Journal of Botanic Gardens Conservation International

BGjournal

Volume 5 • Number 1 • January 2008

Special issue: Conserving forest biodiversity

BGCI
Plants for the Planet


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Cover Photo: Wild walnuts and other nuts from the forests of Kyrgyzstan not only provide livelihoods to local people but also store up potentially valuable genetic variation. (Chris Loades / FFI)

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BGjournal is published by **Botanic Gardens Conservation International (BGCI)**. It is published twice a year and is sent to all BGCI members. Membership is open to all interested individuals, institutions and organisations that support the aims of BGCI (see inside back cover for Membership application form).

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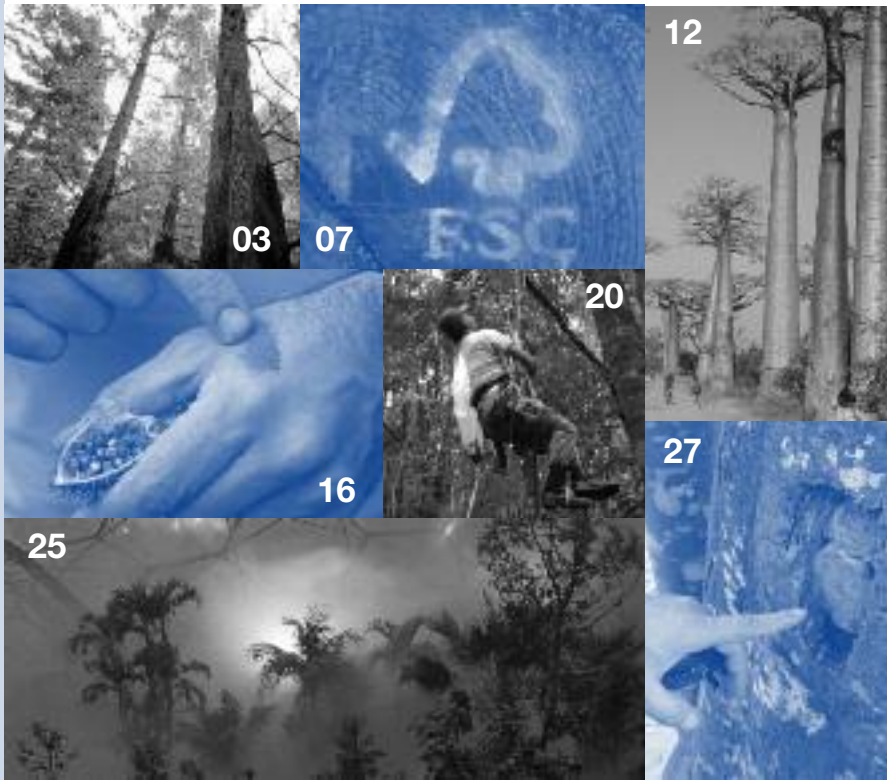
Contents



Editorial - Botanic gardens and the conservation of forest biodiversity

Deforestation is now recognised as the second leading contributor of carbon emissions worldwide, after the burning of fossil fuels. Conversely the protection of forests is increasingly seen as a major response in mitigating the impacts of climate change – a fact recognised recently at the political level at the UNFCC Conference in Bali in December 2007. But, of course, the world's forests are so much more than just carbon sinks. They are major repositories for biodiversity – tropical forests alone, which cover six percent of the earth's surface, harbour over 50 percent of all known species. These same forests provide essential livelihood resources for millions of people who live within them or in surrounding areas. They are also a major source of income for governments through timber revenues. Added to this, forests are crucial in regulating the world's water supplies. Despite all these values global deforestation continues.

Protection of forests through the expansion of the world's protected area network and promotion of sustainable forest management for production forests have been the two main platforms in conserving forest resources over the past twenty years. More recently efforts have focussed additionally on curbing illegal and uncontrolled logging and on forest restoration. International biodiversity policy reflects the importance of both protecting and managing sustainably the world's forests and there have been major success stories. Concerted efforts through innovative partnerships are still however urgently required.

Botanic gardens have a major role to play in conserving forest biodiversity. Work to document and catalogue the flora of forest areas is ongoing with support from botanic gardens around the world. Management and restoration of forests are key activities for a range of gardens and education and raising awareness of the values and threats to forests are undertaken by botanic gardens worldwide. The Eden Project in the UK provides one successful example of interpreting the tropical rainforest to a distant audience who may never have the opportunity to experience a natural rainforest habitat (see p 25).

Botanic gardens around the world are responsible for managing forest reserves. One example is the Rio Botanic Garden (see p 20). Other examples include the Singapore Botanic Garden, the core of which is itself a remnant of the country's original rainforest cover with 314 plant species surviving in the four hectare forest patch. The canopy trees grow to over 50m in height and include representatives of Singapore's original timber trees such as *Dyera costulata* (Jelutong), *Koompassia malaccensis* and a range of dipterocarps.

Recent examples of forest conservation supported by BGCI include the work of Selva Misionera Botanical Garden, Argentina with local communities to develop ecotourism, recreation and marketing of ornamental and medicinal woody species; the Jardim Botânico de São Paulo working with local people to campaign for conservation of the biodiversity of the Atlantic Forest Biosphere Reserve within the São Paulo city green belt; establishing an arboretum of 100 endemic and endangered plants of the Nilgiri Biosphere Reserve by the Coimbatore Zoological Park and Conservation Centre, Tamil Nadu; and supporting the conservation of *Aquilaria* spp. in Cambodia (see p 27).

In addition BGCI's support for forest conservation is delivered through the Global Trees Campaign a partnership with Fauna & Flora International (FFI) that aims to save the world's more threatened tree species and their habitats. The Global Trees Campaign links tree red listing through to action to conserve trees in their natural habitats with *ex situ* collections maintained for back-up and restoration. More information is provided on p 3 and on other aspects of the Campaign on p 10. Much of the work of the Global Trees Campaign is undertaken by members of BGCI working in partnership with Forestry Departments and other local conservation agencies facilitated by FFI. BGCI and FFI are committed to strengthening the Global Trees Campaign in 2008 and BGCI will do this in partnership with our botanic garden members. I am delighted that the Morton Arboretum has recently agreed to work with BGCI taking a lead role in encouraging and coordinating the active support and participation of arboreta in the Campaign. This will provide a tremendous boost.

Another exciting partnership recently entered into by BGCI is with the USDA Forest Service. An MOU has been signed outlining the intention to cooperate in matters relating to the management of rare plant species and the conservation of their habitats and ecosystems. Initially such work will focus on the conservation of endangered oak species with plans for work being developed to start over the coming year.

Tackling the loss of forest biodiversity is a complex problem involving a wide range of organisations from the local to the global level. This issue of BGjournal highlights just a few of the ways that botanic gardens are helping to tackle one of the major environmental challenges that we face. More examples can be found on BGCI's website and we look forward to highlighting future success stories for the world's forests and the huge diversity of plant species they contain.

Sara Oldfield
Secretary General, BGCI

Author: Sara Oldfield

Red Listing for tree conservation and restoration

Assessing the conservation status of plants in the wild is a vital component of biodiversity conservation planning. Since 1963 when Sir Peter Scott first established the Red Listing system, the IUCN (World Conservation Union) Red List Categories have been widely acknowledged as the international standard for species conservation assessment. Initially a set of five categories of threat was adopted: Endangered, Vulnerable, Rare, Indeterminate, and Not Threatened. These were in use until replaced in 1994 by a new objective system of categorisation which, in a modified form, remains the IUCN Red List system in use today.

Left: Participants at a Red Listing workshop in the Philippines. (BGCI)

IUCN cautions that the category of threat applied to a species using the Red List system does not in itself determine priorities for action. It suggests that other factors such as costs, logistics, chances of success and other biological characteristics of the species need to be taken into account (IUCN, 2001). Degree of threat does however clearly have a significant impact in prioritisation of species for conservation action and the process of applying the categories and criteria helps to define the conservation action required. If the species is identified as Endangered due to restricted range and declining and fragmented habitat, for example, habitat conservation and restoration may be inferred as an appropriate response. If the species is Endangered due to population decline caused by levels of exploitation, management of harvesting should be considered as at least part of the solution.

In addition to helping to define species conservation actions, Red List information supports various assessments of the state of ecosystems worldwide. It is used to help identify Biodiversity Hotspots as defined by Conservation International; Important Plant Areas, as defined by Plantlife International and was used in the Millennium Ecosystem Assessment. Red list information is also used to define High Conservation Value forests, initially defined by the Forest Stewardship Council (see p 7) and red list information specifically for tree species is used in the FAO Global Forest Resources Assessment.

Target 2 of the Global Strategy for Plant Conservation (GSPC) calls for *A preliminary assessment of the conservation status of all known plant species at national, regional and international levels*. This target is very important as a baseline for implementation of other GSPC targets relating for example to *in situ* and *ex situ* conservation of plant species. IUCN is the lead facilitating agency for Target 2.

Left: The Critically Endangered *Magnolia ovoidea* is endemic to China (Paul Matthew/ FFI)

Box 1. RapidList

RapidList is an online software application that asks the user a series of questions based on the IUCN Red List Categories and Criteria (Version 3.1) and quickly classifies the species into one of three categories: likely threatened, likely not threatened, or data deficient. With minimal data, it can take an assessor just a few minutes to obtain a preliminary assessment. It can be used at national, regional or global scale.

RapidList is available for use by any plant conservationist who would like to conduct preliminary assessments of plant species. RapidList users can store and manipulate their data in their online space. Users are encouraged to submit finalized assessments to IUCN for posting on the RapidList website and eventually for public view in a special section of the IUCN Red List website. All submitted assessments will be provided to the CBD as a contribution to Target 2 of the GSPC.

A user should conduct a preliminary assessment when:

- there is insufficient data for full biodiversity assessments;
- in situations / regions where resources are insufficient for full assessments;
- to prioritize resource allocation for full assessments;
- when a list of likely threatened species is required urgently.

RapidList is not a replacement for full biodiversity assessments, it is designed to help prioritize species for further assessment work. IUCN will continue to undertake full assessments of a limited number of priority plant groups.

For more information or to use RapidList: www.iucnsis.org
Ms. Julie Griffin, IUCN Species Programme, julie.griffin@iucn.org, +41 (22) 999 0156

Right: Dawn Redwood, *Metasequoia glyptostroboides* is classified as Critically Endangered and can only be found in the wild in China. (Juan Pablo Moreiras / FFI)

At present there are 8,447 plant species recorded as threatened in the 2007 IUCN Red List. Progress in red listing for plants is widely acknowledged to be unimpressive. Problems include the perception that the current IUCN Red List categories and criteria are complicated and difficult to apply; the requirement for relatively extensive supporting documentation; and lack of motivation when many countries have their own national red lists using different categories of threat. In response to the shortfall in data collection, IUCN has developed RapidList to speed up preliminary assessments and this provides an effective way to contribute to GSPC Target 2 (see Box 1).

