	1.42	24	5.14 abcdef	2.06
46	3.55 cde	1.42	27	5.13 abcdef	2.05
60	3.54 cde	1.42	13	4.96 abcdef	1.98
33	3.54 cde	1.42	45	4.90 abcdef	1.96
24	3.50 cde	1.4	53	4.76 bcdef	1.9
10	3.40 de	1.36	60	4.58 cdef	1.83
1	3.4 0de	1.36	36	4.57 def	1.83
31	3.39 de	1.36	10	4.34 ef	1.74
27	3.37 e	1.35	1	4.27 f	1.71

Table 3. *Chukrasia* tree height and DBH at 3 years old after planting at Liangdongjing Forest Farm (Duncan Multiple test, p<0.01)

Prov no.	Height(m)	Prov no.	DBH (cm)
14	3.73 a	8	5.52 a
15	3.60 ab	6	5.27 ab
6	3.56 ab	3	5.01 abc
16	3.54 ab	14	4.99 abc
5	3.49 ab	15	4.86 abcd
3	3.48 ab	10	4.71 abcd
8	3.35 ab	5	4.53 abcd
13	3.34 ab	16	4.47 abcd
10	3.31 ab	13	4.37 abcd
4	3.19 ab	1	4.36 abcd
1	3.04 b	17	4.17 bcde
2	3.03 b	4	3.91 cd
17	2.94 b	2	3.71 d

Results and Discussions

Stock production

Sowing the seeds in the experimental nursery of the Research Institute of Tropical Forestry then delivered and transplanted seedlings to field nurseries in Guangdong and Hainan.

Field trails

Mangelietia data (Table 2) were based on tree height and DBH collected from the first 15 families of the total 4 provenances and 61 families, 2.5 years after planting at Liangdongjiang Forest Farm in Guangdong.

Recommendations

Chukrasia and *Manglietia* have high potential in southern China, where absolute minimum temperature is not below -2 ^{o}C. In southern China, *Chukrasia* height growth was from 0.98 m to 1.24 m per year, and DBH was from 1.24 cm to 1.84 cm per year; and *Manglietia glauca* tree height *growth* was from 1.36 m to 1.90 m per year, and DBH was from 1.71 cm to 2.60 cm per year. Mycorrhizal fungus can improve growth in height of *Chukrasia* seedlings and young trees (Chen *et al*. 2011).

References

Chen, Y., Jiang, Q., Zhong, C., Zhang, Y. and Chen, Z. 2011. Effect of Arbuscular mycorrhizal fungi on seedling growth of Chukrasia tabulari. Scientia Silvae Sinicae, 47 (5):82–86.

Kalinganire A. and Pinyopusarerk K. 2000.*Chukrasia*: Biology, Cultivation and Utilisation. ACIAR Technical Reports No.49. ACIAR, Canberra. 35pp

Pinyopusarerk K. and Kalinganire A. 2003.Domestication of *Chukrasia*. ACIAR Monograph Series. ACIAR, Canberra. 76pp

Pinyopusarerk K., Kalinganire A. and McLeod I. 2001. Seed storage behaviour of *Chukrasia tabularis* and *C. velutina*. Journal of Tropical Forest Science 13: 527–533.

Acknowledgements

Many organizations and projects provided funding support: Project 948 (2009-4-02, Introduction on genetic resources and their silvicultural technology of *Chukrasia tabularis* and *Manglietia galuca*); China-Vietnam government funds (6-02J, Collection, conservation and utilization of genetic resource of some indigenous tree species in Vietnam and China).

Conservation of a Threatened Riparian Tree *Salix Hukaoana*

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Riparian forests are highly valuable because of their ecosystem functions, ecological services, and biodiversity. In Japan, the majority of riparian landscapes have been degraded by anthropogenic activities such as industrial and agricultural land use and hydrologic modifications (Sakio and Tamura 1997). Currently in Japan, the riparian forest is one of the most threatened plant communities requiring urgent conservation and restoration.

Willows (genus *Salix*) are common and typical riparian zone trees. Various species of willow shrubs and trees grow in the northern part of Japan, and often dominate riparian forests on alluvial fans and along lowland rivers (Ishikawa 1983).

Salix hukaoana is a rare riparian tree species endemic to Japan, and is presently categorized as threatened on the Red List of Japan. However, since its first discovery in 1972 (Kimura 1973), knowledge of the species had been restricted. This paper detailed a study of this willow in terms of its distribution, ecology, and genetics with the objective of conserving the species diversity of riparian habitats.

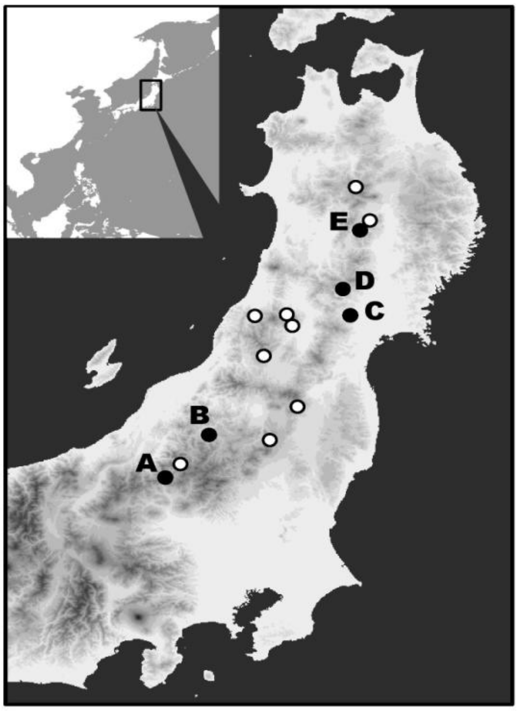

Figure 1. Known distribution of *S. hukaona.* Black circles indicate the populations surveyed in this study: (A) Tone River, (B) Tadami River, (C) Naruse River, (D) Eai River, (E) Waga River. White circles indicate the populations newly discovered during 2004-2008

Methodology

In 2003, *S. hukaoana* was known to exist only in five river basins (Figure 1). In these river basins, a total of 57 plots (100–384 m^2 in area) were established in riparian forest stands of *S. hukaoana*, and the investigation on floristic compositions, the relative dominance of species, stand age, stem size structure, habitat conditions and so on was conducted.

The level of genetic diversity was also evaluated for populations of *S. hukaoana* in each river basin using SSR markers developed for this species (Kikuchi and Suzuki 2006). Moreover, the geographic distribution of *S. hukaoana* was also investigated during 2003–2008, while the environmental conditions of extant *S. hukaoana* populations were investigated using GIS data available online.

Results and discussions

Riparian forest stands of *S. hukaoana* were mainly found in open floodplains. The 57 plots surveyed contained *S. udensis*, *S. jessoensis* and *S.cardiophylla* as well as *S. hukaoana*, and riparian trees of other taxa such as *Pterocarya rhoifolia* and *Ulmus davidiana*. The plots were classified into four major community types, which were characterized by the degree of dominance of each willow tree species (Table 1). The unimodal distribution of stem sizes at each plot suggested simultaneous regeneration after large-scale disturbance. The species richness as measured by Fisher's alpha increased with increasing stand ages (Figure 2), although the stand age never exceeded 50 years, suggesting *S. hukaoana* is short-lived and will be replaced through ecological succession.

Table 1. Floristic composition of each stand type in the study plots

Type	**I**	**II**	**III**	**IV**	**Frequency**
No. of plots	**18**	**9**	**7**	**23**	**(%)**
Salix hukaoana	31.9	21.5	21.9	55	100
Salix saccharinensis	6.5	57.5	6.3	10	61.4
Pterocarya rhoifolia	1.5	4.6	3.9	8.9	52.6
Salix jessoensis	51.2	3	-	0.8	45.6
Toisusu urbaniana	0.6	2.8	56.5	9.8	43.9
Morus bombycis	0.7	0.8	0.2	0.1	28.1
Cornus controversa	0.2	0.1	0.2	0.5	28.1
Alnus hirsuta	0.5	3.2	2.2	2.8	22.8
Betula grossa	-	0.4	1.2	2.5	22.8
Ulmus japonica	0.4	1.3	0	1.1	21.1
Acer mono	-	0.9	0.5	1	21.1
Aesculus turbinate	0	-	0.1	1	15.8
Juglans ailanthifolia	1.9	0.7	1.9	0.2	14
Robinia pseudoacacia	0.7	-	0.5	1.8	12.3
Quercus mongolica	1.5	-	-	0.2	12.3
Acer palmatum	0	0.4	0.1	0.1	12.3
Prunus grayana	0	-	0	0.1	12.3
Zelkova serrata	-	0.1	0.1`	0.7	10.5
Fagus crenata	-	-	0.7	0.3	8.8
Alnus pendula	-	0.6	0.1	0.3	7
Carpinus japonica	-	-	0	0.4	7
Populus maximowiczii	1.5	-	3.1	1	5.3
Salix integra	0.4	-	-	-	5.3
Cercidiphyllum japonicum	0	0	-	0.2	5.3
Ulmus laciniata	-	0.3	-	0	5.3
Parabenzoin praecox	0.1	-	-	0.1	5.3
Acer rufinerve	-	-	0	0.1	5.3
Acer sieboldianum	-	-	-	0.1	5.3
Salix serissaefolia	-	-	-	0.6	3.5
Cryptomeria japonica	-	-	-	0.3	3.5
Carpinus laxiflora	-	-	-	0.1	3.5
Phellodendron amurense	-	0.2	-	0	3.5
Salix bakko	-	-	-	0.1	3.5
Elaeagnus multiflora	-	1.4	-	-	1.8
Alnus japonica	0.1	-	-	-	1.8
Betula ermanii	-	-	0.3	-	1.8
Castania serrata	-	0.2	-	-	1.8
Acer nipponicum	-	-	-	0	1.8
Malus baccata	0	-	-	-	1.8
Clethra barbinervis	-	-	-	0	1.8
Magnolia obovata	0	-	-	-	1.8
Quercus serrata	-	-	0	-	1.8
Euonymus sieboldianus	-	-	-	0	1.8
Acer japonicum	-	-	-	0	1.8
Mean No. of species	**4.7**	**5.6**	**6.6**	**7.9**	**-**

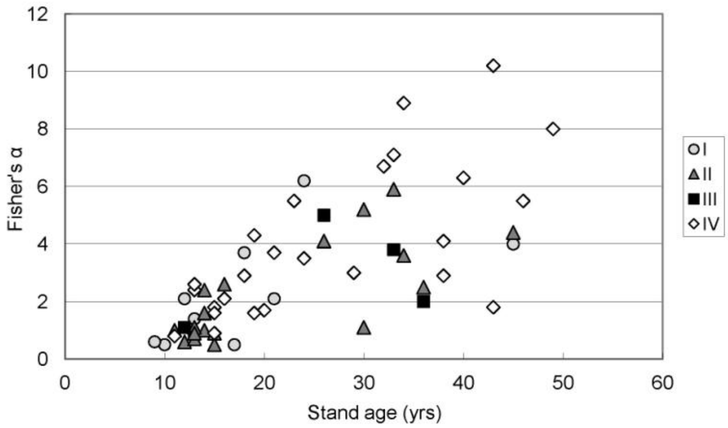

Figure 2. Relationship between stand age and Fisher's alpha of each stand in all the study plots

Genetic analysis using 8 SSR loci detected a total of 117 alleles from 851 individuals in 80 subpopulations. The number of alleles per locus in each subpopulation ranged from 1.9–5.1, but was frequently low in geographically isolated subpopulations and narrowly contracted populations that were within fragmented riparian landscapes (Figure 3).

The distribution survey led to the discovery of five new populations of *S. hukaoana* (Kikuchi and Suzuki 2010). Presently, 13 populations of *S. hukaoana* are known, which are characterized by cool-temperate climate (WI = 59.9 to 87.8) and heavy snow accumulation (often 2–3 m). The habitats tend to be small and restricted to mountainous rivers (170 to 890 m a.s.l., with the mean gradient of the valley bottom ranging from 2.0˚ to 0.5˚).

