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Table of contents

Cover photo: *Araucaria columnaris, in situ* conservation stand, Lifou island, New Caledonia. (P. Sigaud).

Editors of this issue in the
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NOTE FROM THE EDITORS

The present issue of *Forest Genetic Resources* aims to present recent developments in the conservation, sustainable use and management of forest tree genetic diversity, from national, regional or global perspectives. Several articles describe techniques and methodologies used for the characterization, protection, conservation and management of important forest tree species and their genetic diversity, in Albania, Argentina, Chile, Cuba, Hawaii, Indonesia and West Africa. Other contributions address tree breeding and improvement and domestication issues, including preliminary testing of neem provenances in Ethiopia, and a concept paper of a founder project to mark the domestication baseline for forest trees. An article discusses the issues faced at the field level during the implementation of an interdisciplinary and participatory genetic conservation project, through case studies in Argentina and Brazil.

This issue of *Forest Genetic Resources* also explores a number of emerging issues closely associated with the forest genetic resources field. Special emphasis is given to *Biosecurity*, which describes the concept, objective and process of managing biological risks. An article discusses its relevance to the forestry sector. Biological risks, which were traditionally associated with forest health and phytosanitary concerns, also encompass risks associated with the introduction of new tree species and genotypes. Recent concerns over the spread of introduced trees species outside their cultivated areas have the potential to influence the movement and use of tree germplasm, and highlight the importance of carefully testing and monitoring introduced tree species. A summary is provided of a regional evaluation of woody invasive species in four countries and territories of the Western Indian Ocean.

The importance of regional initiatives in fostering collaboration between national institutions of participating countries on priority forest tree species work is documented in Central Africa, Central America and Europe, and an article outlines the outcomes and challenges of the European Forest Genetic Resources programme (REFORGEN).

Over the past months, the forest genetic resources site, at the FAO Forestry Department homepage, has been substantially revised and updated (http://www.fao.org/forestry/fgr). The whole series of *Forest Genetic Resources* in English, French and Spanish (No 1 to No 30) has been digitalized and posted online.

All suggestions, comments and remarks from our readers are welcome. Please write to:

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BIOSECURITY AND FORESTS: AN INTRODUCTION

by
M.J.W. Cock[1] , M. Kenis and R. Wittenberg

INTRODUCTION

'Biosecurity' in food and agriculture describes the concept, objective and process of managing biological risks associated with food and agriculture (in its broadest sense, i.e. including forestry). Biosecurity is emerging as one of the most important issues facing the international community. There is a growing trend by countries to establish national biosecurity systems, either to meet obligations under international agreements (for example, in the environmental sector) or to take advantage of opportunities (for example, in the trade sector). Such systems are traditionally based on sectoral areas, although a number of countries have started to establish cross-sectoral, integrated frameworks.

In the forestry sector, biosecurity encompasses three main fields of activity: forest protection and phytosanitary issues; naturalization of introduced forestry trees and their impact on ecosystems or individual species; and the release of new genotypes, including genetically improved tree varieties.

A global literature review, complemented by in-depth regional and national analyses, shows that the forestry sector is not always aware of the issue. There is a need to raise awareness of the actors involved, and to strengthen a biosecurity perspective when introducing, testing and managing exotic forest resources. This paper presents a summary of the main findings and recommendations of the global review undertaken by the authors for FAO.

PHYTOSANITARY ISSUES

'Pests' are defined by FAO as any species, strain or biotype of plant, animal or pathogenic agent injurious to plants or plant products, i.e. insects, mites, molluscs, nematodes, diseases and weeds. Indigenous pests may be chronic or occur in outbreaks, whereas introduced pests usually occur in an initial outbreak followed by continuous chronic damage. Both types of pest can cause severe losses in forestry, making them important factors to take into account.