Full red listing remains the preferred option for many experts involved in Red Listing particularly where some leeway in the level of supporting documentation is allowed. Currently 5,643 of the plants included as threatened in the 2007 IUCN Red List are tree species many of which were recorded at a time when the documentation requirements were more relaxed. Of these 1,002 tree species are Critically Endangered. Various approaches to tree red listing are ongoing as described further below and the momentum is increasing using a pragmatic approach to the use of the IUCN Red List Categories and Criteria. It is vital that we speed up this process so that tree conservation receives the attention it deserves.

In the early days plant red listing was coordinated by the IUCN/Species Survival Commission (SSC) Threatened Plant Specialist Group with a Secretariat based at Kew. As lists of threatened plants were compiled they were sent to botanic gardens to find out where species were in cultivation. Data received were stored in a central database. The role of collating information on threatened plants in *ex situ* collections was subsequently taken on and developed by BGCI. Now of course botanic gardens and arboreta can enter their collection data online to BGCI's online PlantSearch database (www.bgci.org/plantsearch) and compare this with information in the IUCN Red List.

Over time IUCN/SSC established a range of Specialist Groups to undertake red listing and action planning for plant species. Currently there are 28 such groups involved to a varying extent in these processes. Undertaking red list assessments for plants is a dispersed activity undertaken by individual IUCN/SSC Specialist Groups and also various botanical institutions such as Fairchild Tropical Botanic Garden; Missouri Botanical Garden; Royal Botanic Gardens, Kew and the Smithsonian Institution. Data are collated by the IUCN Species Programme which is based in Cambridge, UK.

The IUCN/SSC Global Tree Specialist Group has been actively involved in undertaking assessments of the conservation status of tree species since its establishment in 2003. The Secretariat of the Group is now hosted by BGCI providing a direct link between the collection of data on species in the wild and their status in *ex situ* collections. The advantage of such a link is that BGCI and its members can help to select priority groups of trees (for example those of ornamental as well as ecological value) to be assessed using the IUCN categories and criteria, can help with the assessments and directly utilise the resulting data in conservation planning. In addition to promoting and implementing red listing, the second function of the Global Tree Specialist

Right: Participants at a Red Listing workshop in the Philippines (BGCI)

Left:
Dr Genlin Jiao discussing magnolias with fellow botanist Li Daxaio (Genlin Jiao)

Group is to provide advice to the Global Trees Campaign, an initiative established by the UNEP World Conservation Monitoring Centre (UNEP-WCMC) and Fauna & Flora International (FFI). The Global Trees Campaign is now being re-developed as a joint initiative by FFI and BGCI with input from UNEP-WCMC on a project basis.

The Global Tree Specialist Group (GTSG) has undertaken a range of regional tree red list assessments for Ethiopia and Eritrea, the Caucasus, Central Asia, Guatemala, dry forest trees of Central America, cloud forests of Mexico and has worked with the Cuban Plant Specialist Group on an assessment of the trees of Cuba. Workshops were held as part of the assessment process in each case (except for Ethiopia and Eritrea) and the workshops were also used to assess priorities for conservation action through the Global Trees Campaign. Current projects resulting from the workshops include a detailed survey of nine threatened *Pyrus* species in the Caucasus involving experts from Armenia, Azerbaijan and Georgia. Another project is underway in Krgyzstan on the conservation needs of two of the most threatened apple species in the country, *Malus niedzwetzkyana* and *Malus sieversii*.

In parallel with the regional tree conservation assessments, the Global Tree Specialist Group has also undertaken global evaluations of the conservation status of selected genera: *Magnolia, Quercus* and *Acer* and has started working on *Diospyros* and *Rhododendron*. Workshops to assess the conservation status of species are also used to define priorities for conservation action. The *Red List of Magnoliaceae* was published in April 2007 following an extensive data-gathering and consultation exercise. The Red List identifies 131 species of Magnoliaceae as threatened – over half the known taxa in the family. Of these, 89 are listed as Critically Endangered and Endangered.

BGCI is now undertaking a comprehensive survey of *ex situ* collections of Magnolias as a basis for planning restoration action for Critically Endangered and Endangered species. So far we have received information from 181 gardens and this is being compiled in BGCI's PlantSearch database. More detailed information is being requested on the Magnoliaceae species held in the collections, including data on the origin and verification of material, related conservation and recovery programmes, methods of and expertise in cultivation and propagation. In 2008 we will move ahead with planning workshops in China, the Caribbean and Colombia to maximise the potential for on the ground conservation action.

Left:
Recent surveys in Kyrgyzstan found that only about 40 adult trees are left of this little-known but Endangered apple species *Malus niedzwetzkyana* (Chris Loades / FFI)

Left: Fall colour of *Acer pentaphyllum* – a critically endangered tree species, Only around 4 populations remain in the wild in China. (Quarryhill Botanic Garden)

Global Trees Campaign projects have already been undertaken for five target *Magnolia* spp. identified as priorities at a *Magnolia* red listing workshop held in Kunming, China in 2004. One project, for example, currently being undertaken by the Kunming Botanic Garden working with FFI is reinforcing the wild population of *M. sinica*, reduced to just 10 individuals in the wild, with saplings found in various nurseries during project surveys.

The Red List of Oaks has recently been published. The assessment includes 207 species leaving around 300 for future evaluations. 29 species are currently considered to be Critically Endangered or Endangered. A BGCI survey of *ex situ* collections will take

Right: Rhododendrons in the wild in Yunnan, China (BGCI)

Below: *Rhododendron decorum*, China (Philippe De Spoelberch)

place shortly using the same approach as taken for Magnolias. Then priority restoration activities will be planned.

Recently a highly successful workshop was held at the University of British Colombia Botanical Garden and Centre for Plant Research in Vancouver to review the conservation status of *Acer* spp. in the wild and to assess priorities for conservation action. A complete assessment of the *Acer* genus was undertaken with 19 species categorised as Critically Endangered or Endangered. At the workshop priorities for immediate action were highlighted for six Chinese species which are Critically Endangered and in need of immediate conservation attention. One such species is *Acer pentaphyllum*. Although safe in cultivation, the fate of wild populations of this species is extremely precarious. Another Critically Endangered species is *A. yangbiense* which is currently known from less than ten individuals in an area of mixed forest, close to agricultural land in the province of Yunnan. *Ex situ* conservation is the only hope for saving this species, at least in the short term.

A regional workshop to assess the conservation status of *Diospyros* and palms in SE Asia was organized by BGCI and hosted by the College of Forestry, University of the Philippines, Los Baños in June, 2007. Nineteen participants from throughout the region attended and began the process of entering data on palms and ebonies into the Data Entry Module of IUCN's Species Information Service (SIS). Dr Scot Zona from Fairchild Tropical Botanic Garden and Chair of the Palm Specialist Group provided training in the application of IUCN Red List Categories and Criteria. It was agreed that by the end of 2007, the conservation status of all endemic palms in the region should be assessed and a regional checklist of ebonies compiled. The ebony work will feed into a global evaluation of the genus.

BGCI also plans to assess the conservation status of *Rhododendron* species as a basis for prioritising conservation action for globally threatened species within the genus. There are over 800 species of *Rhododendron* occurring in the wild extending from Europe to Papua New Guinea with one species in Australia. Only 11 species are currently included in the IUCN Red List but many more species are known to be under threat in the wild. BGCI plans to work closely with the Royal Botanic Garden, Edinburgh (RBGE) in undertaking this project. Marion Mackay a member of the GTSG based at the Institute of Natural Resources, Massey University, New Zealand and her research student Ahmed Fayaz, are currently helping with an initial literature review. A preliminary list of candidate threatened species will be presented at the International Rhododendron Conference to be held at RBGE in May 2008.

Information on the conservation status of individual tree species is valuable for conserving both the species and for supporting habitat conservation. As the species assessments continue, the true scale of the threats to wild plants becomes apparent. Efforts at restoration will become increasingly important as will translocation to new sites in response to global climate change. GSPC Target 8 calls for 10 percent of Critically endangered species to be in restoration programmes by 2010. Can we achieve this goal for trees?

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Right: *Rhododendron anthosphaerum*, China (Philippe De Spoelberch)

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Forest certification – what does it mean for the world's forests?

In the past 15 years, forest certification has emerged as one of the key tools to improve forest management. But what exactly does certification involve and is it worth supporting?

The origins of certification

At its heart, certification consists of an independent assessment of forest management against pre-agreed standards, with or without a product claim element. The concept emerged in the 1990s following several decades of campaigning by environmental groups on the impact of logging. The "Save the Rainforest" and "Boycott Tropical Timber" campaigns of the 1970s and 1980s succeeded in raising awareness amongst consumers and putting pressure on the industry, creating the opportunity to use purchasing power positively to influence practices in the trade. To capitalise on this opportunity, a mechanism was needed to identify timber from genuinely well-managed sources and to reward "good" producers.

It was against this backdrop that a group of forward-looking timber producers, traders and environmentalists (including Fauna & Flora International - FFI) came together in the early 1990s to form the Forest Stewardship Council (FSC). The mission of the FSC is to promote environmentally appropriate, socially beneficial and economically viable management of the world's forests. It does this through certification of forest management units. Since its foundation, the FSC has developed into a global organisation with over 700 members and has certified more than 90 million hectares of forest in 70 countries.

Above: FSC certified log, Mexico
Eric Goethals, 2001

As the FSC grew, other certification schemes have been formed and there are now national schemes in over 35 countries. Ironically, while certification was originally developed in part to address the confusion caused by the plethora of unsubstantiated claims about the source of forest products, the proliferation of certification schemes means that the dilemma has returned: what do the different schemes mean and which really *do* offer reassurance about the sustainability of wood and paper products?

FSC – the "gold standard" in forest certification

The FSC is widely regarded as the "gold standard" in certification. It remains one of only two certification schemes with a worldwide remit and is the only one that enjoys broad support from major environmental groups, including FFI, WWF and Greenpeace.

Right: FSC certified forest in Germany (Juan Carlos Reyes, 2006)

The FSC is designed to be inclusive, requiring a balanced participation of environmental, social and economic stakeholders in its decision-making. Transparency is also a key element in all its operations. The FSC has developed a global set of ten Principles and Criteria of Forest Stewardship (Table 1), from which national standards for forest management are developed in each country. Assessment of forest management against these standards is done by accredited certifying bodies; if a forest meets the required standard, a certificate is issued and timber originating from it can carry the FSC logo. Every link in the chain of custody from forest to shop is also assessed, to ensure the timber is segregated from non-certified timber at every stage. Strict rules govern the use of the FSC logo and accompanying claims to ensure the consumer is not misled.

The FSC has met with a fantastic response and demand for FSC certified products outstrips supply. Major retail chains such as B&Q in the UK and Home Depot in the USA are committed to stocking as much FSC as they can, and several governments have developed timber procurement policies that require them to seek certified products.

What other certification schemes are there?