Discoveries of new habitats have improved understanding of the ecological and geographical distributions of *S. hukaoana.* The species occurs sporadically in limited localities, which are characterized by heavy snow accumulation and mountainous river landscapes. Typical habitats of *S. hukaoana* include gravel floodplains developed on wide valley bottoms, while *S. hukaoana* stands were considered to be regenerated after infrequent large-scale disturbances under natural flow regimes of mountainous rivers. The mechanism that enables *S. hukaoana* to coexist with the other willows, such as *S. udensis*, *S. jessoensis* and *S.cardiophylla*, is unclear. However, the timing of seed dispersal, which begins earlier than the other willows, may facilitate habitat separation from them (Ban and Ide 2004).

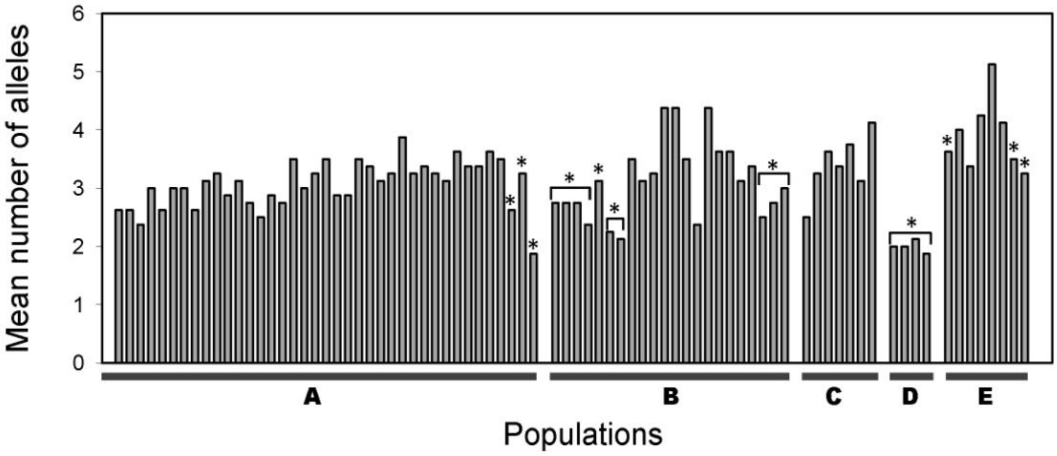

Figure 3. Genetic variation measured by the number of alleles per locus at each subpopulation. Asterisks indicate the subpopulation or groups of subpopulations which are geographically isolated

It can be concluded that *S. hukaoana* is a representative of intact riparian ecosystems of mountainous rivers in the northern part of Honshu, Japan. However, river improvement works such as the construction of check dams and revetments has been implemented at most of these rivers, which may drive vulnerable populations of *S. hukaoana* towards extinction. Moreover, genetic analysis indicated the loss of genetic variation in the isolated populations and subpopulations of *S. hukaoana*, suggesting that riparian habitat deterioration may have harmful genetic effects that expose the populations to the risk of extinction. Continuous and intact riparian forests in the mountainous rivers must be protected; not only to conserve the species but also to maintain riparian biodiversity and ecosystems.

References

Ban, N. and Ide Y. 2004. Life historical traits of *Salix hukaoana* along Yubiso River. *Bulletin of Tokyo University Forest* 112:35–43 (in Japanese, with English summary).

Ishikawa, S. 1983. Ecological studies on the floodplain vegetation in the Tohoku and Hokkaido Districts. *Japan. Ecol. Rev.* 20:73–114.

Kikuchi, S. and Suzuki, W. 2010. Distribution of an endangered willow *Salix hukaoana* in the Japan Sea side of Tohoku district. *Japanese Journal of Conservation Ecology* 15:89–99 (in Japanese, with English summary).

Kikuchi, S., Suzuki, W. and Sashimura, N. 2009. Gene flow in an endangered willow *Salix hukaoana* (Salicaceae) in natural and fragmented riparian landscapes. *Cons. Genet*. 12:79–89.

Kimura, A. 1973. Salicis nava species ex regione Okutonensi in Japonia. *J. Jap. Bot*. 48:321–326.

Niiyama, K. 2002. Floodplain Forests. In: Sakio, H., Yamamoto, F. (Eds.) *Ecology of Riparian Forests* (in Japanese). Tokyo University Press, Tokyo. Pp. 61–93.

Sakio, H. and Suzuki, W. 1997. Overview of riparian vegetation: Structure, ecological function and effect of erosion control works. *Journal of the Japan Society of Erosion Control Engineering* 49:40–48 (in Japanese).

Identifying Tree Populations for Conservation Action through Geospatial Analyses

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Rapid development of information and communication technologies has made it possible to easily collect georeferenced information on species and their environment, and to use it for analyzing biological diversity, its distribution and threats to it. Such analyses can importantly inform development of conservation strategies and priorities, especially across countries or species distribution ranges (Guarino *et al.* 2002).

Data for spatial analyses on species or genetic diversity and its distribution are collected in specifically designed studies, obtained from existing records of species occurrence, or both. Observations may be complemented by species distribution modelling, where the potential occurrence of a species is predicted based on its documented geographic distribution and climate in those areas. Results on the distribution of diversity, documented or modelled, can then be compared, for example, with existing protected areas, rates of forest degradation, threats of environmental changes, or socio-economic indicators, to identify priority tree populations and tailor strategies for their conservation and sustainable use (Pautasso 2009).

In this paper recent case studies on spatial biodiversity analyses across the tropics are presented, demonstrating how such analyses can help to identify most unique or most threatened populations of a tree species for conservation actions. Insights on initiating collaborative research on diversity and distributions of important Asian tree species are also discussed.

Analysis of species distributions

Conservation status of 100 woody plant species of socio-economic importance that are native to Latin America and the Caribbean are being evaluated in a regional initiative called MAPFORGEN (www.mapforgen.org). It is a joint project of Bioversity International and CIFOR-INIA, Spain, in close collaboration with the Latin American Forest Genetic Resources Network (LAFORGEN) and with financial support of INIA, Spain. Georeferenced observations or records of occurrence of the study species were obtained from national information systems and herbaria, literature, members of LAFORGEN, and the Global Biodiversity Information Facility (GBIF, www.gbif.org) which provides free and open access to hundreds of millions of biodiversity records. Observation points per species ranged between 21 and 6527. Potential distribution of each species was estimated by species distribution modelling. The distributions were then compared with protected areas, and with maps of short-term and long-term threats, including accessibility, conversion to agriculture, and fires (Jarvis *et al.* 2010). Specific threat profiles were developed for each species. A regional MAPFORGEN platform and a website are being developed for promoting information sharing among scientists and policy makers about the diversity, geographical distribution, biology and conservation status of the species.

Pinus kesiya and *Pinus merkusii* are economically important species of the natural pine forests of Southeast Asia. Van Zonneveld *et al.* (2009) used species distribution modelling to estimate the potential occurrence of the two species and analyze how their distributions might change as a result of climate change. Data on the locations of 46 and 50 natural populations of *P. kesiya* and *P. merkusii*, respectively, was obtained from literature, seed collection and *in situ* conservation programmes, and the Global Biodiversity Information Facility (GBIF). Distribution modelling revealed several areas in the Southeast Asian mainland where the species could naturally occur although they have not yet been recorded there. Comparison of the current potential distribution with the climate projections for the year 2050 indicated that increasing temperatures and decreasing precipitation may make several current pine populations vulnerable to degradation, especially in lowland areas.

Species distribution modelling can provide a rapid first assessment of the species occurrence in current and future climates. The results need to be compared e.g. with the suitability of soil types, plant community composition and competition in the predicted species distribution areas, connectedness of the existing populations, and provenance trials, to evaluate the validity of the predictions and the ability of the populations to survive under changing conditions (van Zonneveld *et al.* 2009, Pearson and Dawson 2003).

To evaluate the availability of data for collaborative studies on species distributions in Asia, information on selected priority species of the Asia Pacific Forest Genetic Resources Programme (APFORGEN, www.apforgen.org) was extracted from the GBIF (Table 1). Data on some important species in the region seem to be readily available for spatial analyses, and it could be further complemented from literature, national information systems or individual research groups. Data on other important species in the GBIF is surprisingly scanty. For instance, no records are available on *Tectona grandis* (teak) within its natural distribution range.

Table 1. Availability of records on the occurrence of some important tree species in Asia from the Global Biodiversity Information Facility. The data may include non-natural populations (GBIF, www.gbif.org)

Species	No. of specified locations	No. of countries	Countries [1]
Chukrasia tabularis	17	7	Ca, Ch, Ind, Lao, Ma, Th, Vi
Dipterocarpus alatus	22	7	Ca, Ind, Ins, Lao, Mya, Th, Vi
Fagraea fragrans	55	7	Ca, Ind, Ins, Lao, Ma, Th, Vi
Hopea odorata	7	6	Ca, Ind, Ins, Lao, Mya, Th
Pterocarpus macrocarpus	99	5	Ca, Lao, Mya, Th, Vi
Tectona grandis	1	1	Ph

[1] Ca=Cambodia, Ch=China, Ind=India, Ins=Indonesia, Lao=Lao, Ma=Malaysia, Mya=Myanmar, Ph=Philippines, Th=Thailand, Vi=Vietnam

Analysis of the distribution of genetic variation

Cherimoya (*Annona cherimola* Mill.) is a neotropical fruit tree species. It is known for its taste and nutritious value, and it has an excellent market potential to which a very high local diversity further contributes. An international collaborative project called CHERLA, funded by the European Commission, analyzed the genetic diversity of cherimoya at its origins of diversity (van Zonneveld *et al.* 2012). Samples from 1504 cherimoya trees were collected from georeferenced stands in Ecuador, Peru and Bolivia. The samples were used for molecular analysis using microsatellite markers, and spatial analyses then conducted with DIVA-GIS (www.diva-gis.org). Geocluster analysis showed that populations in each country clearly differ from each other. Reserve networks for cherimoya were identified according to the principle of complementarity, i.e. by selecting a combination of reserves that best captures both the areas of highest diversity and those with possibly lower but unique diversity. The results show the highest allelic richness (number of alleles) and locally common alleles in the cherimoya populations in Southern Ecuador and Northern Peru. These areas should be priority when establishing in situ conservation measure. Structure analysis shows that although in Bolivia and southern Peru lower levels of diversity were observed, the allelic composition in those areas is very different from that of Ecuador and Northern Peru. To maintain these unique compositions, some sites from these areas should, thus, also be prioritized for conservation (van Zonneveld *et al.* 2012).

Bark of the valuable *Prunus africana* tree yields medicinal products for treating benign prostatic hypertrophy (BPH). The collection and processing of the bark has created economic opportunities for indigenous peoples, especially in countries where the commercial exploitation is most significant, such as Cameroon, Madagascar and Kenya. A study funded by the Austrian Development Agency collected georeferenced chloroplast and nuclear markers data of *P. africana* to evaluate allelic richness and composition of its populations across the species distribution range (B. Vinceti *et al.* in prep.). The data collected represent the most significant, extensive sampling of an Afromontane tree investigated in genetic studies. The DIVA-GIS software was used to calculate and map the allelic richness of 32 populations of *P. africana* from 9 countries. A cluster analysis was performed to assess the allelic composition of the populations to gain insight on the genetic structure of the species. Reserve selection analysis was conducted to identify a combination of priority conservation sites which would conserve the largest proportion of genetic diversity (measured through microsatellite markers). Use of spatial analysis could be expanded in future studies e.g. by applying spatial analysis tools to markers of adaptive significance, and to derive insight on how to improve the current management practices of the species in the face of climate change (e.g. identifying highly adapted germplasm or monitoring the most vulnerable populations). Spatial analysis tools can also support the interpretation of complex G x E interactions which determine the observed variation in useful traits.