Tropical and subtropical plantation forestry has often focused on a small number of fast-growing, pioneer species, normally planted as pure stands. Monocultures, especially of genetically similar trees, are associated with an increased probability of pest outbreaks and can also transform sporadic pests into permanent problems. Mixed planting of native (and exotic) trees is therefore increasingly preferred as a strategy for avoiding pest problems. Pest risks associated with a particular tree/location combination should be evaluated prior to planting and the results confirmed with test plots.

There is a growing trend towards adopting more sustainable management strategies for forest pests, particularly in developed countries. These changes are related to changes in the perception of the role of the forest, which is increasingly valued not just for economic reasons, but also for its ecological and social functions. Large monocultures are disappearing from many European and North American landscapes and are being replaced by smaller, mixed stands, which reduce pest risks as mentioned above.

Analysing and evaluating pest risk requires reliable information. As might be expected, more information is available on pests of trees grown in developed rather than in developing countries, and also for pests of trees grown in plantations rather than for pests in natural forests. Virtually nothing is known of the pests associated with those trees harvested from natural forests and not grown in plantations, at least in the tropics.

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At operational level, in a majority of countries, quarantine and pest management services are generally under ministries in charge of agriculture, and their overall knowledge on pests specific to the forestry sector is often limited.

ALIEN INVASIVE SPECIES

Alien species can be particularly damaging during plantation establishment, but can also have important impacts on natural forest biological diversity, especially in the tropics. An increasing number of accidental introductions can be expected as a result of the growing internationalization of trade, the increased movement of people and the resultant overstretching of quarantine services.

Little attention has been given so far to the phenomenon of invasiveness by woody forest species at global level. Just like other living organisms, some forest and agroforestry trees have the potential to become invasive when grown as exotics, particularly in the tropics, but it is difficult to predict which alien species are likely to cause serious damage if introduced. Species that are innocuous or minor pests in their area of origin can be devastating when introduced elsewhere. At present, the best guide to potential invasiveness is those species that have already caused problems when introduced into another part of the world. Thus, access to reliable information is critically important for assessing this risk. Studies are needed to determine why introduced trees become naturalized or invasive, and protocols for assessing the risks of introductions must be developed and validated. Pilot planting schemes should include monitoring for any indications of invasiveness. Safer options for introductions (e.g. sterile trees) may also be useful.

The longer an alien species remains undetected after its introduction, the less chance there is for successful intervention: there are fewer options for its eradication, containment or control, and the costs of intervention rise. Often the key to a successful and cost-effective solution is eradication, but this requires both early detection and a rapid response. Once eradication is no longer feasible, the options for control of an alien species include biological control by the introduction of exotic natural enemies from the pest's area of origin. However, this approach should always be based on an appropriate risk assessment and risk–benefit analysis, following international protocols.

Invasive tree species tend to be multisectoral in their impact, and thus need to be addressed with a multisectoral approach. In some cases invasive trees provide useful products or services and, when eradication is not possible, management options should be identified in order to balance the positive and negative aspects. A paper by Haysom and Murphy in this issue of *Forest Genetic Resources* highlights the global issues associated with exotic invasive forest trees.

NEW GENOTYPES

The introduction of new tree genotypes could potentially have adverse impacts, e.g. through the displacement of indigenous taxa or genotypes, or the transfer of genes to local tree populations with the possible development of novel ecological characteristics. However, as yet, there are few documented records of such impacts in the forestry sector. Introductions of other species associated with forestry, including biological control organisms, pollinators, mycorrhizae, etc., should be considered with caution and on a case-by-case basis.

The development of genetic modification has created new challenges in risk assessment. Although the first generation of GM products was not particularly relevant to forestry, there are numerous ways in which the technology could be used in forestry, and research in the field is extremely active. There seems to be considerable potential for improving forest trees by developing new genotypes with useful biological traits. However, assessing risks in long-term crops such as forest trees is difficult, and uptake of GM technology is likely to be slow unless national and international protocols that reliably assess the risks are developed, tested, and agreed upon.