Many of the other certification schemes that have been, or are being, developed are accredited under the umbrella organisation, the Programme for the Endorsement of Forest Certification schemes (PEFC). The majority (18) of the 23 PEFC-endorsed schemes are European, but it also includes schemes in the USA (Sustainable Forestry Initiative - SFI), Canada (Canadian Standards Association - CSA), Brazil (Brazilian Program of Forest Certification - CERFLOR), Chile (CertforChile), and Australia (Australian Forest Certification Scheme). Together, PEFC schemes have certified almost 200 million hectares of forest. The Malaysian Timber Certification Council (MTCC), which is currently seeking recognition from PEFC, has certified 4.7 million hectares of forest, mostly in Peninsular Malaysia. Lembaga Ekolabel Indonesia (LEI), not currently associated with PEFC, certifies forest in Indonesia.

Which schemes are worth supporting?

The merits of different certification schemes have become a topic of significant debate. Several studies have been published (FERN, 2004; Meridian Institute, 2001; CPET, 2006; International Council of Forest and Paper Associations, 2007) as well as guides on how to assess schemes (WWF/World Bank, 2006; Nussbaum *et al,* 2002). Key differences between the schemes include the standards used to assess forest management, the process through which those standards are derived, transparency, stakeholder consultation, decision-making processes and balance of interests within the scheme.

According to the NGO FERN (the Forests and European Union Resource Network), the standards against which

Right: FSC certified pencils (FSC International, 2008)

the forest management is assessed are one of the most important factors (FERN 2004). Standards can be performance-based, requiring a certain level of achievement in given aspects of management, or systems-based, where a system is required to be in place - for example, a biological monitoring system - but the results are not judged. FERN assessed eight certification systems and found that only the FSC used solely performance based standards and therefore was the only one that gave any real guarantees about the impact of logging operations in the forest.

Transparency is also a key issue, and some schemes (e.g. CERFLOR) do not routinely make certification reports or the standards used freely available to the public. The origin of the scheme and major influences (e.g. in standard-setting) is also important, with many schemes (FSC and CSA being notable exceptions) being dominated by industry interests.

Although the findings of comparative studies have varied, it remains the case that the FSC enjoys the broadest support from environmental and social groups. That said, questions have been raised about several FSC certificates which some environmentalists claim should not have been awarded. The FSC's certification of large-scale industrial plantations has been controversial and has led to a review of FSC policy towards plantations. Currently, the issue of FSC certification in old-growth forests is hotly contested by a vocal group of campaigners.

What difference has certification made?

With forest certification now relatively well-established, its effectiveness in improving forest management is coming under scrutiny (Ozinga, 2004). Clearly, awarding a certificate to a forest unit does not in itself mean an improvement in management, and there is concern that the huge demand for certified forest products has led to some schemes simply certifying the *status quo* without any significant improvement on the ground.

Although a comprehensive analysis of the overall impact of certification is lacking, within individual certified forest management units positive effects on biodiversity and increased use of reduced impact practices can be seen. Benefits for land rights and workers rights have also been observed in some areas.

Above: FSC certified wooden cups (FSC International, 2008)

Although certification has had benefits in the management of northern forests, it has been a less effective tool in tackling the crisis of forest destruction and degradation in tropical forests. The vast majority of certified forest is in the northern hemisphere, notably North America and Europe (see Table 2), where arguably the problems of forest management are less acute than in the south. Of those certifications that have taken place in the south, a significant proportion are plantations and there is a marked shortage of certified natural tropical forest. While frustrating for tropical timber-users keen to specify certified timber, this probably reflects the reality on the ground – an International Tropical Timber Organisation (ITTO) report in 2006 estimated that only 5% of the total permanent forest estate in tropical countries is managed sustainably (ITTO, 2006).

The demand for certified products may provide an incentive for improved management in some of these key forest areas, but only if the certification scheme is sufficiently rigorous to require real change. In particular, certification has been criticised by some for not adequately addressing the issue of land tenure that is an underlying problem in many highly forested countries.

A further challenge is the huge and growing market for cheap wood products, particularly in emerging and rapidly developing economies. The existence of this massive, undiscerning demand means that there will always be an opportunity to sell wood products, no matter how they have been produced. Certification is not, therefore, the only answer and a broad range of measures are needed to safeguard the future of the world's forests.

Another concern is that up-take of certification has been greatest in large-scale industrial forestry units, and as a mechanism it may discriminate against small forest owners or community-owned enterprises who cannot afford the up-front costs of the process. The FSC has provisions for certification of small forests or woodlands, but they remain the minority of certified forests.

Certification and illegal logging

Certification is a voluntary, market-led initiative and it is not a substitute for good governance, sound regulatory frameworks and strong law enforcement. Illegal logging and trade in wood products is a major threat to forests in many parts of the world, undermining all efforts at sustainable forest management and undercutting the market for legally, sustainably-sourced wood with cheaper alternatives. Certification may help in ensuring the legality of timber products, since most certification schemes require compliance with national laws. However, some suggest that since certification is not based on unannounced audits and relies on paper-based chain of custody systems, it may not be the most comprehensive solution to the illegal logging and trade problem (SGS, 2003). Specific intergovernmental programmes on Forest Law Enforcement, Governance

and Trade (FLEGT) and systems for the verification of legal origin are being developed and these can be regarded as complementary to certification, especially in countries where the problem of illegal logging is most severe.

FSC and the Global Trees Campaign

Right: FSC certified non-timber forest product (FSC International, 2008)

The Global Trees Campaign (GTC) is a joint initiative between FFI and BGCI aiming to take action for the world's globally threatened trees and their habitats through provision of information, conservation action and support for sustainable use. FFI is a member of the FSC and seeks to contribute to development of its policies and practices. Through its partnership with the Mpingo Conservation Project, FFI and the Global Trees Campaign is working to achieve FSC certification of community-managed African Blackwood *Dalbergia melanoxylon* in Tanzania. Next year, as part of its SoundWood programme, the GTC hopes to support the development of an FSC Chain of Custody group for musical instrument makers. This will allow these generally small-scale enterprises to share the costs of chain of custody certification and produce FSC labelled instruments, including woodwinds made from certified African Blackwood.

Right: Auditor at FSC certified operation, Mexico (Eric Goethals, 2001)

Clearly, sustainable use is only one mechanism through which tree species can be conserved. The Global Trees Campaign is working on a range of projects using various strategies to improve the status of some of the world's rarest and most threatened trees – further information can be found on www.globaltrees.org

Conclusion

Despite some shortcomings, it is clear that the emergence of certification, in particular the FSC, has been a positive force for the world's forests. It has brought diverse stakeholders to the table to discuss sustainable forest management and has led to increased demand for timber products from well-managed forests, thus creating an incentive for producers to improve their practices.

The FSC is the scheme that offers the best guarantees. Whether specifying timber for a construction project, buying outdoor furniture or sourcing products for a shop, botanic gardens can make a useful contribution by seeking to use FSC certified products whenever possible.

It is important to remember the limitations of certification, however, and to continue to support the diverse range of mechanisms and initiatives (such as the Global Trees Campaign) that are needed to improve the conservation and sustainable management of the word's forests and tree species.

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Left: Logging in an FSC certified forest, Germany (Juan Carlos Reyes, 2006)

TABLE 1: Areas covered by the FSC Principles and Criteria

Principle 1:	Compliance with laws and FSC Principles
Principle 2:	Tenure and use rights and responsibilities
Principle 3:	Indigenous peoples' rights
Principle 4:	Community relations and worker's rights
Principle 5:	Benefits from the forest
Principle 6:	Environmental impact
Principle 7:	Management plan
Principle 8:	Monitoring and assessment
Principle 9:	Maintenance of high conservation value forests
Principle 10:	Plantations

Full information is available at www.fsc.org

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Table 2: Certified forest area by scheme and region in Dec 2006 (million hectares)

	North America	South & Central America	Europe	Asia	Oceania	Africa	Russia	Total
FSC	27.3	9.6	29.6	1.6	1.3	2.5	12.3	84.2
PEFC	128.3	2.3	57.4		5.7			193.7
Other(a)	11.0			4.8		1.2		17.0
Total	**166.6**	**11.9**	**87.0**	**6.4**	**7.0**	**3.7**	**12.3**	**294.9**

a) Other in North America refers to American Tree Farm System, in Asia refers to the Malaysian Timber Certification Council, in Africa refers to areas in Gabon recognised under the Dutch Keurhout system

From www.forestrycertification.info

Authors: Laura Snook, Ehsan Dulloo and Barbara Vinceti

Not just the forest, but the trees: Research on the conservation and sustainable use of forest genetic resources

Introduction

Forests and their component species yield a vast array of products, from fruit and nuts for food to barks, leaves and resins for medicinal purposes and fibre for construction materials. Most forest products are harvested from wild populations; many are particularly important to poor people in rural communities in developing countries. Because forest genetic resources (FGR) consist of thousands of useful species, of which very few are domesticated, little is known about their biology, conservation, variation and potential. Furthermore, populations of many of these species are threatened by factors ranging from over-harvesting to land conversion and climate change. Bioversity International focuses on sustaining diversity, particularly intra-specific diversity, through research, capacity building, and advocacy in the policy arena. Since 1993, Bioversity has sought to address the challenges of conservation and enhanced use of the diversity of forest trees by generating information about intraspecific diversity of tree species, the benefits that this variation can confer on users, the threats to this diversity, and the range of approaches that can be applied to conserving and sustainably using forest tree diversity.

Below: Beech forest in Croatia (Annie Lane, 2007)

Understanding genetic diversity

A body of Bioversity's research has focused on analyzing the spatial patterns of diversity in tree species of high local priority, including *Swietenia macrophylla* (mahogany) in Latin America, wild pistachio (*Pistacia atlantica*) in the Middle East, and rare Malaysian dipterocarps (*Neobalanocarpus heimii* and *Shorea lumutensis*). This understanding is being applied to the formulation of conservation strategies *in situ*, collection for *ex situ* conservation in botanical gardens, and domestication to increase availability through planting by users. A study of populations of *Shorea lumutensis* in Peninsular Malaysia elucidated the demography and molecular diversity of these trees and used these insights to define the most important areas for *in situ* conservation. This constituted one of the first attempts to combine ecological and genetic approaches to the conservation of a rare tree species and reveals how research findings can be translated into practical recommendations (Lee *et al*., 2006).

Impact of use on forest species

Thousands of tree products are harvested from wild populations growing on land with ill-defined tenure; these trees are often treated as open-access resources, which frequently leads to over-harvesting. Bioversity has carried out several studies assessing the impact of local use on the regeneration and thus the sustainability of local tree populations, including a study of *Araucaria* nut harvesting in Argentina and Brazil. Research focused on the development of multidisciplinary and participatory approaches for conserving *Araucaria* species and used modelling to reveal the interactions and threats resulting from the respective impacts of nut gathering by local communities, livestock grazing and browsing, and fragmentation of tree populations and inbreeding (Vinceti *et al*. 2004). The project enabled local communities to contribute to decision-making on policy, management and use of the resources (van Breugel *et al*., 2004).