Regional collaboration in diversity distribution analyses

Predictions of species distributions or diversity analyses are based on field observations, and their accuracy directly depends on the amount and quality of available data. Figure 1 demonstrates how adding observation data from different countries affects the predicted distribution of a species. Collaboration among countries to collect and compile data along species distribution ranges can greatly enhance the usefulness of spatial analyses and facilitate identification, conservation and sustainable use of species of common interest and their genetic resources.

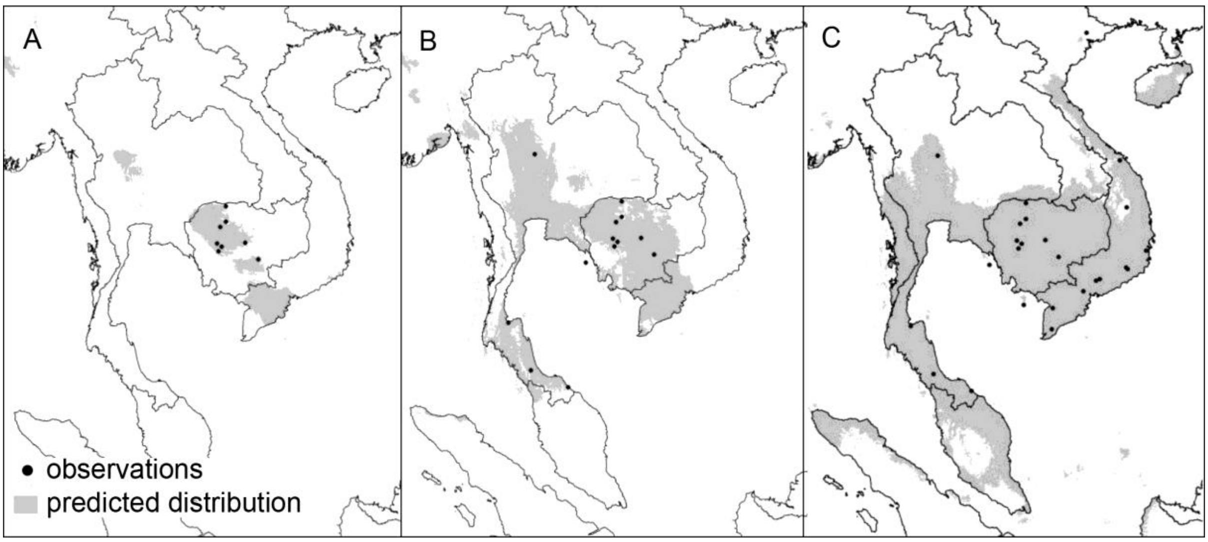

Figure 1. Effect of adding observations from different countries on the predicted distribution of *Fagraea fragrans*. (a) one country, (b) two countries, (c) three countries. Data from the Global Biodiversity Information Facility (GBIF) and the WORLDCLIM database (Hijmans *et al.* 2005) was analyzed using DIVA-GIS and the species distribution modelling programme Maxent (Phillips *et al.* 2006)

References

Hijmans, R.J., Cameron, S.E, Parra, J.L., Jones, P.G. and Jarvis, A. 2005. Very high resolution interpolated climate surfaces for global land areas. *Int. J. Climatol*. 25: 1965–1978.

Jarvis, A., Touval, J.L., Castro Schmitz, M., Sotomayor, L. and Hyman, G.G. 2010. Assessment of threats to ecosystems in South America. *J. Nat. Conserv*. 18:180–188.

Pautasso, M. 2009. Geographical genetics and the conservation of forest trees. Perspect. *Plant Ecol. Evol. Syst.* 11:157–189.

Pearson, R.G. and Dawson, T.E. 2003. Predicting the impacts of climate change on the distribution of species: are bioclimate envelope models useful? *Global Ecol. Biogeogr.* 12: 361–371.

Phillips, S.J., Anderson, R.P. and Schapire, R.E. 2006. Maximum entropy modelling of species geographic distributions. *Ecol. Model.* 190: 231–259.

van Zonneveld, M., Koskela, J., Vinceti, B. and Jarvis, A. 2009. Impact of climate change on the distribution of tropical pines in Southeast Asia. *Unasylva* 60: 231/232.

van Zonneveld, M., Scheldeman, X., Escribano, P., Viruel, M.A., Van Damme, P., Garcia, W., Tapia, C.; Romero, J., Sigueñas, M., and Hormaza, J.I. 2012. Mapping genetic diversity of Cherimoya (*Annona cherimola* Mill.): application of spatial analysis for conservation and use of plant genetic resources. PLoS ONE 7(1): e29845. doi:10.1371/journal.pone.0029845

Resource Status and Conservation of Four Endangered and Valuable Trees in Hainan Island of China

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Hopea hainanensis, *Madhuca hainanensis*, *Alseodaphne hainanensis* and *Cephalotaxus mannii* can be considered as noble wood trees not simply because of their hue, grain and texture, but more because of their strength and durability. Being versatile and have high aesthetic qualities they are the tropical hardwood in demand by a specific market segment of "luxury" applications including buildings, furniture, ships and decorative components (Zhou 2001). In addition, the most important use of *Cephalotaxus mannii* is the anticancer active ingredients which can be extracted from it, and have been used in anticancer formulation (Fu *et al*. 2003). Unfortunately, all of them have narrow natural distribution, especially for *Hopea hainanensis* and *Madhuca hainanensis* which occur naturally only on Hainan Island of southern China. Furthermore, rapid destructions of natural forests have taken place due to over-exploitation to meet timber requirement and reclamation for farming in the past. Resource investment and research on propagation and protection of these four species have been carried out on Hainan Island by the Research Institute of Tropical Forestry, CAF (Huang *et al*. 2010a, 2010b, 2011a, 2011b). At present, natural resources of these four trees are well conserved on Hainan Island natural reserves. However, there are still only a few plantations of them although they are considered as valuable woods. So, there is an urgent need to raise plantations in order to reduce pressure on natural forests and to carry out *ex situ* protection at the same time.

Resource status

Survey of natural resources of *Hopea hainanensis*, *Madhuca hainanensis*, *Alseodaphne hainanensis* and *Cephalotaxus mannii* was executed in 2008–2010. The family, main uses, natural distribution areas, natural resource status, propagation methods at present, and some other information are showed in Table 1. *Hopea hainanensis* and *Madhuca hainanensis* are naturally distributed only in southwestern mountains of Hainan Island in China belonging to the northern edge of tropical zone. *Cephalotaxus mannii* occurs naturally in southern subtropical areas and tropical mountain rain forests, such as India, Burma, Laos, northern Vietnam, western and northern Thailand, southern and southwestern China, and mainly on Hainan Island. *Alseodaphne hainanensis* is native to Hainan Island and southern Yunnan in China, and also northern Vietnam.

Natural forests grew on the whole Hainan Island 540 years ago according to historical records, and *Hopea hainanensis*, *Madhuca hainanensis*, *Alseodaphne hainanensis* and *Cephalotaxus mannii* were abundant and continuous in distribution (Li *et al*. 1996). However, these resources became scarcer and scarcer rapidly after then. There were fewer than several hundreds of *Hopea hainanensi* and *Cephalotaxus mannii* individuals in natural forests, respectively, which are more than 10 cm in DBH according to the survey in 2008–2010 (Huang *et al*. 2010a, 2010b). *Madhuca hainanensis* and *Alseodaphne hainanensis* are found in some small mixed forests with other species in natural resources (Huang *et al*. 2011b). The four species have been listed as national rare and endangered plants since 1984 and national important protected wild plants in 1999.

Endangered reasons

There are two main reasons which may account for the endangered status of these four species on Hainan Island (Huang *et al*. 2010a, 2010b, 2011a, 2011b). First, interfered and destroyed by human activities such as harvesting and reclamation. They were the first selected species to be harvested for their excellent timber properties for a wide array of uses. Second, difficulties in natural regeneration because of their botanical characteristics. They were difficult in fruiting and often no seed for several years continuously. Many *Madhuca hainanensis*, *Alseodaphne hainanensis* and *Cephalotaxus mannii*

Table 1. The family, main uses, natural distribution areas, natural resource status, propagation methods at present, main mixed trees in natural forests and class in state important protected wild plants content (1999)

Species	Family	Main uses	Natural distribution areas	Natural resource status(2010)	Propagation methods	Main mixed trees in natural forests	Class in the state important protected wild plants content（1999）
Hopea hainanensis	Dipterocarpaceae	hardwood	Hainan Island	several hundred individuals in natural forests, which are more than 10 cm in DBH	seed and grafting	*Vitica mangachapoi*, *Litchi chinensis* var. *euspontanea*, *Heritiera parvifolia*, *Gironniera subaequalis, Canarium album*, *Ormosia semicastrata* and *Schima superba*	I
Cephalotaxus mannii	Cephalotaxaceae	hardwood, anticancer medicine	South subtropical areas and tropical mountain rain forests. Mainly on Hainan Island	no more than 1000 individuals in natural forests, which are more than 10 cm in DBH	seed, cutting and grafting	*Polyalthia laui*, *Lithocarpus fenzelianus*, *Podocarpus imbricatus*, *Dacrydium Pierre, Alseodaphne hainanensis* and *Gironniera subaequalis*	I
Madhuca hainanensis	Sapotaceae	hardwood	Hainan Island	some mixed natural forests	seed and grafting	*Dacrydium pierrei*, *Lithocarpus amygdalifolius*, *Castanopsis patelliformis* and *Cyclobalanopsis bambusaefolia*	II
Alseodaphne hainanensis	Lauraceae	hardwood	Hainan Island, southern Yunnan and northern Vietnam	some mixed natural forests	seed and grafting	*Podocarpus imbricatus*, *Winchia calophylla*, *Madhuca hainanensis*,*Dacrydium pierrei*, and *Gironniera subaequalis*	II

fruits and seeds were also eaten by many kinds of wild animals. In addition, most *Hopea hainanensis*, *Madhuca hainanensis* seeds cannot germinate for they have matured in dry seasons (March–April) in Hainan. *Cephalotaxus mannii* seeds are difficult in germinating by themselves without treatment in low temperature. Furthermore, their seedlings grow slowly and it is disadvantage in the competition with other species in natural conditions.

Propagation methods

In this programme, the main study was on the research of propagation. Seeding, cutting, grafting, and tissue culture methods, have been studied. At present, *Hopea hainanensis*, *Madhuca hainanensis* and *Alseodaphne hainanensis* are mainly propagated using seeds with high germination rate at 80–98%(Huang *et al*. 2010a, Huang *et al*. 2011a, Huang *et al*. 2011b). Another method is grafting with survival ratio of 92%. *Cephalotaxus mannii* can be propagated by sowing seeds after storing the seeds in low temperature (5–10°) for 2–4 months, and the germination rate was up to 80% (Huang *et al*. 2010b). But *Cephalotaxus mannii* seeds in particular are few because most of trees have difficulty in fruiting, and often without fruit for several years. *Cephalotaxus mannii* can also be propagated by cutting with survival ratio of up to 85% (Fu *et al*. 1997), and grafting with survival ratio at 96%. Tissue culture for *Cephalotaxus mannii* is being experimenting to circumvent the problem of propagating by seeds and cuttings (Fu *et al*. 2004, Li *et al*. 2005).

Conservation strategy

A two-prong conservation strategy has been executed (Huang *et al*. 2010a, 2010b, 2011a, 2011b). First, *in situ* conservation in natural forests such as Jianfeng National Natural Reserve and Bangwangling National Natural Reserve play an important part in the programme. Most of resources were protected and regenerated well in these ecological forests.

Second, *ex situ* conservation was combined to protect these kinds of resource. They can be found in parks (Haikou Park) for landscaping, in gardens (tropical forest garden) for resource collection and protection, and also there are some plantations for introduction trials and research. Some were planted for economical benefits by individuals and forest farms. In addition, Chinese people prefer to grow these four species at four locations (beside houses, around the village, along roadside, and along riverside and around ponds/lakes), this is a good way of protection. These species have been introduced into Guangdong, Yunnan (Yang *et al*. 2007), Guangxi, Fujian Provinces of China (Lin *et al*. 2004), and also other areas in southern Asia (Huang *et al*. 2010b). It's encouraging that more than half of these plantations grew well and faster than those in natural forests showing good prospect for plantation establishment. However, forest plantations of these species developed very slowly due to their long rotation and other reasons. There is an urgent need to raise plantations in order to reduce pressure on natural forest of these four species. This can be achieved with the improvement of quality of planting stock, which gives more quality timber in shorter rotation. The species should be promoted as prime candidates for trees cultivation by public and private enterprises.