MANAGING BIOSECURITY ISSUES

Forestry activities can contribute to the introduction of alien species in several ways, including the movement of forest reproductive materials and germplasm, solid wood packaging materials, trade in unprocessed timber, and contaminants of forest produce. The forestry sector needs to work with other relevant sectors to prioritize the risks associated with these various activities and to find ways of addressing them.

In establishing the objectives of a biosecurity programme, it is critically important to consider the full range of stakeholders and their various interests in order to identify areas where cooperation is necessary and where synergies and efficiencies may be sought. In doing so, the whole regulatory cycle and the full range of players must be considered. Several groups may need to contribute to the definition of objectives and to the assessment of risks. Raising awareness, training and capacity building should therefore be important components of any biosecurity programme.

CONCLUSION

While several international and national programmes target the issue of alien invasive species, especially in forest and fragile ecosystems, there are relatively few data on the phenomenon of introduced forest trees turned naturalized or invasive. The issue is all the more important since the global movement of forest reproductive material, either through intentional or unintentional ways, is likely to increase in the future. The following paper by Haysom and Murphy is the first global attempt to fill the information gap.

Managing potential pathways for the introduction of alien species is often more efficient than trying to prevent the introduction of individual species.

There is an urgent need for more research on tropical forestry pests, both to develop management methods and for developing pest risk assessments.

ACKNOWLEDGEMENTS

The authors thank all persons who helped to prepare some of the case studies included in the full report (Cock, 2003). The study was carried out in March 2003 and was financially supported by the FAO-Netherlands Partnership Programme on Agro-Biodiversity.

LITERATURE

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THE STATUS OF INVASIVENESS OF FOREST TREE SPECIES OUTSIDE THEIR NATURAL HABITAT: A GLOBAL REVIEW AND DISCUSSION PAPER

by
K.A. Haysom and S.T. Murphy [1]

INTRODUCTION

This paper summarizes the results of a global review of the status of the invasiveness of forest tree species outside their natural habitat. The review covers trees and woody shrubs commonly used in commercial forestry and agroforestry. Information for the review has been collated from published databases and papers, unpublished reports and personal communications.

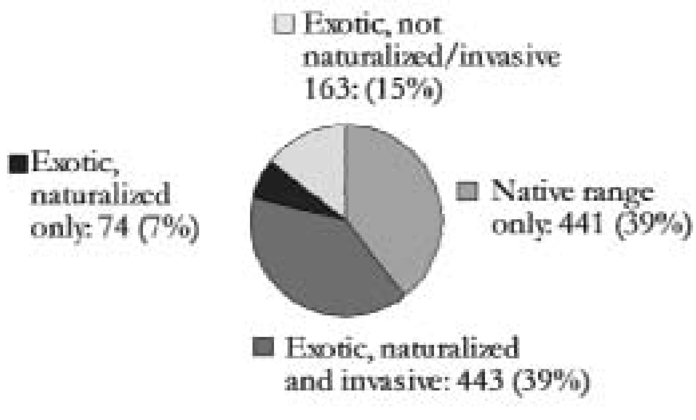
A number of definitions of "invasive species" have been suggested in the literature, some specifically for invasive plants or woody plants. It is recommended here that, in the context of forestry, a common definition be developed that focuses on parameters of population expansion only, because in some common definitions of invasive species impacts are preconceived to be negative.

On a global basis, available information on the status of forestry trees that have become invasive is patchy. The terminology used by authors is also very variable and there is frequent overlap in the terms "invasive" and "naturalized". The evaluation of the extent of invasions by forest trees is most often very qualitative and subjective which makes overall assessments of the magnitude of the problem difficult.

STATUS OF INVASIVENESS OF EXOTIC TREES SPECIES IN FORESTRY

With these caveats in mind, the following summarizes the global situation:
The number of species of trees or woody shrubs that were classed as invasive, including some listed by Binggeli (1996) as possible or potential invaders (based on literature where the extent of invasion was limited or unknown), was 443. A further 74 were reported as naturalized. Some 282 species used in forestry were among those listed as invasive, and a further 40 were reported as naturalized but not invasive. The majority of the species encountered in the review were used for more than one purpose (i.e. the same species may be used in forestry, agroforestry and/or for amenity plantings). Hence, among those species identified as invasive, 203 species were listed as being used in agroforestry and 292 in amenity plantings.