Tropical forest tree seeds - a challenge for conservation and use

Despite the importance and value of indigenous tree species, there is little capacity in most countries to sustain them through planting. In part this is

Left: Bamboo in China (BGCI)

because of the difficulty of maintaining the viability of seeds of most tropical tree species. Most of these lack dormancy, germinating immediately. This makes even short-term storage and transport difficult, and means that maintaining seed samples in genebanks is not an option for thousands of useful tree species. In addition, most valuable fruit species cannot be conserved as seeds, either because they do not breed true or because their seeds (described as "recalcitrant") cannot survive in the cold, dry storage environments used by genebanks for storing the seeds of cereals and other species. Bioversity organized and led a major research project co-sponsored by DANIDA's Forest Seed Centre focused on overcoming the constraints to storing tropical tree seeds as a contribution to increasing the variety of high-value indigenous species available for planting. Standardized protocols were developed to test for desiccation tolerance and applied by national partners in 15 countries world-wide who screened approximately 60 tropical forest tree species to determine how to store their seeds in a viable state. Protocols for seed drying were developed and tested, and for more than half of the species including *Prunus africana*, two important dipterocarps and *Vitellaria paradoxa*, the shea butter tree, germination percentages in excess of 90% were obtained (Pritchard *et al*., 2004). Contrary to expectations, research revealed that 23 species could tolerate desiccation to less than 9% moisture content. Future work will focus on scaling-up the methods developed for seed handling in order to promote the development of seed-supply systems to increase the availability of high-quality germplasm of indigenous species (Sacande *et al*., 2004)

Bamboo and rattan

Much of Bioversity's research on non-timber forest products has focused on bamboo (a large grass) and rattan (a spiny climbing palm). It has been estimated that 1.5 billion people depend on these resources which, as well as being important for local use, also feed an export market worth $US 5 billion/yr, providing significant income to small-scale farmers. Bioversity carried out studies characterizing the diversity *in situ* of ten bamboo and rattan species, and evaluated their status. An analysis of major threats in China, Vietnam and the western Ghats of India revealed that over-harvesting threatened this diversity. As a safeguard, key material was collected and established in *ex situ* bamboo collections: 34 species in the botanic garden at Malaya University, Malaysia, 20 populations of *Dendrocalamus asper* in Bondowoso, East Java, Indonesia and 40 species of bamboo at Cau Hai, Vietnam. A collection was established in China to serve as a source of planting stocks for local communities. A study on the demographic status and genetic variation in populations of *Calamus mannan*, an economically valuable rattan, was also undertaken in Indonesia.

Increasing income and nutrition through research on fruit trees

Bioversity has been particularly interested in fruit trees, which contribute not only to income generation, but also to the nutrition of rural people. Major efforts have been carried out in Asia to evaluate the diversity of priority regional fruits, among them Citrus, and mango, including not only domesticated varieties, but also their wild relatives, which can be crossed with them to yield improved fruit characteristics and enhanced resistance to pests, diseases, drought or flooding. Fruit tree species have also been a major focus of Bioversity's work in Sub-Saharan Africa, where expert consultations and networks of collaborators from across Africa have been organized to define research needs and assess the conservation status of priority species, including many specifically suited to semi-arid environments. Because they are deep-rooted, trees integrated into agricultural systems are particularly important in areas vulnerable to drought and crop failure. *Zizyphus mauritania* is one of those in which intraspecific diversity has been tapped to produce larger-fruited varieties that are grafted onto local root stocks on farmers' fields in the Sahel to increase incomes, address nutritional deficiencies, and contribute to adaptation to climate change. In Syria, molecular characterization (using AFLP) and ecogeograhic studies of Pistachio (*Pistacia vera*) in the Middle East were carried out to determine the extent of genetic diversity and its characteristics. The study allowed the identification of 25 female pistachio varieties, some of which were described for the first time (Ibrahim-Basha *et al*., 2007).

Left: Mangos (Fairchild Tropical Botanic Garden)

Strengthening collaboration through regional partnerships

Bioversity carries out research in partnership with collaborators in countries around the world. This yields multiple benefits, including facilitating multi-location comparative research, providing for integrated capacity building and increasing the likelihood of uptake and implementation of research results by local and regional stakeholders. During the past five years, collaborative relationships have been forged among experts in forest genetic resources through Bioversity's sponsorship of regional Forest Genetic Resources (FGR) networks. These have been modelled on the European Forest Genetic Resources Network (EUFORGEN), a successful self-funded partnership among European countries for research, conservation and use of forest resources, which is carrying out cutting edge research on the evolution of genetic diversity among forest trees and associated organisms, linking different disciplines (ecology, genetics, genomic, and evolutionary). One of the main objectives is to identify genes of adaptive significance in the face of global change, in model species of trees (*Pinus*, *Populus* and *Quercus*), phytophagous insects and mycorrhizal fungi (www.evoltree.eu).

The Sub-Saharan African Forest Genetic Resources Network (SAFORGEN) was established in 1998 to support research by facilitating capacity-building and collaboration around important FGR issues, and to identify conservation and use options worthy of study and dissemination in resource-poor areas. SAFORGEN members are currently carrying out a study across 10 countries extending from West to East Africa, including Madagascar, to evaluate the genetic diversity among populations of *Prunus africana*, and the corresponding chemical diversity among their barks, of which the medicinal properties are used to treat prostate disease. The results will provide the foundation for developing strategies for domestication of these trees through planting to provide income to local farmers; and for the conservation of populations, both *in situ* and *ex situ*. Since 2003, the Asia Pacific Forest Genetic Resources Programme (APFORGEN; www.apforgen.org) has been facilitating collaborative research and information sharing on FGR among partners from 14 countries in Asia and Oceania. In 2006, an informal collaborative platform on FGR, LAFORGEN, was established in Latin America, the region with the world's highest tropical forest area – and the highest proportion of global deforestation. Representatives from national and international research institutions in nine countries participated in a workshop to exchange information, define priority species and develop thematic research priorities: conservation of genetic diversity in threatened native forest species; the impact of use of native forest species on their genetic diversity; domestication and tree breeding; and storage and exchange systems for tree germplasm.

Right: Baobab avenue, Madagascar (Annie Lane, 2006)

Increasing the critical mass of research on forest genetic resources

To increase the critical mass of researchers in the arena of forest genetic resources and the recognition among other key stakeholders of the issues associated with the conservation and utilization of genetic diversity of forest species, Bioversity carries out capacity building activities linked to our research, as well as providing training courses, and sponsoring several fellowships. For example, the DANIDA-funded Bioversity project on tropical forest tree seeds supported researchers in 18 institutions to conduct high-quality research on optimal seed-handling and storage of recalcitrant tree seeds for local species. Young researchers from Southeast Asia were trained by Bioversity in the collection and identification of bamboo, while the APFORGEN network has provided training on the use of molecular markers. With Austrian support, Bioversity has offered a short course on Forest Genetic Resources Conservation and Use, carried out most recently in Kuala Lumpur, Malaysia in 2006 and Tashkent, Uzbekistan in 2007. Other capacity-building activities have included a regional training course on *in vitro* and cryopreservation techniques for conservation in New Delhi, India. Bioversity is currently producing a training module on the conservation and sustainable use of FGR, integrating insights from a range of case studies. Bioversity's Abdou Salam Ouedraogo Fellowship, Vavilov-Frankel Fellowship, and Austrian-funded Forest Genetic Resources Fellowships have provided opportunities for young developing country researchers to carry out research in collaboration with scientists in advanced research institutes on FGR topics including the impacts of domestication on *Uapaca kirkiana*; strategies for enhancing the conservation and use of *Melia volkensii*; genetic diversity and geneflow in *Fagus orientalis*; genetic variability and sustainable utilization of *Blighia*

Left: Santa Cruz, Bolivia (Annie Lane, 2006)

Left: *Araucaria* landscape (Barbara Vinceti, 2004))

sapinda; and the application of molecular and ethnobotanical tools to the development of conservation and domestication strategies for diversity in baobab (*Adansonia digitata*), an important source of food, fibre and resins in traditional agroforestry systems in West Africa (Assogbadjo *et al*. in press).

Conclusions

The world's forest genetic resources are both threatened and underutilized. Research is crucial to understanding and addressing these threats, and to developing effective strategies for conservation and sustainable use. Bioversity International and our partners around the world seek to contribute to this process, and to support other actors who must play key roles in the implementation of these strategies, among them botanic gardens, Ministries of Forestry and of the Environment, local communities and international conservation organizations. The challenges are great, but so are the benefits to be obtained by tapping into the great diversity of forest trees.

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The role of botanic gardens in supporting the conservation and sustainable use of non-timber forest products

Right: *Etlingera elatior* (Torch ginger) a Southeast Asian forest species (BGCI)

Introduction

Commercial logging to satisfy the growing demand for cheap timber has been one of the main threats to the world's forests. A landmark study in the late 1980s commissioned by the International Tropical Timber Organisation (ITTO) revealed the lack of sustainability in tropical timber production (Poore, *et al* 1989) and led indirectly to the formation of the Forest Stewardship Council. At the same time "extractive reserves" were being established to promote commercialisation of a wider range of forest products that could be harvested sustainably without destroying the forest resource. Thus the concept of non-timber forest products became important in considering management options for forest biodiversity, providing a mechanism to add value to forest resources.

Non-timber forest products (NTFPs) are any biological resources found in woodlands except timber. Also known as non-wood forest products (NWFPs), they include edible and medicinal plants, species that are of high demand for the handicraft industry and plants that are of ornamental interest. NTFPs include some widely traded products such as cocoa, rubber, incense and other plant derivatives. The value of NTFPs in global trade is currently estimated at US$4.7bn annually (Marshall *et al*, 2006). Interest in the uses of NTFPs world-wide is mainly related to the benefits it is felt they can deliver for the economy, society and the natural environment.

The Food and Agriculture Organization of the United Nations was one of the first agencies to promote NTFPs through their programme on non-wood forest products (NWFP) and over the past 15 years, numerous other international agencies have incorporated the concept of NTFPs into their programming. A quick scan of FAO reports and the bibliography of NTFP literature, both of which can be found on the FAO-NWFP web site (www.fao.org/forestry/site/nwfp/) reveal the growth of international interest in the topic of NTFPs for tropical and subtropical forests.

While the main focus for NTFP research has been the tropical and subtropical regions of the world, there has also been a parallel, albeit smaller growth of interest in the NTFPs of boreal and cold temperate forests. For example, in 2003 the UK's Forestry Commission funded a small survey on NTFP use in Scotland. The survey found that around one quarter (24%) of respondents had gathered wild fungi, plant and tree materials from Scottish woodlands in the last five years, with 80% of these, having collected products in the last 12 months (Forestry Commission, 2003).

Many of the plant species extracted from forests for trade are exclusively harvested from the wild and indeed

Left: Orchid species from the Atlantic rainforest, Brazil (Brent Stirton - Getty Images WWF - UK)

may be difficult to cultivate in a non-forest situation. An increasing demand for many of these species – fuelled for example by a growing interest in 'natural remedies' - can put extreme pressure on populations, as individuals are harvested indiscriminately and unsustainably from the wild. As a result, many NTFP species are of increasing conservation concern.

Ensuring the conservation and sustainable use of NTFPs is a complex task, requiring actions by a wide range of stakeholders. Botanic gardens are well placed to take direct and supportive actions towards this goal and this paper describes some of the ways in which this is happening.