Acknowledgements

We thank Drs. D. P. Xu, C. L. Zhong, J. Zeng for their good advices in this project. This project is supported by special fund of national non-profit research institute, the Research Institute of Tropical Forestry, Chinese Academy of Forestry (200806).

References

Fu, W.Y., Du, D.L. and Fu, M.J. 2004. Callus induction and culture of *Cephalotaxus mannii*. *Plant Physiology Communications* 40(1):34–36.

Fu, W.Y., Du, D.L. and Xing, Y.W. 2003. Study on the protection and exploitation of *Cephalotaxus mannii*. *Molecular Plant Breeding* 1(5/6):795–799.

Fu, W.Y., Pan, X.F., Chen, X.H., Liu, G.M. and Li, R.Z. 1997. Study on cutting and rooting of *Cephalotaxus mannii*. *Natural Science Journal of Hainan University* 15(3):239–244.

Huang, G.H., Liang, K.N., Zhou, Z.Z., Lin, M.P. and Ma, H.M. 2010a. The research and development of rare plant *Hopea hainanensis*. *Acta Agriculturae Universitatis Jiangxiensis*. 32(supplement):108–111.
Huang, G.H., Liang, K.N., Zhou, Z.Z., Lin, M.P. and Ma, H.M. 2010b. The research and development of anticancer medicinal plant *Cephalotaxus mannii*. *Acta Agriculturae Universitatis Jiangxiensis* 32(supplement):57–61.
Huang, G.H., Liang, K.N., Lin, M.P., Zhou, Z.Z. and Ma, H.M. 2011a. Propagation techniques of rare plants *Hopea hainanensis* and *Alseodaphne hainanensis*. *Practical Forestry Technology* 10:23–24.
Huang, G.H., Liang, K.N. and Zhou, Z.Z. 2011b. Research and preservation of *Madhuca hainanensis* and *Alseodaphne hainanensis*. *Gongdong Forestry Science and Technology* 27(5):67–71.
Jiang, Z.G. and Ma, K.P. 2009. Status, challenges and strategy in conservation biology. *Biodiversity Science* 17(2):107–116
Lin, J., Ye, G.F., Sheng, D.Y. and Huang, H.T. 2004. Introduction of *Manglietia glauca* and *Madhuca hainanensis* at southern Fujian mountain area. *China Forestry Science and Technology* 18(1):18–20.
Li, Z.L. and Huang, S.M. 1996. Study on natural distribution of *Madhuca hainanensis*. *Tropical Forestry* 24(2):71–74.
Li, Z.Y., Wang, Z.N. and Xu, L. 2005. *In vitro* rapid propagation of *Cephalotaxus mannii*. *Plant Physiology Communications* 41(6):786.
Yang, D.J. and Qiu, Q. 2007. Preliminary Study on Introduction of *Hopea hainanensis*. *Jiangxi Forestry Science and Technology* 2:27–29.
Zhou, T.F. (Eds.) 2001. *Cultural Technologies of Main Tropical Economic Trees in China*. Chinese Press of Forestry, Beijing, China.

Genetic Diversity of *Aquilaria crassna* (Thymelaeaceae) in Thailand Using Microsatellite Markers

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Aquilaria crassna or agarwood is one of five species of genus *Aquilaria*, family Thymelaeaceae in Thailand which has distributed from India, Burma, Indochina, SE China and SE Asia (Hou 1964, Lecomte 1915). In Thailand, so far five species have been recorded namely: *A. malaccensis* Lamk., *A. crassna* Pierre ex Lec., *A. subintegra* Hou, *A. hirta* Ridl. and *A. rugosa* L.C. Kiet & KesslerA (Peterson 1997, Eiadthong 2007). *A. crassna* and other species in the genus *Aquilaria* sometimes produce resin impregnated heartwood that is fragrant and highly valuable. This species is in high demand for traditional medicine, incense and perfume across Asia and the Middle East.

Due to the increasing demand and high price, agarwood is over-harvested in Central and Southeast Asia (LaFrankie 1994, Chakrabarty *et al*. 1994, Soehartono and Newton 2001a). As a result, seven *Aquilaria* species are categorized as vulnerable. In addition, *A. crassna* is on the IUCN red list as critically endangered and considered to be at risk from overexploitation (Olfield *et al.* 1998). All species of *Aquilaria* and *Gyrinops* were placed on the Appendix II list of Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) to improve control of commercial agarwood trade.

Molecular technology has been used to investigate the phenotype and genotype of gene expression, genetic variation, genetic diversity, genetic relationship and classification of species of flora and fauna because it provides accurate results compared to other methods. Nuclear microsatellites, which consist of tandemly repeated short DNA sequence motifs, are highly informative, PCR based molecular markers. Microsatellite markers have been useful in detecting genetic variation in animals and plants including tropical tree species in threatened forests and forest fragments (Aldrich *et al*. 1998). Microsatellites are also powerful tools for assessing genetic variation within and among populations.

The objectives of this study were to measure genetic variation and population genetic structure in natural populations of *A. crassna* in Thailand and to suggest guidelines for species conservations using the acquired genetic information

Methodology

Young leaves of agarwood were collected from seven populations in different parts of Thailand. The procedure to extract DNA from agarwood leaf tissue was modified from Doyle and Doyle (1990). Primers, developed for *A. crassna* (6pa18, 10pa17, 16pa17) (Eurlings *et al*. 2010), and *A. sinensis* (BMX1, BMX3, BMX7)(Zhang *et al*. 2010)(Table 1), were used.

Table 1. Microsatellite loci and allele size, number of alleles detected (*A*) ,observed (*Ho*) and expected (*He*) heterozygosity values, and Wright's *F*-statistics (F_{st}) for six polymorphic microsatellite loci in *Aquilaria crassna*

Locus	Expected allele size (bp)	*A*	*Ho*	*He*	F_{st}
6pa18	210	6	0.8081	0.8110	0.3668
10pa17	156	7	0.7691	0.7718	0.3901
16pa17	155	7	0.7901	0.7929	0.4387
BMX1	397	5	0.7382	0.7408	0.4778
BMX3	365	5	0.7554	0.7581	0.4811
BMX7	366	5	0.6783	0.6807	0.4847
All loci		5.83	0.7565	0.7565	0.4440

The following genetic parameters were estimated: percentage of polymorphic loci (*P*), average number of alleles per locus (*A*), the average effective number of alleles per locus (*Ne*), observed (H_o) and expected heterozygosity (H_e), genetic distance (Nei 1978), genetic differentiation among populations (F_{st}) (Weir and Cockerham 1984, Wright 1978) and UPGMA clustering analysis (Nei 1972, 1978).

Results and discussions

Genetic diversity

A total of 140 samples were genotyped for six microsatellite loci. Thirty-five alleles were found. The number of alleles per locus varied from 5 to 7 with an average of 5.83 alleles per locus (Table 1). The highest allelic diversity was found in Phetchabun population and lowest in the Chiang Mai and Trat populations with an average of 2.69. The loci characterized here can also be used for genotyping of cultivars for plant breeding studies. Furthermore, genetic diversity within and among agarwood plantations can now be studied to quantify loss of genetic variability, inbreeding depression worldwide, and selection of suitable germplasm for *in situ* conservation.

The effective number of allele per locus (*Ne*) ranged from 1.62 in the Chiang Mai population to 2.54 in the Udon Thani population. Genetic diversity varied among populations, with *He* values ranging from 0.3606 in the Chiang Mai population to 0.5060 in the Khon Kaen population. The mean expected and observed heterozygosity was 0.4951 and 0.4522, respectively (Table 2). The level of genetic diversity estimated based on six microsatellite loci in this study was moderate and comparable with those reported on other *Aguilaria* species such as *A. sinensis* (0.4531–0.8372) (Zhang *et. al*. 2010)

Table 2. Number of individuals in population (*N*), alleles per locus (*Na*), effective number of alleles (*Ne*), observed (*Ho*) and expected heterozygosity (*He*) in *Aquilaria crassna* populations over all loci

Population	Samples size	Latitude-Longitude	*Na*	*Ne*	*Ho*	*He*
Khon Kaen (KKN)	20	16°26'18"-102°50'20"	2.83	2.03	0.4167	0.5060
Udon Thani (UDN)	20	17°10'03" -102°46'50"	2.83	2.54	0.5074	0.5028
Phetchabun (PNB)	20	16°26'35"-101°08'57"	3.17	2.06	0.5000	0.4573
Chiang Mai (CMI)	20	18°46'35"-99°14'53"	2.33	1.62	0.5083	0.3626
Prachinburi (PRI)	20	14°06'36"-101°47'06"	2.83	1.89	0.5333	0.4417
Chanthaburi (CTI)	20	13°08'14"-102°13'08"	2.50	2.03	0.5000	0.4607
Trat (TRT)	20	12°13'54"-102°30'48"	2.33	2.05	0.5000	0.4553
Overall	20		2.69	2.03	0.4951	0.4552

Genetic differentiation

The coefficient of population differentiation (F_{st}) among populations ranged between 0.1649 (BMX5) and 0.7430 (6pa18) with the mean of 0.4552 (Table 1). Genetic distances between populations ranged from 0.1571 to 0.5658. A dendrogram based on Nei's genetic distance showed that seven populations were divided into three groups (A, B and C) (Figure 1). Separation of group A (KKN and UDN population from the Northeast and PRI, CTI and TRT from the East) from group B (PNB population from the West) and C (CMI population from the North).

The genetic structure of species is affected by a number of evolutionary factors including mating system, gene flow and seed dispersal, mode of reproduction, as well as natural selection (Hamrick *et. al.* 1992). This naturally low and scattered abundance over a large geographic region means that future sampling should be as extensive as possible. Species of Aquilaria for which the pollination biology was investigated, were found to be insect pollinated and obligate outcrossers. Seed production is generally high but seed dispersal is very limited (Soehartono and Newton 2001b). This study provides data on the genetic diversity of *A. crassna* in natural populations and is helpful in resource conservation, introduction trials, and further studies of *A. crassna* and related species.

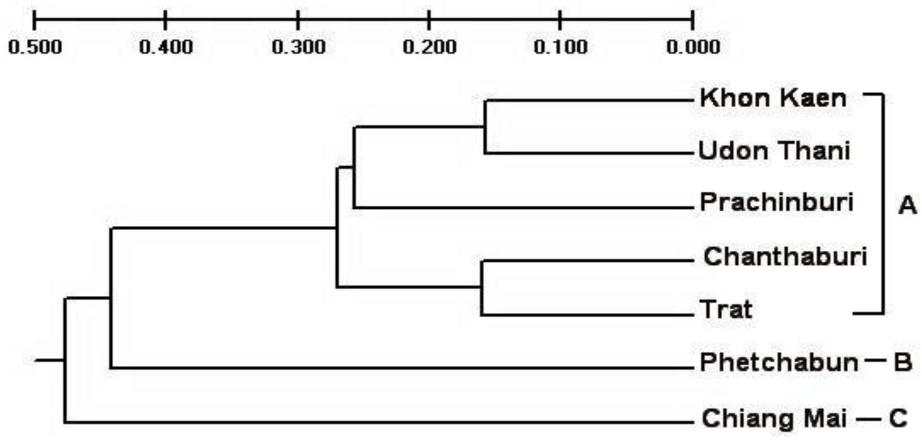

Figure 1. Genetic distance among the seven populations of *Aquilaria crassna* in Thailand; dendrogram using unweighted pair group method with arithmetic average (UPGMA) cluster analysis based on Nei's (1978) unbiased minimum distance. The UPGMA tree separated the populations into three groups (A, B, and C). The bootstrap values are based on 1000 replicates and were generated by TFPGA software (Miller 1997)

Acknowledgements

This study would not have been possible without the help from the laboratory of Forest Genetic Conservation and Biotechnology Research Division (National Park, Wildlife and Plant Conservation Department, Bangkok). This work was supported by research fund for publication in International journals from the Graduate School, Kasetsart University.