Figure 1. A summary of the distribution of the 1121 trees in the dataset according to geographical distribution and invasion behavior.



Fifty-eight families included at least one invasive forest tree species, and 34 families contained more than one invasive species. The latter represents half the total number of families with members used for forestry that are known to be grown outside their native range. Thirteen families contained no invasive forestry tree species. There were examples of both angiosperm and gymnosperm invasive species. In decreasing order, the majority of invasive forestry trees occurred in the families Leguminosae, Pinaceae, Myrtaceae, Rosaceae and Salicaceae.

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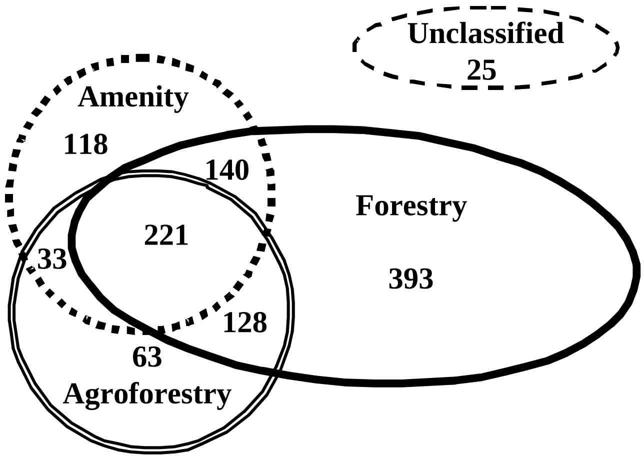
Invasive species were reported in all seven geographic regions (Europe, Africa, Australasia, North America, South America, Pacific, and Asia). Most invasive trees were reported from Africa (87 species) and fewest from Europe (12) and Asia (14). However, the majority of species were invasive in only one of the seven regions, and even among the most "invasive" species the number of countries where they were reported as invasive was generally much smaller than the number of countries where they had been introduced. Most invasive species had a native range that included Asia, and the fewest a range that included the Pacific.

During the examination of these data it was notable that most accounts gave little information on the use of the trees, details of their management (forestry, agroforestry, amenity, etc.), the history of their introduction or on the scale of planting and of invasion (land area). This lack of information limited discussion to the number of invasive species encountered in different situations and restricted interpretation. Geographically, it was notable that most invasive species were reported from countries and regions where investment in cataloguing or researching the number and impact of species had been high, e.g. South Africa, Puerto Rico and North America. There were distinct gaps in knowledge of the occurrence of invasive species in some other areas, namely Africa (outside South Africa, Zimbabwe, Botswana and the oceanic islands), Asia and parts of South America. It is therefore highly likely that the list of species known to behave invasively would expand, given further work in such locations.

Figure 2. The uses of the 1121 tree species included in the literature review



Numbers in the diagram refer to the number of species ascribed to each category. The uses of 25 species could not be determined

EFFECT OF INVASIVE FOREST TREES

Few studies have been conducted on the positive and negative aspects of the impacts of invasive forest trees. Positive impacts include providing timber, wood, fuel and other resources for resource-poor communities. The trees may also contribute to soil stabilization in over-exploited natural forest areas such as in India. Although hybridization between introduced species can potentially produce new invasive species, only a few instances have been reported in forestry: that of *Leucaena* and *Prosopis* hybrids and these are only locally important. Invasive forest trees have been reported as major problems in grassland pastures throughout the world, but there are fewer instances where trees invade other agricultural systems or forest plantations. Most reports of invasiveness relate to natural or semi-natural habitats, e.g. riparian and wetland systems. One of the most quantitative studies conducted on the impact of invasive trees in a natural habitat was undertaken in the fynbos biome in South Africa. Here trees cause substantial losses in local biodiversity and prevent natural run-off of water from catchment zones. This is reported to affect South Africa's water supply, especially in the dry seasons.