Roles of botanic gardens

Research, identification and conservation

Remarkably little is known about the reproductive biology of relatively widespread tree species within forest ecosystems (Newton, 2007) and the same is generally true for the ecology and biology of shrubs, herbs, and fungi found in the understorey layers. Research questions relating to NTFPs include questions such as what factors control their distribution, establishment and reproduction, what physiological and morphological aspects control their usefulness and/or potency as NTFPs, as well as how these factors control the sustainability of their harvest.

These are the amongst the questions that many botanic gardens are addressing. For example the Fushan Botanic Garden (FBG), part of the Taiwan Forestry Research Institute (TFRI) has a natural forest consisting of some 30 ha. It is a site of long-term ecological research (LTER) in Taiwan with about 20 research projects each year undertaken by scientists of various institutes and includes the first large-scale subtropical forest plot in the world. FBG also includes a section where threatened or endangered species are grown, and which is also used for education.

Inventorying and surveying forests is key to developing effective conservation and sustainable use strategies. However, many of the countries harbouring important and biologically diverse forests have limited capacity to identify and document this diversity. In this respect, BGCI has helped to develop and fund a professional training programme for Cambodian botanists. The course has provided officers of the Ministry of Environment with the necessary skills to participate in a 'National Plant Team' which will conduct botanical and ecological research and evaluate plant diversity and habitats.

Similarly, the Royal Botanic Gardens, Kew, UK is involved in a project to assess and conserve plant diversity in commercially managed tropical rainforests in Sabah, Malaysia. The project team teaches courses or assists in: training in plant identification; use of herbarium specimens; targeted collecting and the production of print and web-based checklists and interactive keys; habitat assessment and vegetation mapping, using ground surveys and interpretations of satellite imagery and aerial photographs in order to identify high conservation-value forests based on plant diversity and vegetation type (www.kew.org/science/directory/projects/DiversityForestsSaba.html).

Above: Medicinal plants on sale in China (BGCI)

Many of the most important NTFPs are medicinal plants and botanic gardens around the world are very much involved in research on such plants. For example the Xishuangbanna Tropical Botanic Garden in China has begun a research programme into the propagation and reintroduction of local *Dendrobium* species, used extensively in Chinese Traditional Medicine. This includes fieldwork to assess the status of populations in the wild and research into cultivation techniques.
Botanic gardens are also well placed to take direct conservation action for threatened NTFP species, through collecting and conserving seeds or establishing conservation collections as part of their living collections. Such *ex situ* collections are then available for use in research, re-introduction and education and awareness raising activities. In this respect, BGCI has been working with the Nature and Wildlife Division of the Myanmar Forest Department to establish an *ex situ* collection of orchids native to Shan State, many of which are under increasing threat from over harvesting, illegal trade and forest degradation. The project staff have held information meetings with local villagers to explain the importance of conservation and propagation studies are underway for some of the commercially viable

Left: A traditional healer explains how her Dzao culture uses medicinal plants, Hanoi University of Pharmacy, Vietnam (BGCI)

Right: Bluebells in the Loder Valley, UK (RBG Kew)

species, with the aim of improving the livelihoods of the villagers while decreasing harvesting pressure on wild populations.

Community support and sustainable harvesting

High demand for NTFPs can result in over-harvesting of these products from the wild, in some cases putting the very survival of the species in question. Where the product being over-harvested is a plant, botanic gardens may well have the horticultural expertise to support cultivation as an alternative to wild harvest or can work with the local communities to develop more sustainable methods of harvesting from the wild.

Right: Annatto is produced from the reddish pulp which surrounds the seed of the achiote (*Bixa orellana*) tree which grows in tropical regions of the Americas. It is used as both a colouring agent and for flavouring (BGCI)

Palm leaves in Belize

In central America three *Chamaedorea* palm species (*C. elegans, C. oblongata* and *C. ernesti-augustii*) are increasingly under threat due to the over-harvesting of their leaves to supply the florist industry. The leaves of the 'fishtail palm' or 'xate' are harvested from palms in the forests of Mexico, Guatemala and Belize where they grow naturally. Many people, called xateros, rely on the harvest of palm leaves as their source of income. Unfortunately so much leaf is being collected it has made a large impact on the health and population of the palms in the wild. Much of the supply comes from Guatemala – but the high demand has led to severe over-collection. Now the harvesters (xateros) from Guatemala are starting to cross the Belizean border to gather the leaf. Unfortunately this illegal harvest comes with a high price to the forests of Belize. Not only are *Chamaedorea* palms threatened by xatero activities but xateros have also been responsible for the looting of artifacts from Maya sites, poaching young scarlet macaws to sell and collecting other plants and seeds such as the 'ponytail palm' (*Nolina* spp.). They also hunt for food while working in the forest, killing agouti, deer, guan and tapir, Belize's national animal.

Sustainably growing xate is one way to protect the populations of this plant. Belize Botanic Gardens (BBG) is working with a number of local organizations to create a fair and environmentally sound xate industry in Belize. With funding from the UK Government, through the Darwin Initiative, BBG has developed a Grower's Guide for xate, providing information for farmers on how to produce xate sustainanably. In addition, at the garden they are cultivating three species of *Chamaedorea* in order to develop propagation and cultivation protocols and produce seeds and plants to pass on to Belizean farmers (www.belizebotanic.org/xate.html).

Conservation through cultivation in Cameroon

Limbe Botanic Garden in Cameroon has a 'Conservation through Cultivation' programme that works for the conservation of threatened useful wild species. It has long been involved with promoting *ex situ* cultivation of Eru, to reduce pressure on wild stock and to improve the livelihoods of rural farmers through the sale and consumption of the vegetable. Eru (*Gnetum africanum* and *G. buchholzianum*) is a climbing rainforest vine of West and Central Africa that is used as a highly priced vegetable but is threatened by the excessive pressures of wild-harvesting. Its protein content is high, so it can play an important role in preventing malnutrition, and it is also thought to have medicinal qualities. It is locally popular within Cameroon, and tonnes of it are also regularly exported to Nigeria and beyond, supporting the employment of thousands of people.

Limbe developed a domestication technique for inclusion in local agroforestry systems, using trial plots and gene banks. It then went on to train relevant community members using theoretical and practical techniques and maintains strong links with the farmers who are involved in the cultivation of the crop, which helps with further research into its domestication.

Commercialization and sales

In many areas harvesting and sale of NTFPs provides the only source of income for local communities, and they are completely dependent on them for survival. A recent study by the UN Environment Programme's World Conservation Monitoring Centre (UNEP-WCMC) identified how commercial development of NTFPs could enable rural communities to escape poverty without irreversibly damaging the environment. A key recommendation of the 2006 report was that aid should be targeted at developing the business skills of rural communities to help them avoid exploitation by entrepreneurs and other middle men in the trade of NTFPs (Marshall *et al* 2006).

Botanic gardens have an important role to play in supporting the commercialisation and sale of NTFPs by promoting such products in their gift shops and developing relationships with local producers to ensure that production techniques are sustainable. One such example is The Missouri

Botanical Garden, which has joined forces with The Blessing Basket Project in an effort to conserve a biologically important forest in Madagascar. The Blessing Baskets that are sold at Missouri are produced in the small village of Mahabo in Madagascar and their manufacture provides a source of sustainable employment for the villagers with the Blessing Basket Project paying the weavers at Mahabo nearly five times the fair trade price. This relationship forms part of a strong international linkage between the Missouri Botanical Garden and Madagascar, in which scientists from Missouri discover new plants and describe them; provide training and support for local partner institutions, including the herbarium; and use botanical data to help the Malagasy government identify national conservation priorities and carry out conservation projects. Garden scientists also work with local communities to develop sustainable agricultural techniques so villagers can survive without destroying the forest. As a result of these initiatives, a direct improvement in the conservation of the Mahabo forest is already being seen. (www.blessingbasket.org).

Education and interpretation

Many botanic gardens are involved in educating and informing the public about the diversity and value of NTFPs. From the award-winning rainforest biome of the Eden Project (see p 25) to the small-scale displays and interpretative panels found in most gardens, botanic gardens are ideally placed to raise awareness of the importance of NTFPs.

The Living Rainforest provides another example from the UK. Here, visitors have the opportunity to be immersed in a real rainforest experience and the centre provides a unique educational visit for people to learn how the future of tropical rainforests and other ecosystems is closely connected to human lives and lifestyles. Through the displays and special educational tours, the public learn about the multiple facets of a tropical rainforest and gain an understanding of the extreme diversity of this ecosystem. With a particular focus on the linkages between the forest and humankind, The Living Rainforest communicates the importance of tropical biodiversity to an audience far removed from the reality (www.livingrainforest.org).

Looking ahead

The livelihood values of NTFPs are enormous with around 350 of the world's poorest people depending almost entirely on forests for their basic needs. A recent article has emphasised the great potential of the use of NTFPs in helping to achieve the Millennium Development Goals (Chaudhury, 2007). Botanic gardens, with their traditional interest in economic botanic, can help in a wide range of ways to promote, research and conserve key species of particular value, working with local communities and informing the wider public of the multitude of forest products that are often overlooked.

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Below: Mr Aung Kyaw Win of the Nature and Wildlife Division, Myanmar Forest Department examines an orchid (BGCI)

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Left: Wild walnuts from the forests of Kyrgyzstan provide livelihoods to local people as well as conserving potentially valuable genetic diversity (Chris Loades / FFI)

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Research on biodiversity and conservation of the Atlantic Rainforest at Rio de Janeiro Botanical Garden

Introduction

The Rio de Janeiro Botanical Garden (RJBG) is one of the most important scientific institutions in Brazil. Its research is focused on the management of Brazil's plant diversity and in 2008 it is celebrating its 200th anniversary. Its scientific resources count amongst others, a collection of more than 453,000 herbarium specimens covering almost 5,000 species, including a large number of type specimens. This collection has been digitised since 2005.

The botanical garden has a public visiting area of 54 ha and its *ex situ* collections include around 7,900 samples of 1,443 species, growing in gardens and greenhouses. In addition, there is an *in situ* conservation area of forest which is contiguous with the National Park of Tijuca. This provides an excellent opportunity for visitors to experience one of the world's biodiversity hotspots – the Atlantic Rainforest.

Located within the city of Rio de Janeiro, the RJBG receives nearly 300,000 visitors every year, and is particularly popular with students from all regions of Rio de Janeiro state. The garden also has an active exchange programme for national and international scientists in a range of subjects, including taxonomy, systematics, wood anatomy, ecology of ecosystems and populations, genetics, molecular biology and ethnobotany.

Right: Collecting botanic samples for the herbarium from trees of the Atlantic Rain Forest (Rio de Janeiro Botanical Garden)

This dynamism, together with the Masters degree in plant biology offered by the National School of Tropical Biology (NSTB), enhances the effect of research efforts towards biodiversity conservation, especially within the remaining areas of the Atlantic Rainforest.