References

Aldrich, P.R., Hamrick, J.L., Chavarriaga, P. and Kochert, G. 1998. Microsatellite analysis of demographic genetic structure in fragmented populations of the tropical tree *Symphonia globulifera*. *Mol. Ecol.* 7:933–944.

Chakrabarty, K., Kumer, A. and Menon, V. 1994. *Trade in Agarwood*. TRAFFIC-India publications, New Delhi.

Doyle, J.J. and Doyle, J.L. 1987. A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochemical Bulletin* 19:11–15.

Eiadthong, W. 2007. *Aquilaria rugosa* (Thymelaeaceae): A New record for Thailand. *The Thailand Natural History Museum* 2(1):63–66.

Eurlings, M.C.M., Gravendeel, B. and Beek, H.H.V. 2010. Polymorphic microsatellites for forensic identification of agarwood (*Aquilaria crassna*), *Forensic Sci. Int*. 197: 30–34

Hamrick, J.L. and Godt, M.J.W. 1990. Allozyme Diversity in Plant Species. *In*: Brown, HD., Clegg, MT., Kahler, AL. and Weir, BS. (Eds.), *Plant Population Genetics, Breeding, and Genetic Resources*. Sinauer Associates Inc., Sunderland.

Hou, D. 1964. Note on some Asiatic species of Aquilaria (Thymelaeaceae). *Blumea* 12 (2):285–288.

LaFrankie, J.V. 1994. Population dynamics of some tropical trees that yield non-timber forest products. *Econ. Bot*. 48(3):301–309.

Lecomte, H. 1915. Thymelaeaceae. *Flore Générale de Lí Indo-Chine*. 5 (3):179.

Miller, MP. 1997. Tools for population genetic analyses (TFPGA) version 1.3: A Windows program for the analysis of allozyme and molecular population genetic data. Available from www.marksgeneticsoftware.net/tfpga.htm [accessed 25 March 2010].

Nei, M. 1972. Genetic distance between populations. *American Naturalist* 106:283–292.

Nei,M.1978. Estimation of average heterozygosity and genetic distance from a small number of individuals. *Genetics* 89:583–590.

Olfield, S., Lusty, C. and MacKinven, A. 1998. *The World List of Threatened Trees*, World Conservation Press, Cambridge.

Peterson, B. 1997. Thymelaeaceae. In: Smitinand, T., Larsen, K. (Eds.), Flora of Thailand 6 (3). Royal Forest Department, Bangkok, pp. 226–245.

Soehartono, T. and Newton, A.C. 2001a. Conservation and sustainable use of tropical trees in the genus Aquilaria II. The impact of gaharu harvesting in Indonesia. *Biol. Conserv*. 97(1): 29–41

Soehartono, T. and Newton, A.C. 2001b.Reproductive ecology of Aquilaria spp. in Indonesia, *For. Ecol. Manag.* 152:59–71.

Weir, B.S. and Cockerham, C.C. 1984. Estimating F-statistic for Analysis of Population Structure. *Evolution* 38(6):1358–1370

Wright, S. 1978. *Evolution and the Genetic of Population, Vol. 4: Variability within and among natural population.* University of Chicago Press. Chicago.

Zhang, Y. T., Wang, Z.F., Cao, H.L., Li , X.Y., Wu, L.F., Zhuo, S.B. and Huang, X. F. 2010. Isolation and characterization of polymorphic microsatellite loci in *Aquilaria sinensis* (Lour.) *Gilg Conservation Genet. Resour* 2:5–6.

Gall Rust Disease Epidemic on *Falcataria moluccana* in Indonesia and Malaysia

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Gall rust disease caused by *Uromycladium tepperianum* (Sacc.) is one of the most destructive diseases on *Falcataria moluccana* in some part of the South East Asia region from 1990 up to now. The disease causing severe damage to all developmental stages of the plant: from seedlings in the nurseries to mature trees in the field. Range of the symptoms includes development of chocolate brown, cauliflower-like or whip-like galls on stem, branch, petiole, shoot and pod (Rahayu *et al*. 2011). Objectives of this study were: to determine the status of gall rust disease in Malaysia, and Java Islands of Indonesia; to estimate the relationship between incidence of gall rust disease and environmental factors that may influence those phenomena at the sites and to predict the origin gall rust spore sources. Sampling intensity was 1% to 5% of the total area at each site. Three blocks, three replicates, three plots each with 10 trees were observed. In each site. More open site forest, flat topography, absence of fog, older age and lower altitude were significant local site conditions which could reduce gall rust disease incidence. However, high relative humidity and slower wind speed, are able to promote gall rust disease development. Based on the wind blew predominantly from the northeast, gall rust spores may spread from the north, probably from the Philippines, to Tawau-Malaysia, then to Celebes-Indonesia.

Introduction

The disease was first detected in 1990 in Mindanao then reached epidemic level in the entire of Philippines in 1995 (Braza 1997). The epidemic disease was also detected in Brumas Estate, Sabah, Malaysia, in 1993 (Mohd. Hatta Jaafar, pers. comm. 2003). In 2005 the disease was also reported causing severe destruction on 3 to 4-year-old *F. moluccana* plantations in new ex-mining area at an altitude of about 400 to 500 m above sea level in Sorowako, South Celebes, Indonesia (Kasno and Hadi 2005). During the period 1998–2001, gall rust disease epidemic also occurred in East Timor on *F. moluccana* trees used as shade trees for coffee (Old and Cristovao 2003). Since 2005, gall rust disease has devastated *F. moluccana* in the plantation and community forests on Java Island, Indonesia. The time of the initial outbreak was not recorded but the condition of the worst-affected plantations suggests that the fungus had been present for more than five years. As epidemic diseases such as gall rust diseases are polycyclic, the causes of the disease outbreak can only be determined if the conditions at which it occurs are well understood. According to Rosso and Hansen (2003), different environmental conditions, including climate, topography and forest stand characteristics, have to be determined in order to understand the disease outbreak.

Methodology

Gall rust disease surveys were conducted in 2006 to early 2010, in plantations in Sabah, Malaysia; and community forests in Indonesia. Each region (country) consisted at least 7 sites has 3 blocks each site was set up randomly, which were near the road, mid-way at the site and deep inside the site with approximate distance between blocks of at least 100 m. Each block was divided into three replicates with three plots per replicate. Each plot was represented by 10 young or mature trees as a unit sample. Gall rust disease status at each location was rated based on value of gall rust disease incidence (DI), and were calculated using formula DI = (n / N) x 100%, where n = number of infected trees, N = total number of trees of each plot. In order to indicate the dominant local site and meteorological factors related to gall rust disease incidence, local data (age of the tree, altitude, topography, fog condition, forest opening) and meteorological data (number of sunshine hours, wind speed, relative humidity, rainfall, number of raining days, and temperature for Sabah, and relative humidity and temperature only for Java, were paired to get a regression equation, then used for determination of the dominant factor.

Results and discussions

Since 1990, gall rust disease of *F. moluccana* has been spreading rapidly in South East Asia. Hence, gall rust disease has become a major threat to *F.moluccana* in some countries, particularly in the Philippines, Sabah in East Malaysia, several islands of Indonesia, and the Republic of East Timor. Gall rust spores are known to be dispersed by wind. From 1993 to 2009 it was noted that the wind blew predominantly from the northeast at Brumas Estate, Tawau, Malaysia, possibly spreading the spores of gall rust from the north, specifically from the Philippines to Sabah, Malaysia. Earlier, Lee (2004) had mentioned that it was not inconceivable that the infection of the Sipitang, Sabah, plantation in 1992 had its origin in the Philippines, given the proximity of Sabah to Mindanao, the dispersal of the spores by wind and the high volume of traffic between the two regions. In addition, referring to global wind system, wind is running from high calm pressure likely from the Philippines to low calm pressure in some parts of Kalimantan Island including Sabah, and small parts of Celebes Island. Conversely, the gall rust spores at Bali and Java Island will have their origins from the South, likely from Moluccas and East Timor.

The occurrence of gall rust disease can differ from site to site or can be similar across vast regions, depending on the complex interaction between the disease, the tree, the environmental and the human management practices of the site or region. The interactions between local site condition and meteorological factors at the time monitored will determined the level of gall rust disease incidence. More open site forest, flat topography of the site, absence of fog, pruning, thinning, clear cutting activities, maturity and lower altitude, were significant local site conditions that could reduce gall rust disease incidence. However, forest opening, topography and foggy conditions are the major factors; pruning, thinning and clear cutting are the intermediate factors; while age of trees and altitude are the minor factors. Relative humidity and wind speed are two meteorological factors significantly related to gall rust disease incidence. High relative humidity (RH ≥ 90%) and slower wind speed (WS ≤ 80 km/hours/day) were able to promote gall rust disease development.

The status of gall rust disease incidence of *F. moluccana* in Indonesia and Malaysia since 2006 to 2010 vary. However, from 2006 to 2009 gall rust disease incidence was increasing from common to widespread in Malaysia, while from 2009 to 2010 was decreasing from widespread to common. The factors which were closely related to reduce gall rust disease in Malaysia were clear cutting, opening the forest and conversion of the batai plantation into oil palm plantations which resulted in reduced relative humidity in the plantation. In contrast, the gall rust disease incidence in Indonesia was increasing since 2006 to 2010, from common to become widespread. High relative humidity due to global climate change which has changed the precipitation pattern to be more intensive, closed forest of the agro forestry ecosystem, heavy fog particularly during 2009 to 2010, were closely related to increased gall rust disease incidence in Indonesia, particularly at an elevation more than 400 m above sea level.

Future comprehensive risk assessment as well as enhance knowledge management system using a variety of information technologies such as simulation models, geographic information systems (GIS) and remote sensing could also play a role in protecting forest health from the impacts of climate change and gall rust disease infestation. Thus, gall rust disease monitoring and investigations should be seen as an on-going commitment in any *F. moluccana* plantation programme. Monitoring can be made directly through direct observation or indirect (recording environmental conditions which affect disease development). Regular monitoring of gall rust disease in the field is important. Assessment of changes in the incidence of gall rust disease, and also changes in the type of disease should be done regularly as these occur over time. Hence, establishing a collaboration programme among countries with *F. moluccana* plantations is an important strategy to be initiated in order to prevent and control the gall rust disease epidemic.

References

Braza, R.D. 1997. Gall rust disease of *Paraserianthes falcataria* in the Philippines. *Forest, Farm, and Community Tree Research Reports 1997.* 2:61–62.

Kasno and Hadi, S. 2005. *Pest and diseases of forest trees and general impression on the implementation of reforestation in the post mined area of PT. INCO, Sorowako, South Sulawesi*.

Visit Report Department of Silviculture Faculty of Forestry, Bogor Agricultural University. Bogor, Indonesia.

Lee, S.S. 2004. Diseases and potential threats to *Acacia mangium* plantation in Malaysia. *Unasylva* 217(55):31–35.

Old, K.M. and Cristovao, C.S. 2003. A rust epidemic of the coffee shade tree (*Paraserianthes falcataria*) in East Timor. *ACIAR Proceedings* 13:139–145.

Rahayu, S., Lee, S.S. and Nor Aini, A.S. 2011. Gall *Rust disease of Falcataria moluccana: characterization of the pathogen, environmental condition supported, genetic relationship and screening for resistance.* Lambert Academic Press, Germany. 198 p.

Rosso, P.H. and Hansen, E.M. 2003. Predicting Swiss Needle Cast Disease Distribution and severity in Young Douglas-Fir Plantation in Coastal Oregon. *The American Phytopathological Society* No. P-2003-0513-01R.