PREVENTION, CONTROL AND MANAGEMENT: A BIOSECURITY PERSPECTIVE

Over time there has been a growing national and international awareness of the possible risks of invasiveness of forestry trees, but it is likely that some stakeholders in plantation forestry remain ignorant of the risks. Awareness has been highest in environmental sectors but some of the risks have been highlighted by those in agricultural sectors. This has led to conflicts of interest in some parts of the world that are partly fuelled by the general lack of quantitative information on the ecological and economic impacts of invasive forestry trees. A compounding factor is the lack of information and tools (methodologies, etc.) to make such assessments. In the light of the above, it is recommended that a number of case studies be conducted in collaboration with countries that have a high dependence on planted forests.

Such case studies should cover a range of plantation forestry situations (commercial, development, environmental) and include the development and promotion of tools for ecological and economic assessments. Particular attention should be paid to those regions of the world where little information exists concerning the invasiveness of exotic forestry trees (e.g. tropical and temperate Asia).

Many biological attributes (e.g. life history, taxonomic status, genetic constitution) are poor indicators of invasiveness if considered alone. However, some of these characteristics (in combination with other factors such as the extent of invasiveness expressed) are being used in risk assessments (see below). For those species that have already been recorded as highly invasive in at least one area, it would be of more practical significance to examine whether or not some form of control or management by local communities contributes to non-invasiveness in other areas.

Globally, the development and implementation of prevention, control and management tools for invasive forestry trees has been cautious and patchy because of the basic economic and developmental benefits of the trees concerned. Some countries, sometimes in collaboration with international partners, have made large investments in exotic trees and are therefore reluctant, given the general lack of quantitative information on the negative impacts, to take action against those species that have become invasive. An additional constraint that prevents many countries from implementing risk assessments, control and management schemes, is the general lack of both the necessary tools and relevant information concerning their use.

Work on prevention has included the development of risk assessment and risk management models. There are a number of discussions and suggested schemes in the scientific literature, some of which cover environmental aspects. All of these schemes are aimed at exotic plant introductions in general rather than forestry trees *per se*. Overall, the development of risk assessments poses some problems – such as factoring in the time lags that can occur before a tree becomes invasive as well as the problem of unpredictable hybridization with other tree species.

Practical risk assessments, based on information such as whether the plant is invasive elsewhere and various biological attributes, are now in use in Australia, New Zealand and the USA. A few other countries/territories have schemes under development. The most common assessment method to date is based on assigning numerical scores to various attributes. There is an urgent need for such risk assessments to be further evaluated for use in forestry and for them to be more widely promoted if they are considered appropriate.

Some research groups are developing alternative approaches to risk management, including the production of seedless clones of pines and near sterile hybrids of *Leucaena* species; however, propagation methods still need to be developed for the latter.

Risk assessment and management of alien plants (i.e. introduced plants that are not yet invasive) has also been considered in some cases. New Zealand, for example, already has a qualitative system in place. Many researchers in this field have called for monitoring schemes to be set up once a plant has been introduced. For forestry trees this would entail planting trials that would have to be monitored for many years. Practical guidelines on monitoring aimed at forestry programmes are not readily available and this is an area where further work is required.

In some countries large-scale eradication programmes employing mechanical and chemical methods have been undertaken against woody legumes, such as *Prosopis,* that are invasive in pastoral systems. However, these methods are costly and it has generally not been possible to eradicate the trees concerned. In some cases, therefore, methods are now focused on control and use rather than eradication. Nevertheless, eradication methods (with sponsorship from the government) are being used effectively in South Africa to clear water catchment zones. Eradication methods have also been successful in clearing alien forest trees in areas of conservation value in Mauritius and Florida. Biological control and integrated control (biological with mechanical and chemical methods) have been used for the control of woody legumes in Australia, Southeast Asia and South Africa. These programmes are still largely ongoing and experience suggests that a complex of complementary natural enemies will be required to effect full control.