The Atlantic Rainforest

Currently the Atlantic Rainforest is reduced to a mere 8% of its original area (Conservation International do Brasil, 2000), and is the typical forest landscape of the Brazilian lowlands and mountains from Rio Grande do Norte to Rio Grande do Sul. The southeast region of Brazil is believed to contain the largest remaining area of Atlantic Rainforest and this ecosystem is distributed through most of Rio de Janeiro State, in different successional stages and levels of use and exploitation. In 2000, the Atlantic Rainforest covered 817,788 ha, representing 18.76% of the total area of the State, with 29.8% of this area being protected within conservation units. During the 5-year period between 1995 and 2000, 3,773 ha of native forest were destroyed and by 2006, a further 630 ha had been lost (Fundação SOS Mata Atlântica, 2006). The forest is distributed in the most populous area of Brazil, where 85% of the Brazilian population live and where the biggest cities such as Sao Paulo, Rio de Janeiro, Recife and Salvador are located.

Initial studies on the Atlantic Rainforest

Since 1988, the RJBG has concentrated its efforts on improving awareness of the Atlantic Rainforest and promoting conservation, especially in the remaining areas of forest in Rio de Janeiro State. These include lowland forests (Reserva Biológica de Poço das Antas), lower montane forests (Estação Ecológica Estadual de Paraíso), and finally montane and upper montane forests (Área de Proteção Ambiental Macaé de Cima e Itatiaia). The programme "Linhas de Ação em Botânica" supported by CNPq (Conselho Nacional de Desenvolvimento Científico e Tecnológico) was an important project aimed at increasing knowledge of the flora, ecology and conservation needs of the Atlantic Rainforest.

Left: Cloud forest at Itatiaia National Park, a part of the Atlantic Rain Forest (Rio de Janeiro Botanical Garden)

Through the Programa Mata Atlântica (PMA), the RJBG has attempted to evaluate existing plant diversity and compare this with the diversity represented in herbarium specimens collected mainly during the 19th Century, focussing on areas most threatened for conservation. Based on this, the central highlands of Rio de Janeiro, more precisely the Rio Macaé basin in Serra do Mar in the Nova Friburgo County, was selected as the PMA pilot area. According to Guedes-Bruni (1998), that region was explored by renowned foreign naturalists whose botanical collections are mostly deposited in international herbariums such as St.Hilaire (1818), Schott (1820), Lund (1825-1828), Riedel (1831-1833), Gardner (1841), Peckolt (and the zoologist Deske em 1848), Burmeister (1853), Glaziou (1861), Saldanha (1866 -1884), Mendonça (1884) and Dusén (1902-1904).

Five interdisciplinary research themes were implemented: taxonomy, community ecology, ecological anatomy, phenology and seed germination. The scientific expeditions to Macaé de Cima resulted in the collection of more than 5,000 samples, from more than 1,300 taxons representing the different vegetation types of the area. A total of 462 samples were taxonomically described, and published in two volumes, including floristic and ecological studies (Lima & Guedes-Bruni, 1996) and anatomical studies (Barros, 1997, 2001).

The interaction among the teams promoted a series of research projects based on the PMA's main objectives. As an example of success, 54 species were identified during the taxonomic survey, 9 of them located in the Macaé de Cima site. Eight of the nine species had been discovered by Glaziou in the past but one was new to science – and was described by Gomes. (Lima & Guedes-Bruni 1994a, Peixoto & Pereira 1994). Similar results were found by Gomes (1996) for Rubiaceae, increasing from 45 to 53 the number of known species, of which two had not been described before. Species only known by type specimens, such as *Miconia breviflora* Cogn. collected by Glaziou in Macaé de Cima, were shown after the inventory of that area not to be extinct, but instead occurring in high density in Macaé's mountains at over 1,200 meters of altitude (J. F. A. Baumgratz,

Left: Preparing plant collections in the field for future botanical identification (Rio de Janeiro Botanical Garden)

Above: The Carlos Botelho park is a key fragment of Brazil's Mata Atlantica forest (Evan Bowen-Jones / FFI)

pers. comm.). According to the assessment of geographical distribution of 874 taxa, Lima *et al* (1996), described the occurrence of 26.9% of the vascular species as endemic to Southeast Brazil, 26% endemic to Serra da Mantiqueira and Serra do Mar, in Rio de Janeiro, and 7.8% endemic to Macaé de Cima region.
This data provided the basis for the county to establish conservation units to ensure the conservation of significant forest fragments. The establishment of the ecological reserve of Macaé de Cima in 1989, with an area of 7,000 ha, initiated a process of awareness raising for the remaining fragments of the Atlantic Rainforest in Nova Friburgo. Some years later, the conservation of the mountain areas increased with the implementation of two other State conservation units: Environmental Protected Area of Macaé de Cima in 2001 and State Park of Três Picos in 2002. The establishment of these conservation areas however made the management of the conservation units difficult, since the status of the two units were legally contrasting: the first one allowing the management of natural resources by the local community and the second one forbidding this.

Continuing the inventory of different areas, from 1995 the PMA started its activities in the Itatiaia National Park (INP) which was created in 1937 as the first National Park in Brazil.

The INP was in the past a research station of the RJBG where researchers developed long-term studies – such as those of Alexandre Curt Brade, who worked there for 30 years collecting a significant part of the Itatiaia collection held in the RJBG herbarium.

Biological Reserve of Poço das Antas

The studies developed in Macaé de Cima, and afterwards, from 1992 in Paraíso, at Serra dos Órgãos basin, in Guapimirim, enabled the PMA to initiate studies in a new area in 1993. This new area was the Biological Reserve of Poço das Antas (POA) located in the lowlands of Rio de Janeiro where the forests were practically extinct, over swamp areas and low hills (not higher than 200 meters).

Besides the research lines developed by the researchers, the PMA accepted the challenge of developing extension programmes to complement the field experiments and the ecological restoration, promoting not only experimental planting in different conditions, but also integration with the traditional rural community established in the POA surroundings.

New inventories were established in order to study variation in plant physiology, floral behaviour at different altitude gradients, the phenology of arboreal species for potential restoration, population studies of arboreal species, seed production and the germination process, the efficiency of establishing connectivity corridors between the islands of forests in the interior of the POA and finally the growth of tree species, evaluating the anatomy of the wood growth rings.

Experimental seeding of native tree species was the main action derived from the research on forest restoration; various models were used and the results published (Moraes *et al*, 2002 and 2006(a); Moraes & Pereira 2003 and 2007). Every year, approximately 10,000 seedlings of tree species are produced, 6 ha are monitored and 1 ha planted.

In order to promote the integration among the institutions working inside the POA, and the assimilation of conservation concepts by the local community (regarding the value of the forest tree and animal species), an average of 4,000 seedlings are produced annually by the PMA to support education and environmental awareness, through the reforestation of degraded areas in that region. The identification of the strong appeal of this kind of action among the local population led to the publication of a technical reforestation manual for Atlantic Rainforest areas (Moraes *et al*, 2006 (b)).

Working with the local community

The interaction between the RJBG and the local community aims to support the development of a scientific culture in an area where education is not a priority. As an example of this interaction, educational activities have been developed with the rural community of Macaé de Cima. During these activities people from the community have the opportunity to visit the scientific installations, which are very near their homes, but very far from their normal daily lives. Among the aims of the PMA are the production of seedlings in cultivated areas of RJBG and guided visits for students and visitors to the arboretum during special days such as: Atlantic Rainforest Day, Environment Day, RJBG Anniversaries and Tree Day.

In addition, the activities of RJBG are integrated into the National Science Week, promoted since 2004 by the Ministry of Science and Technology.

In the past, the opposing interests of researchers and farmers from the local community resulted in damage to the scientific experiments and penalties to farmers. The intensification of contact between RJBG and the communities located in the areas surrounding the conservation units has solved this problem and led to the development of partnerships between researchers and local people. Most importantly, the recognition of the traditional knowledge of the people from the community about the use of plants and the dynamics of the forest has promoted the self-esteem of the local community (Christo *et al*, 2006, Sobrinho, 2007).

Other activities of the PMA

In 2000, when Brazil celebrated its 500th anniversary, PMA produced the CD-Rom *Atlantic Rainforest 500 years* (Guedes-Bruni *et al*, 2000). The CD records the history of forest occupation and the scientific perceptions of those who recorded the forest and nature. The most important tree species are identified both from an historic as well as an environmental perspective. The CD was developed to reach a range of different audiences for various educational purposes. A second, more scientific CD was also produced to support responsible tourism in Brazil's natural areas.

In 2002, following a request from the Ministry of Environment, the PMA started an inventory of the Tinguá Biological Reserve, in collaboration with the Universidade Federal Rural do Rio de Janeiro. Tinguá is an important urban forest fragment of 26,000 ha located between the two largest cities of the Rio de Janeiro lowlands – Nova Iguaçú and Duque de Caxias.

In 2003, before RJBG had developed a post-graduate programme, various staff undertook training in Atlantic Rainforest ecology and floristic resources. A total of 17 MSc dissertations and 7 PhD theses were developed from the data produced by the PMA.

During 2004-5, the PMA was selected as an educational area for the National School of Tropical Biology (NSTB) and fieldwork methodologies developed by the PMA were taught as part of the degree programme.

Conclusions

Through its work on the Atlantic Rainforest, the RJBG is working to achieve the goals of the Global Strategy for Plant Conservation (GSPC). Specific targets being addressed are: (i) to consolidate an accessible list of identified plant species as a step towards the creation of a list of Brazilian Atlantic Rainforest species; (ii) cooperating with the preliminary evaluation of the current conservation status of the plant species of the Atlantic Rainforest at the regional level; (iii) providing examples of how to secure the protection of Atlantic Rainforest areas important for plant diversity; and (iv) collaborating on the conservation of threatened species of the Atlantic Rainforest.

The RJBG was originally built 200 years ago with a strategic aim to protect the economic interests of Brazil, through the acclimatization of plant species introduced for commercial purposes. Today the strategic vision of the garden includes not only economic alternatives, but also the sustainable use of natural resources in support of improved human well-being and environmental protection. Conserving the Atlantic Rainforest is a strategic mission which the RJBG assumes and emphasises in this important anniversary year, a year dedicated to all the botanical scientists who devoted their lives to the understanding and conservation of Brazil's unique and diverse floral heritage.

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Left: The Mata Atlantica ecosystem supports a high diversity of species, such as this black capuchin monkey (Evan Bowen-Jones / FFI)

Right: Discussing the uses of Atlantic Rain Forest plants with local women (Rio de Janeiro Botanical Garden)

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Opposite: Gardens for Life brings people together to share their experiences (Eden Project)

Impatiens 'Ray of Hope' is sold at the Eden Project to raise funds and awareness for conservation in the Seychelles Islands (Eden Project)

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Eden Project: A case study in the interpretation of a tropical rainforest

Eden Project is a Millennium project conceived in 1994 and built in a former Cornish clay pit in the South West of the United Kingdom. Eden opened to the public in March 2001 and is a not-for-profit Charitable Trust. Its mission is to promote understanding and responsible management of the vital relationship between plants, people and resources leading towards a sustainable future for all. Eden is amongst the top five paying visitor attractions in the UK, has hosted eight million visitors and provides a 'Living Theatre' where examples of positive initiatives from around the world are displayed, explained and supported. Eden communicates its story through various media using a backdrop of great architecture and over 1,000,000 plants representing 5,000 species from many of the climatic regions of the world. The biomes feature plants, crops and landscapes from the humid tropics (Rainforest Biome), the warm temperate regions (Mediterranean Biome) and the temperate landscape (Temperate Biome.)