Natural Distribution, Endangered Mechanism and Conservation Strategy of an Endangered Tree Species, *Erythrophleum Fordii* Oliv.

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Erythrophleum fordii Oliv. is an evergreen broad-leaved tree species of Caesalpiniaceae, commonly known as "iron wood" in China. It is one of valuable timber tree species in tropical and subtropical regions. Its wood is classified as high-quality wood, with clear distinction between heartwood and sapwood, and heartwood can be used for making ships, high-grade furniture and flooring, sculpture and crafts, etc. (Fang *et al.* 2007). *E. fordii* has important medicinal value. Alkaloids such as diterpenoids (Tsao *et al.* 2008) and triterpenoids (Li *et al*. 2004, Yu *et al*. 2005) have been found in its seeds, bark, and leaves. In the natural forests and plantation of this species, *Ganoderma lucidum* (Curtis) P. Karst could occur when stumps decayed, which has high medicinal value. *E. fordii* also has important ornamental value and ecological benefits (Xue *et al.* 2004),

In recent years, natural forests of *E. fordii* have drastically been reduced, even have disappeared in some areas (Huang *et al.* 1997, Trung 1998, Zhao *et al.* 2009), due to heavy deforestation, land alteration for large-scale development of cash crops or fast-growing tree species (Sala *et al*. 2000). The remainder populations were smaller and the degree of population fragmentation increased, which would negatively affect adaptability and stability of the species, (Young *et al.* 1996, Fuchs *et al.* 2003, Farwig *et al.* 2008). This had made *E. fordii* severely endangered (Huang *et al.* 1997, Wang 2002), and thus it has been listed as a national key protected plant in China and included in the IUCN Red List of Endangered Species. Thus more attentions should be paid to research on conservation biology of this species.

This study investigated its distribution range, disturbance type and its effect on natural populations. It also reviews the strategy of germplasm resources collection and conservation, and studies the spatio-temporal structure and dynamics of natural population since 2007 in south China, aiming to optimize conservation, management and utilization of this species.

Methodology

Distribution survey and Germplasm resources collection
The study began with collecting references such as national and local flora, articles about *E. fordii* and checking its specimen in the main specimen centres of south China. This was followed by investigating its natural populations, recording the position of existing populations, population size, management history, disturbance, site type, etc. At the meantime its seeds were collected for *ex situ* conservation, and two germplasm pools were established in Guangdong and Guangxi Provinces.

Site and method for study on population ecology
An intact forest of *E. fordii* was found in Guangxi Daming Mountain Natural Reserve, Wuming County, Guangxi Province. Its upper altitude was the highest and altitude span was the widest in China. Five fixed plots were set along altitude, Plot II was located in the centre with area of $10000m^2$(100m×100m), and the other four plots were $6400m^2$ (40m×40m). Each plot was divided into quadrates of 10m×10m. The relative positions and growth traits including DBH, height, crown diameter, height under the live and death branches, of each individual were measured.

Population spatio-temporal structure analysis
Age class division was conducted according to DBH, with one class every 2 cm for DBH less than 4 cm, and one class every 4 cm for DBH larger than 4 cm. There were a total of 11 age classes: I, seedlings and saplings, DBH<2cm; II, DBH2–3.99cm; III, 4–7.99cm; IV, 8–11.99cm; V, 12–15.99cm; VI, 16–19.99cm; VII, 20–23.99cm; VIII, 24–27.99cm; IX, 28–31.99cm; X, 32–35.99cm; and XI, ≥36cm. Population age structure and dynamic were studied by static life table, and distribution patterns were analyzed by six indices (Zhang and Ru 2010).

Results and discussions

Geographical distribution
E. fordii is naturally distributed between the latitudes of 16º and 24ºN, which includes southern China and northern Vietnam (Huang *et al*. 1997, Trung 1998), and perhaps also in Laos (Sirivongs 2006), and the distribution altitude range is below 600 m above sea level in China. It grew well at middle and lower slopes.

Age structure, dynamics and distribution patterns
Disturbances with serious impact on the population age structure, such as Plots IV and V (Figure 1).

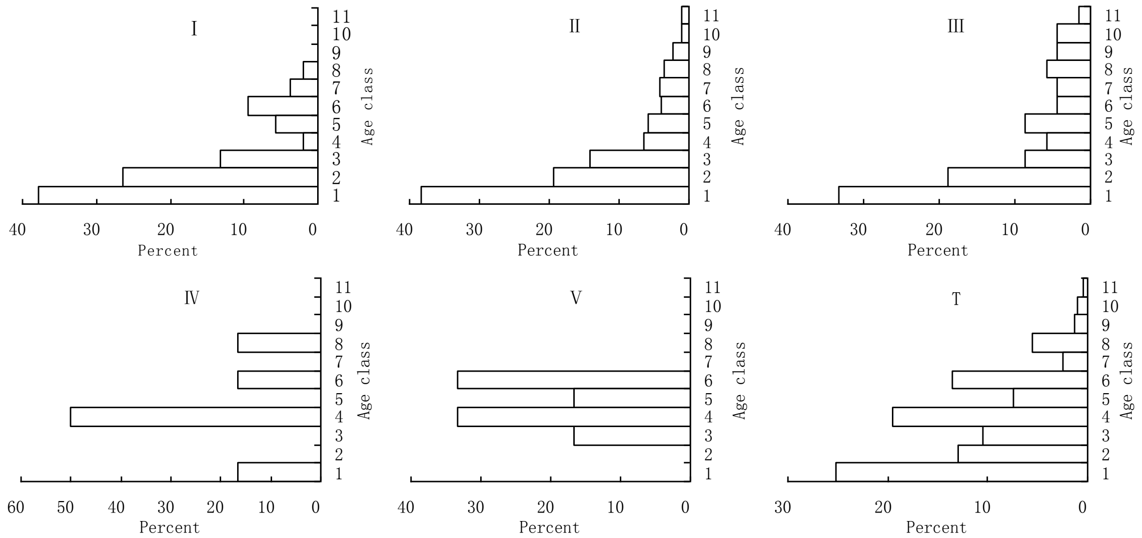

Figure 1. Age structure of *E. fordii* Oliv. in the five plots

Through analysis of static life table, the population of *E. fordii*, seedlings and sapling was mass was found to have higher mortality rate and survival rate, mortality density, and hazard rate declined while cumulative mortality rate increased with increase of age. Thus *E. fordii* population survival curve followed Deevey III (Figure 2).

As for distribution patterns, *E. fordii* grew in cluster at Daming Mountain, and disturbances would have probably changed the distribution pattern from cluster to random trends (Table 1). The populations were naturally regenerated by seeds mainly.

Endangered mechanism and conservation strategy
E. fordii seeds are hard and with poor permeability, it can be stored at room temperature for several years (Chen and Fu 1984). However in natural forest, decay rate of its seeds was over 95% in one year after fallen (Huang *et al.* 1997), and seed dispersed mainly by gravity, mostly under the canopy. Compared to other local climax tree species such as Lauraceae and Fagaceae species, its seedling competitiveness is not dominant for insect pest, which mainly affect its apical dominance. So its population diffusion and regeneration were both limited under natural conditions.

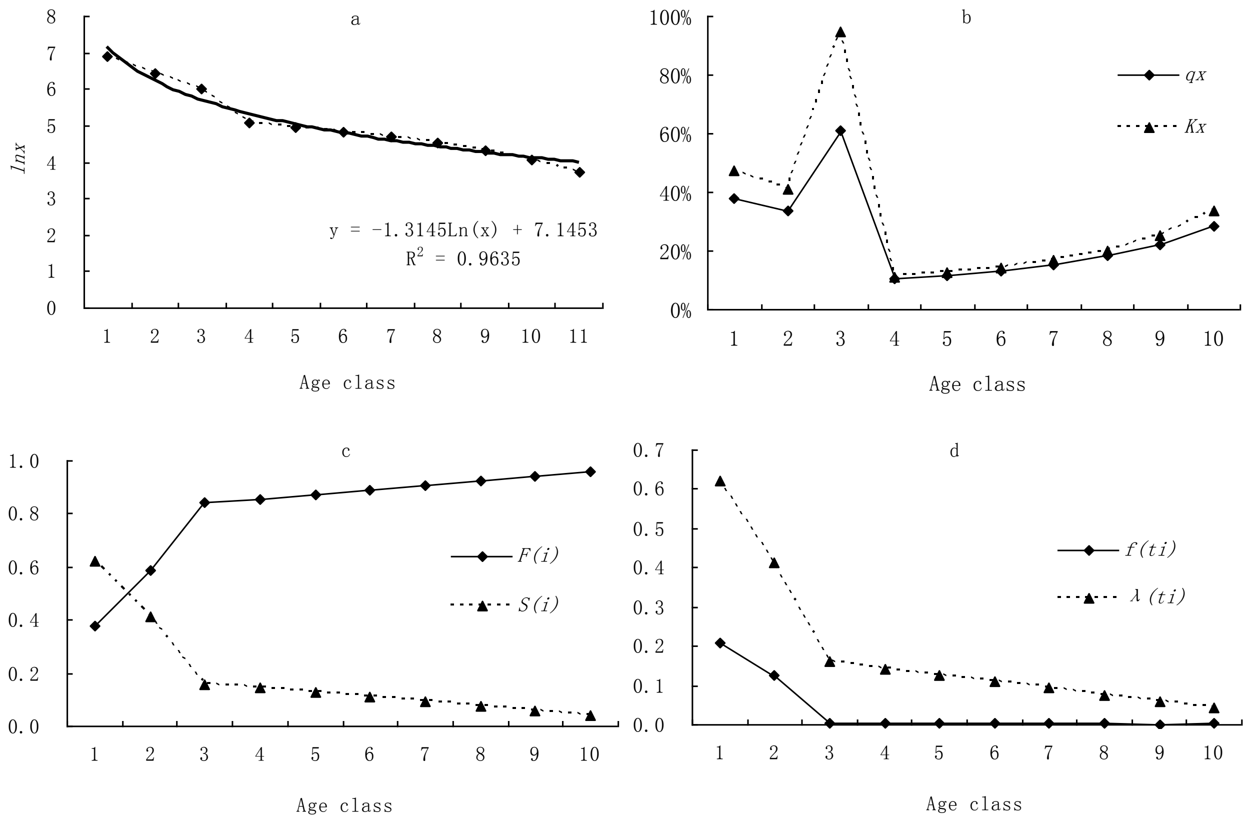

Figure 2. Dynamic analysis of *E. fordii* Oliv. population(PlotII)
a: survival shape curve ; b: Mortality rate(q_x) and Vanish rate(k_x);
c: Survival rate ($s_{(i)}$) and Cumulative mortality rate function($F_{(i)}$); d: Mortality density ($f_{(ti)}$) and Hazard rate function($\lambda_{(ti)}$)

Table 1. Distribution patterns of *E. fordii* Oliv. natural populations

Plot	*C*	*I*	*M **	*Ca*	*PAI*	*K*	Distribution patterns
I	2.85	1.85	5.16	0.56	1.56	1.79	Cluster
II	4.09	3.09	6.19	1.00	2.00	1.00	Cluster
III	3.18	2.18	6.49	0.50	1.50	1.98	Cluster
IV	1.73	0.73	1.11	1.96	2.96	0.51	Cluster
V	1.38	0.38	0.75	1.01	2.01	0.99	Cluster
Total	$C > 1$ Cluster	$I > 0$ Cluster	$M^* > \bar{x}$ Cluster	$Ca > 0$ Cluster	$PAI > 1$ Cluster	$K > 0$ Cluster	

Recently however, anthropogenic impacts are the main causes for biodiversity loss of tropical forest (Morris 2010). *E. fordii* is mostly occurred at the lower parts of mountains or hills where human disturbances frequently took place, resulted in severe fragmentation of its natural forests and habitats. Human interference is the main factor of endangered mechanism for *E. fordii*. Strengthening *ex situ* conservation of germplasm resources is an effective way to conserve this species.