Some efforts are now being made to resolve conflicts of interest by developing management schemes rather than control programmes for invasive trees. In South Africa, on the basis of economic models, seed-feeding bruchids have been introduced to control the seed output of several leguminous trees that have become invasive (e.g. *Acacia mearnsii*) and these efforts are reported as being successful. These programmes are now supported by new legislation that restricts the planting of trees that have invasive tendencies. At more of a research level, work on pasturelands in other countries has shown that, under some management regimes, invasive woody legumes can complement pasture grasses for livestock feed. All these experiences can serve as models for other countries trying to resolve problems associated with invasive forestry trees.

CONCLUSION

Trees have now been identified as one of the most significant groups of invasive plants by a variety of authors (e.g. Richardson 1998). However, even though there are several well-documented cases of invasions by exotic forestry trees, these cases form only a small proportion of all the records in the literature. It should also be emphasized that not all of the effects recorded for invasive trees are detrimental: some human communities derive significant benefits from the invasive character of some species. A case-by-case approach, associating all actors and concerned stakeholders, is necessary to review the positive and negative impacts of invasive forest trees, and provide elements for balanced decisions in the matter. The forestry sector should be at the forefront of these investigations, and work closely with other sectors, including the environment and agriculture.

ACKNOWLEDGEMENTS

The authors wish to thank all contributors to the global review, whose inputs are duly acknowledged in the full report (Haysom and Murphy, 2003). The study was carried out in March 2003 and was financially supported by the FAO-Netherlands Partnership Programme on Agro-Biodiversity.

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CONSERVATION-THROUGH-USE OF FOREST GENETIC RESOURCES IN LATIN AMERICA: CASE STUDIES FROM LOCAL COMMUNITIES OF BRAZIL AND ARGENTINA

by
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THE ISSUE

Tropical forests provide a wide range of products as well as socio-economic benefits and ecological services that contribute to livelihood and particularly to the subsistence of people living in or nearby the forests. However, forest resources in the tropics are declining at an alarming rate (FAO, 2001). The underlying causes are complex and diverse. Some major transformations are associated with land-use changes caused by population growth, changing/growing market demands (Whitmore, 1998), poor and conflicting development policies, unequal land distribution, and land speculation practices (Reydon, 2000; Johnson and Cabarle, 1993; Anderson, 1989a; Fearnside, 1989). In general, local communities who depend directly on forest resources will be the first ones to be affected by such changes. On the other hand, they are often partially responsible for forest degradation and deforestation. Therefore, for the development of alternative forest management practices or conservation strategies, it is vital to understand the factors that influence management and land-use decisions of local communities. Equally important is to know how management practices or conservation strategies will in return affect local communities.

This article discusses some of the main challenges and problems faced during the implementation of an interdisciplinary and participatory research project. The initiative interests different socio-economic contexts, four different ecosystems, and involves a large number of stakeholders and research partners.

CONCEPTUAL FRAMEWORK OF THE PROJECT

The development of management systems that are environmentally, socially and financially sustainable is crucial for the conservation of forest genetic resources, but it is also fundamental to guarantee the local communities a sustainable additional income (FAO, 2000). A better understanding of key factors determining the long-term conservation of forest genetic resources is vital and requires an interdisciplinary approach, integrating ecological, genetic and socio-economic information (IPGRI, 1997; Namkoong, 1997; Bawa, 1997; Gandara *et al.*, 1997). Ecological and genetic research helps to define the limits beyond which forest management interventions will jeopardize the environmental and socio-economic benefits over time.

Very often information on the status of forest genetic resources and the factors having an influence on them is not available or only partially, the development of conservation-through-use guidelines and strategies requires substantial research input, which is expensive and time consuming.

The project “Conservation, management and sustainable use of forest genetic resources with reference to Brazil and Argentina”, supported and coordinated by IPGRI, and funded by BMZ (Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung, Germany), aims at developing appropriate management strategies or guidelines for conservation of key forest genetic resources, through an improved understanding of human impact on the genetic diversity and ecological processes in four selected ecosystems.