Eden's aim is to present, to the widest possible audience, the need for environmental care through celebrating what nature gives to us. Eden's education programme comprises major themes such as energy and climate change, food, nutrition, health and well-being, biodiversity and sustainable use of natural resources.

The Eden Project communicates the importance of tropical biodiversity to an audience far removed from the tropics by showing a large rainforest in captivity. The Rainforest Biome provides the public with an unforgettable 'immersive' experience of the tropics, the plants and their uses. Eden has invited world class canopy researchers to showcase their research equipment and to directly engage with the public to highlight their positive conservation work. Eden Projects pollinator team, bands, artists and actors provided a fun learning experience for adults and children during the Summer Canopy and Jungle Seasons and a Canopy Conversation conference brought together leading tropical conservationists, natural scientists and politicians for the first time to share their experiences with the public and to network, debate and find solutions towards safeguarding the future of our rainforests.

Above: The canopy bubble, a research tool used by researchers to study the rainforest canopy (Eden Project)

Eden Project's Education team run workshops such as 'Don't Forget your Leech Socks' and the 'Crazy Chef

Right: The rainforest biome at night (Eden Project)

Below: The Canopy Conversation conference held at the Eden Project (Simon Bert / Eden Project 2004)

Challenge' which aim to educate children about plant adaptations in the humid tropics, the way in which indigenous people use tropical plants for their survival and the significance of plants to their own daily lives. Eden Project's book publishing group endorsed the book titled Deep Jungle, by Fred Pearce which compliments the messaging within the Rainforest Biome.

A new ornamental hybrid called *Impatiens* 'Ray of Hope' has been bred using the critically endangered Seychelles endemic *Impatiens gordonii* as a parent at the Eden Project.

The selling of this plant through Eden Project's plant retail has raised money and awareness for conservation of rare and endangered Seychelles plants with fifty percent of the profits from sales going directly back to the Seychelles to assist in the conservation of their rare and endangered plants.

The Eden Project goes beyond its visitor destination by collaborating with numerous like-minded people from around the world such as Earth University in Costa Rica, the Forest Restoration Research Unit (FORRU) in Asia and the Ballabu Conservation Project in The Gambia. Eden has also received funding from the Darwin Initiative to undertake conservation projects in Argentina and the Seychelles. Finally through many projects such as Gardens for Life, the Eden Project acts as a broker to bring people together from across the planet. Gardens for Life supports children, young people, teachers, project leaders, families and communities worldwide to garden and grow crops in three continents, in the UK (Cornwall, Bristol and Gloucester), Africa (Kenya) and India (Maharastra State). This work aims to create a global community who understand more about the major issues concerning food which we all face today encompassing - food security and health, climate change and water, cultures, indigenous knowledge, cooking, medicine, outdoor learning, participation, global citizenship, youth empowerment and inclusion.

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Right: The aerial antics of Colobus Monkeys in the rainforest biome performed by artists from Swamp Circus as part of Eden's half-term fun for Canopy Season (Eden Project)

Authors: Joachim Gratzfeld and Bian Tan

Agarwood - saving a precious and threatened resource

Left: A plug in a wound in an agarwood tree (BGCI)

There are many names for the resinous, fragrant heartwood produced primarily by trees in the genus *Aquilaria*. The commoner names include agarwood, aloeswood, eaglewood, gaharu or oudh, and it is also mentioned in the Old Testament as 'aloe' or 'ahaloth'. This valuable and highly fragrant wood has been used in many ways for over two thousand years, especially as incense in Buddhist, Hindu, and Islamic traditional ceremonies, and as a significant component of traditional Ayurvedic, Tibetan and Far Eastern medicine and Middle Eastern perfumes.

The genus *Aquilaria* of the Thymelaeaceae (Daphne family) consists of generally fast-growing trees found in lowland tropical forests. It occurs naturally in South and Southeast Asia, from the foothills of the Himalayas (Bhutan) and northern India, through Myanmar, IndoChina (Lao PDR, Cambodia, Vietnam), Thailand, Malaysia, the Philippines and Indonesia to Papua New Guinea. Seedlings of most species establish best in shady, moist conditions, but large adult trees sometimes become emergent in the forest and can withstand full sun. Some species can be found growing on steep, rocky, exposed slopes, and in regions that experience a hot, dry season. Wherever they occur naturally, they provide an important source of livelihood for local communities who harvest the fragrant agarwood to sell.

Other genera in the family of the Thymelaeaceae known to produce agarwood include *Gonystylus, Gyrinops, Aetoxylon, Enkleia, Wikstroemia* and *Phaleria*. However, it is still unclear which species within these taxa produce agarwood and in what quantities. The taxonomy of *Aquilaria* is in need of review. A new species, *A. rugosa* L.C. Kiet & Kessler, was described in 2005 from central Vietnam and northern Thailand, and a possible new species has been reported from Lao PDR (Sourioudong Sundara, pers. com.).

How the agarwood resin is produced by the tree

It has long been known that the production of the fragrant resin is associated with wounding and associated fungal invasion, possibly assisted by insects. As a response to the fungal infection, the tree produces a resin high in volatile organic compounds that aids in suppressing or retarding the growth of the fungus. Various fungi are associated with agarwood formation although it is still not completely clear which ones make the plant generate the resin.

While the unaffected wood of the tree is light in colour the resin dramatically increases the mass and density of the affected wood, changing its colour to dark brown or black. In natural forests, only an estimated 7-10% of the trees are infected by the fungus (Ng *et al*., 1997). The major constituents of

Below: Large Aquilaria trees are increasingly rarely found (BGCI)

Above: *Aquilaria* plantation, North Vietnam. *A. chinensis* trees, and *A crassna* seedlings below (BGCI)

agarwood oil are sesquiterpenes, which are difficult to synthesize artificially, and therefore there are presently no good substitutes for high quality agarwood.

Exploitation and trade in agarwood

Today, the demand for agarwood far exceeds supply. A recent study revealed that supply rates are only 40% of the demand and a litre of agarwood oil can be sold for around $US10,000 - 14,000 on the market (Vietnam Chemical Technology Institute, 2007). Indeed agarwood is reputed to be the most expensive wood in the world and it is estimated that specialized buyers are prepared to pay as much as ten times more for this product.

There are no obvious external signs that a tree may contain agarwood and, if it does, the quantity can only be fully determined after the tree has been felled and cut open. The search for the product therefore results in indiscriminate felling of trees and degradation of habitats, causing a loss of the ecological niche for agarwood-producing species and a dramatic decline in wild *Aquilaria* species in the last few decades.

Populations of eight *Aquilaria* and 15 *Gonystylus* species have declined to the point at which they are categorized as threatened according to the 2007 IUCN Red List (IUCN, 2007). Out of four listed species of *Wikstromia* two are believed to be extinct. All species of *Aquilaria, Gonystylus* and *Gyrinops* are listed in Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) requiring CITES Parties to issue export permits or re-export certificates in international agarwood trade.

Even though it is illegal to cut and harvest agarwood-producing species in most countries of Southeast Asia, the value of agarwood is so high that wild populations continue to be under threat in all countries where the taxa occur. Tracking down and documenting trade quantities is therefore challenging, and it is virtually impossible to determine which species are being traded, as all agarwood reported in trade is generally referred to as *Aquilaria* spp. or *A. malaccensis*.

Agarwood is exported in various forms (wood chips, powder, oil and as finished products such as perfumes, incense and medicines), and the main importers are countries in the Middle and Far East – in particular the United Arab Emirates and Saudi Arabia (where agarwood is known as oudh), as well as Hong Kong, Taiwan and Japan.

Artificial agarwood induction and harvesting practices

While a large part of agarwood comes from the exploitation of wild plants, local communities, over time, have developed a number of techniques to artificially induce the generation of agarwood, although with uneven rates of success. For instance, communities in northern Vietnam cut a hole in the trunk or main branches of *Aquilaria* trees. If the wound is kept open by regular chipping, agarwood generation may be induced after several years and can be extracted in nominal quantities each time when chipped, as long as the tree remains alive. This method may be adapted and further developed as “tapping” of agarwood, and may be a more sustainable alternative to felling the entire tree.

Right: Mass-produced Aquilaria seedlings for plantations, Research Institute of Science, PDR Laos (BGCI)

Another technique takes the wounding a step further by plugging the wound with a piece of wood or pottery shard. This prevents the wound from closing and therefore would seem to be a more reliable method for inducing agarwood production.

A method of coppicing by indigenous Penan people is reported from Borneo (Donovan and Puri, 2004). Although harvest quantities are small, the trees develop a dense coppice and provide continuous yield. The periodic coppicing wounds the trees and promotes further formation of agarwood.

Agarwood cultivation

Another, more recent way of producing agarwood, is to grow trees in plantations. A drill is usually employed to make holes in the trunks and main branches of mature trees which are then inoculated with agarwood powder. Generally, agarwood is harvested when the trees are between five and ten years old. Agarwood plantations exist in a number of countries, including Bangladesh, Bhutan, India, Indonesia, Laos, Malaysia, Myanmar, Papua New Guinea, Thailand and Vietnam.

Towards conservation and sustainable management of agarwood

The high value of agarwood and the potentially lucrative nature of mass production has restricted the free exchange of information regarding sustainable production methodologies. There has therefore been little opportunity to capitalize on lessons learnt in this area. On the other hand, farmers and investors have been hesitant to invest in cultivation because of the 5-10 year wait for returns, and perhaps because of fear that agarwood produced in plantations may be of lower grade, and therefore unprofitable.
In this respect, concerns are raised that cultivation may not necessarily reduce the demand and may well increase wild harvesting. Furthermore, there is the concern that increased production may flood the market and cause price deflation.

As a result, many questions remain regarding successful conservation and sustainable management of agarwood.

Knowledge gaps about the biology and ecology of agarwood-producing species need to be filled and traditional, management practices should be integrated with the latest scientific research findings. In addition, it will be essential to devise mechanisms to allow benefits to return to local communities that have made available their knowledge of management practices for agarwood production.

Botanic gardens worldwide are increasingly being recognized as having a vital role in plant conservation. They function as "Noah's Arks", holding rare and endangered plants in protective custody until such time as they can be reintroduced into suitable wild habitat. As such, they are well-placed to play a central role in the conservation of threatened *Aquilaria* and other agarwood-producing species.

In collaboration with local botanic gardens and related partners in Southeast Asia, BGCI has been working on finding solutions to the challenges of agarwood conservation. A joint project with the Research Institute of Science (RIS) in Vientiane, Lao PDR, has enabled a national survey and the design of a database of wild populations of *Aquilaria*, including GIS data and vouchers, as well as the successful production of nursery stock for plantations of six *Aquilaria* species. A public exhibition on environmental resources including a display of agarwood and the inoculation process for plantation trees has been instrumental in raising awareness of the conservation status of agarwood and the need for sustainable management of this valuable natural resource.