References

Chen, R.Z. and Fu, J.R. 1984. Physiological studies on the seed dormancy and germination of *Erythrophloeum fordii*. *Scientia Silvae Sinicae* 20(1):35–41. (In Chinese with English abstract).

Fang, X.F. and Fang, B.Z. 2007. Wood physical and mechanical properties of *Erythrophleum fordii* in southern Fujian. *Jour. of Fujian Forestry Sci. and Tech*. 34:146–147. (In Chinese with English abstract).

Farwig, N., Braun, C. and Böhning-Gaese, K. 2008. Human disturbance reduces genetic diversity of an endangered tropical tree, *Prunus Africana* (Rosaceae). *Conservation Genetics* 9:317–326.

Fuchs, E.J., Lobo, J.A. and Quesada, M. 2003. Effects of forest fragmentation and flowering phenology on the reproductive success and mating patterns of the tropical dry forest tree *Pachira quinata*. *Conservation Biology* 17:149–157.

Huang, Z.L., Guo, G.Z. and Zhang, Z.P. 1997. A study about endangered mechanism of *Erythrophleum fordii*. *Acta Ecologia Sinica* 17(6):671–676. (In Chinese with English abstract).

Li, N., Yu, F. and Yu, S.S. 2004. Triterpenoids from *Erythrophleum fordii*. *Acta Botanica Sinica* 46 (3):371–374.

Morris, R.J. 2010. Anthropogenic impacts on tropical forest biodiversity: a network structure and ecosystem functioning perspective. *Phil. Trans. R. Soc. B*. 365:3709–3718.

Sala, O.E., Chapin, F.S., Armesto, J.J., *et al*. 2000. Global biodiversity scenarios for the year 2100. *Science* 287:1770–1774.

Sirivongs, K. 2006. Forest genetic resources conservation and management in Lao PDR – An update on activities, challenges and needs since APFORGEN inception in 2003. *In*: Hong, L.T. and Sim, H.C. (Eds). *Proceedings of the Asia Pacific Forest Genetic Resources Programme (APFORGEN) National Coordinators Meeting and International Tropical Timber Organization (ITTO), Dehradun, India, 2006.*

Trung, T.V. 1998. *Ecosystems of tropical forests in Vietnam*. Science and Technics Publishing House. Ha Noi.

Tsao, C.C., Shen, Y.C. and Su, C.R. 2008. New diterpenoids and the bioactivity of *Erythrophleum fordii*. *Bioorganic and Medicinal Chemistry* 16 (22):9867–9870.

Wang, S. and Xie, Y. 2002. *China species red list (Vol.1.).* Higher Education Press Bei Jing. (In Chinese)

Xue, L., Chen, H.Y., Xu, Y.B., Peng, Y.Q., Xu, S.K..and Chen, W. 2004. Soil physical properties, microbial biomass and enzyme activity in mixed stands. *Chinese Journal of Soil Science* 35(2): 154–158. (In Chinese with English abstract)

Young, A., Boyle, T. and Brown, T. 1996. The population genetic consequences of habitat fragmentation for plant. *Trends in Ecology and Evolution* 11:413–418.

Yu, F., Li, N. and Yu, S.S. 2005. A new diterpenoid glucopyranoside from *Erythrophleum fordii. Journal of Asian Natural Products Research* 7(1):19–24.

Zhang, J.T. and Ru, W.M. Population characteristics of endangered species *Taxus chinensis* var. mairei and its conservation strategy in Shanxi. *China. Popul. Ecol*. 52:407–416.

Zhao, Z.G., Guo, J.J., Sha, E., Lin, K.Q., Zeng, J. and Xu, J.M. 2009. Geographic distribution and phenotypic variation of fruit and seed of *Erythrophleum fordii* in China. *Chinese Bulletin of Botany* 44 (3):338–344. (In Chinese with English abstract)

Panel Discussion

An interesting and interactive round of panel discussed the prospect and challenges of Strengthening Multinational and Traditional Conservation of Valuable and Endangered Forest Tree Species – How? Mr Dede Rohadi, Scientist, Centre for Research and Development on Climate Change and Forest Policy, Bogor moderated the panel.

Dr, Zhong Chonglu, quoting examples of a number of projects carried out by the Research Institute of Tropical Forestry, stressed the importance of implementing multinational and transboundary conservation of valuable and endangered forest tree species among countries that share common tree species. He further commended the efforts of putting this workshop together to promote this kind of collaboration. In particular Dr. Zhong addressed the important of supporting genetic resource exchanges of High Valuable and Endangered Tree Species (HVETS) among the countries. Dr. Zhong reminded the participants that the HVETS should not limited only to woody species, but includes all possible tree species, such as ferns, medicinal plants and mychorriza. Strength that 'utilization' should be best way to conserve of valuable and endangered forest tree species, here utilization does not mean just to use wood or non wood products, which must include to set artificial plantations with large of scales for multiple purposes. Meanwhile, *ex-situ* conservation should pay more attention to beneficial symbiotic microorganism application, e.g., mycorrhizal fungus, *Frankia*, rhizobium, and so on, which would be precondition of survival for some valuable and endangered tree species, particularly on new planting sites.

Dr. Laskar Muqsudur Rahman described this workshop as needful during the critical moment when a vast endangered and vulnerable plant species are becoming extinct throughout the nation. Though discussions are being held at various levels and intensity; land degradation and loss of habitat are still contributing to the vast disappearance of our biodiversity genetic pools. He opined that a list of vulnerable species to be obtain as a mean to study and protect them. He further suggested that a 'leadership' (may be a network, an organization or unit) would need to be developed to organize all such conservation efforts.

Dr. Portia Gamboa Lapitam, analyzed the reason for the loss of vulnerable and endangered tree species globally. She said that several situations like forest utilization and global climate change have contributed to the loss. With particular attention to vulnerable tree species and habitat protection, she suggested that APAFRI or other relevant network to consolidate all the efforts that have been taken so far and its effect to our environment. She added that appending resolution of rehabilitation, protection, conservation of forest species and its habitat in a complete programme will gain attention to address the vulnerable and endangered tree species. She called for putting priority to the conservation of the whole habitat, not just the individual endangered species.

Dr. Anto Rimbawanto gave a synopsis of how biological genetics and geographical locations to be put into consideration towards the approach of conservation. He briefly explained that the panel discussion question is easier said than done. Conservation is effective when the biological diversity and important genetic information are addressed; genetic information helps to develop conservation strategies while geographical information addresses the transboundary diversity. Subsequently, a longer time is required to cover the whole spectrum. Dr. Rimbawanto stressed that conservation efforts need good political will and real supports from high decision makers in the countries. Scientists therefore should have good communication strategies to ensure that the decision makers have well understanding on the critical issues and the impacts of their decisions in the conservation efforts. One important question; How to make conservation attractive? Conservation has to be combined with utilization to benefit and attract the communities, he opined. “Make sure conservation benefits the people and the species itself” he quipped.

Dr. Nguyen Hoang Nghia described decreasing genetic resources as a common denominator to increase genetic base and expand collaboration among Asia Pacific countries. He cited on the millions of USD spent by Vietnam to buy seeds from Australia. “An effort to work together however only worthy to both parties by establishing collaboration”, he lamented. Perhaps China should take the lead, looking at their expertise, qualified scientist and available fund. He also pointed that, India, Indonesia, Malaysia or APAFRI can take the lead and Vietnam will willingly join.

A.C. Lakshmana expressed his satisfaction to see the active participation of a good blend of the younger along with elderly, experienced scientists assembled here in addressing forest conservation and development. Simultaneously, he pointed out that changes in our attitude are crucial in tackling the climate change and scarcity of forest products that we are facing globally. Forest scientist ought to tune-up to be a good speaker apart from being a good advocate, as science dwells with asking, learning and experimenting. He further emphasized that conservation and development should go hand in hand as they are the two faces of the same coin. Industrialists are focused on the industry and do not attach much importance to the conservation of the natural resources; subsequently, the industry confronts a challenging prospect of declining raw materials. Hence, an integrated approach involving connected people and also industrialist towards the conservation of forest is essential. In India, another important factor that can strengthen this initiative is the support from politicians and also from the media.

The panel then took up questions from delegates and discussed further on the challenges in tackling multinational and traditional conservation of valuable and endangered forest tree species in the Asia Pacific region; including a point of view from Dr. Sim Heok-Choh on the raised issue regarding the need for another network to facilitate the conservation efforts.

Appendix I

Field Trip Report

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Field Trip Overview

Field trips are a key component of the Multinational and Transboundary Conservation of Valuable and Endangered Forest Tree Species workshop. Field trips are aimed at fostering greater identification with management and experimental activities through field experiences. On December 6, 2011 the workshop participants participated in a field trip to two selected locations in Guangdong Province, highlighting the research of Sandalwood in a Sandalwood Research Base owned by Dragon Pearl Island Sandalwood Industrial Technology Corporation Limited and the management of valuable tree species at Tiexi Operation Section, State-own Beiling Mountain Forest Farm of Zhaoqing City.

The primary goal of the field trip were to further knowledge about the management of Valuable Tree Species (VTS); providing an overview of several interesting methods and ecologically interesting sites; enable participants to build a network among professionals; sharing the same interest and expose participants to the practical applications of research and development in field. Research includes product development, plant host configuration and management of other valuable tree species. A map of the field trip area pointing the distribution of valuable tree species provided during the trip can be found in Figure 1.

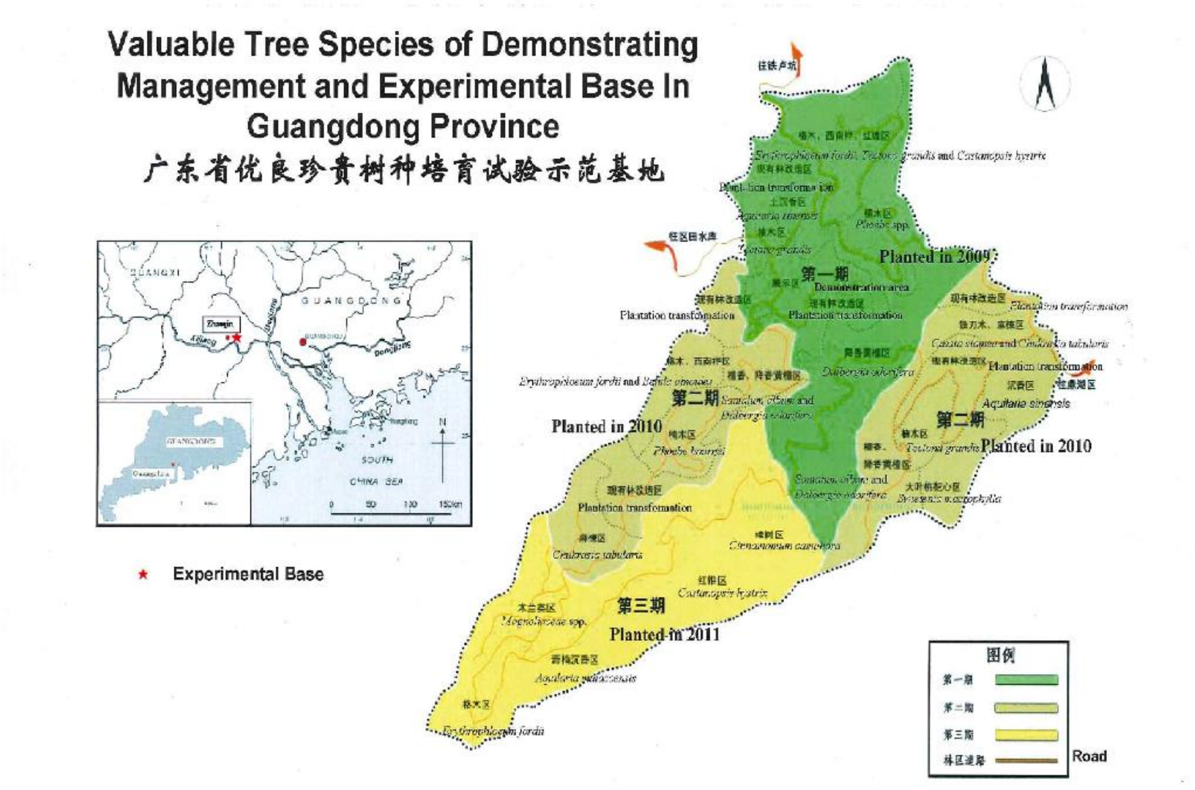

Figure 1. Map of experimental base in Guangdong Province

Tuesday, 6 December 2011

We began with the trip by a visit to the Dragon Pearl Island (D.P.I.) Sandalwood Research Base which located in Gaoyao city, Guangdong Province. This centre was established in 2003 and the successional plantation schemes were dominated by Sandalwood (*Santalum album*). There were many different kinds of management regimes tried at this base, and D.P.I. strives to find out the best suitable tending methods for sandalwood in China. The total area of D.P.I Sandalwood Research Base currently is about 40 ha, and may be enlarged to 100 ha in the near future. *Santalum album*, or Indian sandalwood, is a threatened species; indigenous to South India, and grows in the Western Ghats and a few other mountain ranges. Sandalwood is commercially valuable because of its highly valued fragrant heartwood, which contains sandal oil that is used in perfumes, cosmetics, medicines and also in incense sticks industries.