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Resource management and use are analyzed across sites to extrapolate guidelines for conservation-through-use, applicable to a range of different environmental and socio-economic circumstances. The result is achieved in collaboration with local communities, local research institutes and other local governmental and non-governmental organizations. The project addresses a set of priority species with contrasting life history and reproductive strategies (Table 1), selected by all stakeholders based on their economic or potential economic importance for livelihoods, and for local and regional markets.

Table 1. Priority species within the project "Conservation, management and sustainable use of forest genetic resources with reference to Brazil and Argentina"

Scientific name	Common name	Study region	Forest type
Araucaria araucana	Pehuen	Neuquén, Argentine	Araucaria forest ecosystem
Hevea brasiliensis	Seringueira	Acre, Brazil	Amazon tropical rainforest
Euterpe precatoria	Açaí	Acre, Brazil	Amazon tropical rainforest
Bertholetia excelsa	Castanheira	Acre, Brazil	Amazon tropical rainforest
Carapa guianensis	Andiroba	Breves, Acre, Brazil	Amazon tropical rainforest
Euterpe oleracea	Açaí	Breves, Brazil	Amazon tropical rainforest
Araucaria angustifolia	Pinheiro do Paraná	Paraná, Brazil & Missiones, Argentina	Araucaria forest ecosystems
Copaifera langsdorffii	Copaiba	São Paulo, Brazil	Atlantic Forest
Hymenaeae courbaril	Jatobá	São Paulo, Brazil	Atlantic Forest
Cedrela fissilis	Cedro	São Paulo, Brazil	Atlantic Forest
Peltophorum dubium	Canafistula	São Paulo, Brazil	Atlantic Forest

Why working with local communities, and with which communities?

A close look at local communities, within the research process, leads to the formulation of guidelines for conservation-through-use which reflect the complex and wide range of existing relationships between people and forest resources. Furthermore, an effective implementation of the elaborated strategies depends greatly on the degree of empowerment of local communities, their involvement in process of formulation of these strategies and their empowerment.

In Brazil and Argentina there are many local communities that depend, to a different degree, on forest resources in their environment (Table 2). In some areas, principally in the Amazon, there are still indigenous populations with a traditional, pre-colonial life pattern. They have an intimate knowledge of natural resources (Begossi *et al.*, 1999) and their use of the forest in general is non-destructive, although they do alter its structure and composition (Whitmore, 1998). However, in most contemporary communities a shift can be observed from a subsistence economy towards a more market oriented economy (Anderson, 1989b; Whitmore, 1998).

Table 2. Different local communities, landscape types and main threats on forest resources within the various regions involved in the BMZ project

Study region	Stakeholders	Landscape type	Threats
Neuquén, Argentine	Indigenous communities	Woodlots of Araucaria forest and pasture land	Ecosystem fragmentation Over-grazing Over-harvesting of Araucaria seeds
Acre, Brazil	Rubber tapers and rural settlers	Large continuous extension of rainforest	Logging, clearcutting Expansion of agricultural frontier and immigration Over-exploitation of forest products
Breves, Acre, Brazil	Riverbank communities	Tropical forest, riparian vegetation	Over-exploitation of forest products
Paraná, Brazil & Missiones, Argentina	Farmers	Mosaic of woodlots of Araucaria and other forest species, alternated with crops and pasture	Over-exploitation of Araucaria timber Market forces leading to low income from forest products and ultimately to land-use change Immigration Counterproductive legislation regulating the use of forest resources
São Paulo, Brazil	Landless people	Forest fragments of various size, mostly small, surrounded by cropland	High depletion of diversity due to fragmentation Lack of local awareness on the importance of conservation

Changes in the daily life of indigenous communities are promoted by globalization and global and local trends towards economic liberalization (McNeely and Vorhies, 2000). Increasing demands for forest products brings immediate benefits but undermine the sustainability of the exploitation.