For many years, the RIS has been encouraging rural farmers to plant *Aquilaria* in plantations, and as a result, there are now approximately 1,000 hectares of plantation established in Bori Khamxay Province, Lao PDR. RIS has also isolated three species of the resin-inducing fungi from wild agarwood producing trees. Using an electric drill to make small holes in plantation trees, wooden pegs infected with the fungus are hammered into the opening. Tree trunks containing agarwood are foreseen to be harvested after five years.

Capitalising on these experiences, BGCI is pursuing efforts to secure and conserve remaining wild populations of *Aquilaria* and other threatened agarwood- producing taxa. The plan of action, initially developed for Lao PDR, Cambodia and Vietnam includes:

- Strengthening institutional cooperation and coordination, by bringing together various stake-holders including local collectors, processors, traders, government and conservation agencies, botanic gardens and businesses;

- Capacity building and training for integrated agarwood conservation, by assisting in the development of in-country training capacity (of resource owners, users and conservation practitioners) focussing on surveying remaining wild populations, integrated *ex-* and *in situ* species recovery programmes and silviculture; and

- Practical conservation in demonstration projects, aiming to enhance i) conservation of remaining wild populations of agarwood-producing tree species (e.g. in community managed protected areas); ii) *ex situ* propagation of critically endangered species in village nurseries, local botanic gardens, etc. and, iii) subsequent reintroduction into the wild.

With the implementation of this action plan it is hoped to provide a complementary approach to harvesting wild trees and to relieve pressure on the remaining highly threatened natural populations of *Aquilaria* and other agarwood-generating species, while supporting those local communities whose livelihoods depend on this precious natural resource.

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Left: Mr. Trieu Nguyen Duong indicates a wound for extraction of agarwood (BGCI)

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Resources

Review

Forest Ecology and Conservation: A Handbook of Techniques
Adrian Newton, 2007
Oxford University Press, 472 pp.
Price: £60.00 (Hardback)
ISBN-10: 978-0-19-856745-6
Price: £27.50 (Paperback)
ISBN-13: 978-0-19-856745-5
Great Clarendon Street, Oxford
OX2 6DP, UK
Web: http://www.oup.co.uk

Conserving the world's forests is a major challenge. As the introduction to this highly important book points out "conservation management depends on understanding the interplay between social, economic and political issues relating to a particular forest, and on appreciating the values held by different people with an interest in it." Scientific understanding plays a relatively minor role in forest conservation but can be crucial in ensuring that conservation management is effective.

This handbook describes a wide range of research methods and techniques relevant to understanding forest ecology, with a particular focus on those that are relevant to practical conservation and sustainable forest management. It provides a comprehensive synthesis for use by graduate students, researchers and practising conservationists and will be a welcome addition to the libraries of botanic gardens worldwide. Methods are presented for assessing forest extent and condition, structure and composition, and forest dynamics at a variety of scales. Techniques for assessing genetic variation and reproductive ecology of forest species, and for evaluating the habitat value of and threats to forests and their species are also described.

The value of this book is not only in the information it conveys but in the inspiration it provides. Throughout the text, the huge biodiversity and ecological knowledge gaps that exist are highlighted. Adrian Newton points out that scientifically robust forest monitoring, adaptive management and sustainable management all remain very rare and that we cannot even estimate with reasonable accuracy how many species are being lost as a result of deforestation. Reading this book helps to emphasise how much work still needs to be done, how much is possible and how important forest research efforts continue to be. The chapter, *Towards effective forest conservation* sets out how this research can be applied in protection, sustainable forest management, restoration and in the sustainable harvesting of NTFPs - all areas of work where botanic gardens can be and are involved.

Sara Oldfield

Please note: BGCI members receive a 30% discount on purchases before 29 February 2008. Visit www.oup.co.uk/sale/signup/websocbgci

Resources

Forests in Landscapes: Ecosystem Approaches to Sustainability
Recent innovations in Sustainable Forest Management and Ecosystem Approaches are resulting in forests increasingly being managed as part of the broader social-ecological systems in which they exist. *Forests in Landscapes* reviews changes that have occurred in forest management in recent decades. Case studies from Europe, Canada, the United States, Russia, Australia, the Congo and Central America provide a wealth of international examples of innovative practices. Cross-cutting chapters examine the political ecology and economics of forest management, and review the information needs and the use and misuse of criteria and indicators to achieve broad societal goals for forests.

Edited by Jeffrey Sayer and Stewart Maginnis assisted by Michelle Laurie, 2005
Earthscan. 280 pp.
Price: £29.95 (Paperback, 2007)
ISBN: 9781844071968
8-12 Camden High Street, London,
NW1 0JH, UK.
Email: orders@earthscan.co.uk
Internet: www.earthscan.co.uk

The Forest Landscape Restoration Handbook
This book, authored and collected by leading international authorities in the field of forestry, is the first comprehensive, practical treatment of Forest Landscape Restoration (FLR). As an approach to conservation, FLR provides a complementary framework to sustainable forest management and the ecosystem approach in landscapes in cases where forest loss has caused a decline in the quality of ecosystem services. The main aim of FLR is not to re-establish pristine forest, even if this were possible, rather the objective is to strengthen the resilience of landscapes and thereby keep future management options open. It also aims to support communities as they strive to increase and sustain the benefits they derive from the management of land. The result here is an indispensable, easy-to-read handbook for practitioners in all aspects of forestry and natural resource management.

Edited by Jenny Rietbergen-McCracken, Stewart Maginnis and Alastair Sarre, 2006
Earthscan. 160 pp.
Price: £49.95 (Hardback)

ISBN: 1844073696 / 9781844073696
8-12 Camden High Street, London,
NW1 0JH, UK.
Email: orders@earthscan.co.uk
Internet: www.earthscan.co.uk

Potential and Challenges of Payments for Ecosystem Services from Tropical Forests
This paper summarises current potential and challenges facing the development of payments for ecosystem services (PES) as a means of promoting the sustainable management or conservation of tropical forests, including the challenge of combining equity or poverty reduction objectives with environmental objectives, and the interaction of PES with broader forest sector and 'extra-sectoral' policies.

Michael Richards and Michael Jenkins,
December 2007
ODI Forestry Briefing 16. 8 pp.
Available for free online:
http://www.odi.org.uk
Overseas Development Institute,
111 Westminster Bridge Road, London,
SE1 7JD, UK.
Publications and bookshop:
publications@odi.org.uk

State of the World's Forests 2007
FAO's biennial State of the World's Forests series offers a global perspective on the forest sector, including its environmental, economic and social dimensions. This seventh edition examines progress towards sustainable forest management.

FAO, 2007
Available online:
http://www.fao.org/docrep/009/a0773e/a0773e00.htm
FAO, Viale delle Terme di Caracalla,
00153 Rome, Italy.
Email: FAO-HQ@fao.org
Internet: www.fao.org

Laws for forests: An introductory guide to international forest and forest related legal materials that shape forest ethics and practice
The aim of this guide is to arm marginalised managers of forest resources with a basic understanding of key international legal instruments that relate to forests. It introduces the reader to the main purpose of each instrument. Tables within the annexes then show to which specific sections of legislation an appeal might be made if any one of these broad ethical principles is contravened. The guide therefore serves to identify how marginalised people might appeal to the agreed texts of international law in their fight for social and environmental justice. Coverage within this guide is deliberately broad – it deals with hard and soft law currently available in the three fields of environmental, human rights and economic law. It makes no attempt to be exhaustive, but rather highlights the most important and broadly adopted legal instruments.

Feja Lesniewska, 2005
IIED, 39 pp.
Available for free online:
www.iied.org/pubs/pdf/full/13505IIED.pdf
International Institute for Environment and Development (IIED),
3 Endsleigh Street, London
WC1H 0DD, UK
Email: info@iied.org
Internet: www.iied.org

Internet Resources:

The United Nations Forum on Forests was established in 2000 with the main objective to promote "… the management, conservation and sustainable development of all types of forests and to strengthen long-term political commitment to this end…" Internet: www.un.org/esa/forests/

The Collaborative Partnership on Forests (CPF) is a partnership of 14 major forest-related international organizations, institutions and convention secretariats. It was established in April 2001, with the objectives to support the work of the United Nations Forum on Forests (UNFF) and member countries and enhance cooperation and coordination on forest issues for the promotion of sustainable management of all types of forests. Internet: www.fao.org/forestry/site/cpf

The International Tropical Timber Organization (ITTO) is an intergovernmental organization promoting the conservation and sustainable management, use and trade of tropical forest resources. Its 59 members represent about 80% of the world's tropical forests and 90% of the global tropical timber trade. Internet: www.itto.or.jp

The World Agroforestry Centre (ICRAF) has invigorated the ancient practice of growing trees on farms, using innovative science for development to transform lives and landscapes. Their research focuses on four global themes: Land and people, Environmental services, Strengthening institutions and Trees & Markets. Internet: http://www.worldagroforestrycentre.org

The Center for International Forestry Research (CIFOR) is a leading international forestry research organization established in response to global concerns about the social, environmental, and economic consequences of forest loss and degradation. CIFOR is one of 15 research centers within the Consultative Group on International Agricultural Research (CGIAR). Internet: www.cifor.cgiar.org

International Union of Forest Research Organisations (IUFRO) promotes global cooperation in forest-related research and enhances the understanding of the ecological, economic and social aspects of forests and trees. It disseminates scientific knowledge to stakeholders and decision-makers and contributes to forest policy and on-the-ground forest management. Internet: www.iufro.org

The IUCN Forest Conservation Programme (FCP) is a global thematic programme of the IUCN Secretariat and supports the forest-related activities of the Union, including its Members and Commissions. Internet: www.iucn.org/themes/fcp/index.htm

Forest Peoples Programme (FPP), an international NGO, supports forest peoples to secure and sustainably manage their forests, lands and livelihoods. Internet: www.forestpeoples.org

WWF 's The Forests for Life Programme consists of a global network of more than 250 staff working on over 300 projects in nearly 90 countries. Internet: www.panda.org

Non-wood News An information bulletin on non-wood forest products is compiled by the Forest Products Service of the FAO Forest Products and Industries Division. Internet: www.fao.org/forestry/nwfp/non-wood.htm

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Name of responsible person	
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*Contents of the Botanic Garden Management Resource Pack: *The Darwin Technical Manual for Botanic Gardens, A CITES Manual for Botanic Gardens, A Handbook for Botanic Gardens on the Reintroduction of Plants to the Wild, BGjournal - an international journal for botanic gardens (2 past issues), Roots - environmental education review (2 past issues), The International Agenda for Botanic Gardens in Conservation, Global Strategy for Plant Conservation, Environmental Education in Botanic Gardens, BG-Recorder (a computer software package for plant records).*

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This publication is supported by the
Rufford Maurice Laing Foundation

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Printed on 100% recycled paper

ISSN 1811-8712

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