Sandalwood is a kind of root hemi-parasite tree species, and it cannot grow normally without being planted together with a suitable host plant. The current standard practice at DPI Sandalwood Research Base is to ensure the host plants are well established prior to field establishment. It is suggested that the best hosts for Sandalwood are the native nitrogen-fixing trees. At this research base, *Kuhnia rosmarinifolia* appears to work well as the pot host for Sandalwood seedlings. A significant difference has been identified in the establishment and growth of Sandalwood, therefore the centre recommends a range of species as pot host, intermediate host and long term Sandalwood hosts. White Tephrosia *(Tephrosia candida)* is also a nitrogen fixing tree and although slower to establish has also been included as the intermediate host at this centre.

The research base also includes a nursery for Sandalwood and other valuable tree species with the main objective to explore the selection of fast growing and high yielding varieties of trees.

Figure 2. One month old Sandalwood seedling

Figure 3. Sandalwood tree at the DPI Sandalwood Research Base at the Sandalwood Nursery

The expedition to this research base was also aimed at introducing the participants to the many uses of Sandalwood in China. As we are aware, prior to the modern ages, indigenous cultures rely on plants for a wide variety of purposes such as food, medicine and hunting. This was a common practice and the spark to develop Sandalwood products at this centre. The Sandalwood products developed through R&D includes sandalwood pastry, sandalwood tea, sandalwood wine, sandalwood honey, sandalwood chopsticks, sandalwood pillows, sandalwood beads, and sandalwood carvings etc.

Figure 4. Among the Sandalwood products on display during the field trip

Figure 5. *Caesalpinia sappan* and *Sterculia nobililis*; among the host plant and high yielding tree available at the centre

After a short walk, participants were exposed to the "mixed horticulture" forestry involving a mixture of tree species including *Eucalyptus* spp and *Casuarina* spp grown in conjunction with agricultural crops. Next, a visit was also made to the experiment and demonstration base for the management of Valuable Tree Species at Tiexi Operation Section, a State-own Beiling Mountain Forest Farm of Zhaoqing City. Zhaoqing is located 110 km northwest of Guangzhou, in the west Pearl River Delta. The city lies on the north shores of the Xijiang River, which flows from west to east, and opposite of Gaoyao.

Figure 6. An overview of the Forest Farm

The project was initiated in 2009 and expected to be completed in 2014 with the establishment of approximately 340 ha plantation of Valuable Tree Species (VTS). This section also functions as the collection and conservation area of VTS province/family test area, and research and demonstration area of intensive cultivation techniques for VTS; trusted to provide the innovation of forestry research with a new platform integrated with scientific research and demonstration.

The implementing institutions for the success of this forestry farm are Forestry Science and technology Extension Station, Guangdong Provincial Forestry Bureau, Research Institute of Tropical Forestry (RITF), Chinese Academy of Forestry and State-Own Beiling Mountain Forestry Farm of Zhaoqing City.

The facility is currently planted with major selected species such as; *Santalum album* Linn, *Pterocarpus macrocarpus* Ku, *Aquilaria sinensis* (Lour) Gilg., *Aquilaria malaccensis* (Lam.) Kuntze, *Betula alnoides* Bush Ham, *Tectona grandis* L.f., *Erythrophloeum fordii* Oliv, *Castanopsis hystrix* Miq., *Phoebe bournei* (Hemsl,) Yang., *Cinnamomum camphora*, *Cassia siamea* Lam, *Swietenia macrophylla* King, *Chukrasia tabularis* A. Juss., *Michelia macclurel*, *Mesua ferra* Linn., *Hopea hainanensis* Merr., *Acacia melanoxylon*, and *Magnoliaceae glanca* Blume.

Among the Teak clones planted are produced through tissue culture techniques ready for early growth in a nursery, followed by deployment for establishment in plantations throughout China.

Figure 7. *Pterocarpus macrocarpus*

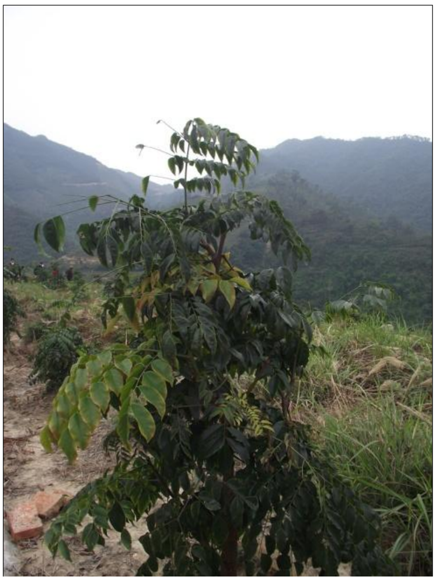

Figure 8. *Michelia macclurel*

Figure 9. Left: *Betula alnoides;* Right; *Magnoliaceae glanca* planted at the farm

Tiexi Operation Section employs land clearing without any burning, as such only with the application of chemicals and belt-like cultivation with planting holes determined at 50×50×40cm. Additional fertilizer are applied twice a year essential to limit the loss of soil fertility. The experimental layouts are alienated into provenance trials and family test. The provenance trials are practiced in 3–4 randomized block design while the family test is completed in a randomized single tree plot with a spacing of 4m × 2.5m.

The unique opportunity to walk through the interesting research base and the forest farm at the mountainous area were followed by a sumptuous dinner at the Cruise along the Pearl River. We returned feeling deeply impressed by the R&D essence and the stunning scenery along the cruise.

Workshop Programme

Day 1 5 December 2011

08:00– 08:50 *Registration*

09:00 – 10:00 *Opening*

- Address by Korea Forest Research Institute
- Address by IUFRO (Dr Liu Shirong)
- Address by APAFRI
- Address by SFA
- Address by FAGP(Forestry Administration of Guangdong Province)
- Opening by RITF

10:00 – 10:30 *Group Photo Session and Coffee Break*

10:30 – 11:50 ***Management, Collaboration and Plantation***
(Chair: *Anto Rimbawanto*)

- Management of transboundary landscape for conservation of the sundarbans biodiversity – *Laskar Muqsudur Rahman*
- Growth and genetic diversity of native tree species exchanged between Vietnam and China –*Nguyen Hoang Nghia*
- Mixed plantation of *Santalum album* L. and *Dalbergia odorifera* T. Chen. in China –*Xu Daping*
- Strategy for conservation of genetic resources of valuable hardwoods in East and Southeast Asia –*Wang Huoran*

12:00 – 13:00 *Lunch*

13:30 – 15:30 ***Conservation of Valuable and Endangered Forest Tree Species I***
***(*Chair*: Liu Shirong*)**

- Diversity among *Betula alnoides* plantations and adjacent natural forests – *Zhang Jinfeng*
- *Schleichera oleosa* – a case for Transboundary Conservation – *Animesh Sinha*
- Conservation of valuable and endangered forest tree species in protected area in the Philippines –*Portia Gamboa-Lapitan*
- Conservation of *Melia dubia* Cav. and *Santalum album* Linn. by extension and development: Trials in tobacco farms in South India –*A.C.Lakshmana*
- Conservation of genetic resources of sandalwood (*Santalum album* L. var. *album*) in Timor Islands –*Anto Rimbawanto*
- Seed characteristics of *Xanthoceras sorbifolia* in several areas of China –Yin Zhiyang
- Conservation of *Aquilaria* (Thymelaeaceae) in Peninsular Malaysia –*Lau Kah Hoo*

15:30 – 15:50 *Coffee Break*

15:50 – 17:50 ***Conservation of Valuable and Endangered Forest Tree Species II***
(Chair: *A.C.Lakshmana*)

- Conservation and protection of Songga tree (*Strychnos lucida* R Brown) as rare and valuable tree species. A case study in Sumbawa Island, Indonesia – *Zuraida*
- Community participation in conservation and protection of rare and valuable tree species Sandal wood*(Santalum album)–Anura De Silva*
- Germplasm and conservation of rare and endangered tree species endemic to east China –*Liu Jun*

- The traditional knowledge survey of plants in Gangwon Province, Republic of Korea –*Lee Hyunseok*
- Camphor tree resources and utilization –*Zeng Linghai*
- Conservation status of threatened dipterocarps in Peninsular Malaysia –*Suhaida Mustafa*

19:00 *Welcome Dinner*

Day 2 6 December 2011

08:30 Depart Hotel for Field Trip
21:00 Arrive at the hotel

Day 3 7 December 2011

08:30 – 09:50 ***Strategies and Policies* (Chair: *Shin JoonHwan*)**

- Legal settings to conserve valuable and endangered trees using village common forest and forest tree tenure in Bangladesh –*M Al-Amin*
- Strategies for sustaining sandalwood resources in East Nusa Tenggara, Indonesia –*Dede Rohadi*
- Landscape management approach as a key to transboundary conservation of valuable forest tree species –*Dhananjaya Lamichhane*
- Almaciga (*Agathis philippinensis* Warb.): Valuable but diminishing tree species in the Philippines –*Arsenio B. Ella*
- Conservation and restoration strategy for wild forest Ginseng (*Panax ginseng* C. A. Meyer) –*Yi JaeSeon*

09:50 – 10:10 *Coffee Break*

10:10 – 11:50 ***Genetic Diversity and Conservation I* (Chair: *M Al Amin*)**

- Phylogeography and refugia of the Peninsular Malaysian endemic timber species, *Neobalanocarpus heimii* (Dipterocarpaceae) –*Tnah Lee Hong*
- Chloroplast DNA variation of *Dalbergia cochinchinensis* Pierre in Thailand and Laos –*Ratree Yooyuen*
- Introduction of *Quercus rubra* tree and its *ex situ* conservation in Guangdong of China –*He Liping*
- Introduction trials of *Chukrasia* sp and *Manglietia glauca* in southern China –*Zhong Chonglu*
- Conservation of a threatened riparian tree *Salix hukaoana* –*Satoshi Kikuchi*

12:00 – 13:00 *Lunch*

14:00 – 15:40 *Genetic Diversity and Conservation II* **(Chair: *Portia Gamboa-Lapitan*)**

- Identifying tree populations for conservation action through geospatial analyses –*Riina Jalonen*
- Resource status and conservation of four endangered and valuable trees in Hainan Island of China –*Huang Guihua*
- Genetic diversity of *Aquilaria crassna* (Thymelaeaceae) in Thailand using microsatellite markers –*Sudarat Buapech*
- Gall rust disease epidemic on *Falcataria moluccana* in Indonesia and Malaysia –*Sri Rahayu*
- Shoot drying and its cause in *Calamus simplicifolius* in Nanmeiling of Hainan –*Li Rongsheng*

15:40 – 16:00 *Coffee break*

16:00 – 17:30 ***Panel Discussion* (Chair: *Dede Rohadi*)**
17:30 Closing

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