Another type of community is made by recent rural settlers, formerly landless people re-settled by the government, or who have occupied private lands or colonized public lands (Leite, 2000). New settlements have been established in areas still largely covered by forest, where they have started agriculture (Romeiro and Reydon, 2000) or extractive reserves (Leite, 2000). Other settlements have been established in areas with no forest or with only few remaining forest fragments, left by the former owners (ITESP, 2000; Carvalho *et al.*, 2000). These recently settled communities derive most of their income from forest resources, especially in the first year (Carvalho *et al.*, 2000, Santos, pers. comm.), but they lack a deep knowledge of their environment (Begossi, 1998).

COMMUNITIES ASSOCIATED WITH THE PROJECT

The project activities in the Amazon are located in Acre, addressing two main groups of stakeholders, the rubbertappers and rural settlers. The area is representative of traditional systems applied for the extraction of latex (seringal) and a new agricultural settlement, recently established under the guidance of INCRA (Brazilian National Institute for Agrarian Reform). The research study offers the possibility to investigate the specific relations of both communities with their natural environment as well as their mutual relationship.

Rubbertappers and rural settlers in the Amazon rainforest

Traditionally, rubbertappers (seringueiros) have been in the area since the beginning of the latex exploitation, without formal land-use rights or ownership. Their communities are rather small their use of forest resources is in balance with resource availability, producing a low impact as opposed to the more recent settlers. The need to integrate traditional practices with additional sources of income has led in some areas to a shift towards agriculture and small livestock raising. In Caquetá however, rubber and other forest products sold on the market (Brazil nut, *Bertholletia excelsa*, and Açai, *Euterpe precatoria*) are the main resource. These valuable NTFP (non-timber forest products) could provide an economically viable alternative (e.g., Açai) (Rocha, 2002), however, transport and casing costs are relatively high and more information on the ecology of the species is necessary to elaborate management plans. Use of alternative forest products has been encouraged and supported by the state governmental institute SEFE (Executive Secretariat for Forests and Extractivism), responsible for the commercialization of forest products.

Recently, INCRA planned to established a settlement in the study area. Rubbertappers made pressure to maintain control of their land, and INCRA finally defined the area as an Extractive Settlement Project (ESP). ESPs are "project modalities destined to the exploitation of rich areas, through activities economically viable and ecologically sustainable, to be carried out by the populations occupying or coming to occupy the mentioned areas". Land can only be used for extraction of forest products with exception of a small lot that can be used for agriculture. The official establishment of an extractive reserve introduces restrictions in land use, but guarantees exclusive use and ownership rights to the rubbertappers. A management plan was defined by a community council and subsequently approved by the authorities.

The project is addressing two rural settlements created by INCRA, established at different times. The land allocated to each family is about 40 hectares, used partially for agriculture (mainly cassava and other crops in the first years). Timber is taken from the forest to build houses and other small constructions (fences, tools storage etc.). An additional lot of 40 hectare per family has been set aside as a continuous reserve, but the area partly overlaps with the Caquetá ESP. The CNS (National Council for the Defense of Rubber Tapers) claimed the area, while INCRA strongly supported the implementation of the Agrarian Reform programme, leaving the conflict unresolved, and determining negative repercussion on the use of the main forest products.

Representatives of the local communities participating in a project workshop in 2002 indicated their interest in implementing more sustainable practices. However, lacks of information on their rights of use of the legal reserves as well lack of capacity (financial and technical) seemed to be major obstacles.

Landless people and the fragmented remnants of the Mata Atlantica in Pontal

One of the project sites involves two rural settlements, established in different periods in Pontal, within the state of São Paulo, on land occupied by forest at the time of establishment. The original vegetation of this region is classified as "Mata Atlântica do Interior or Planalto" (seasonal semi-deciduous forest). Forest fragmentation started 50 years ago, determining a deforestation of more than 98 percent of the area. The region is therefore predominantly covered by pasture (71 percent) and to a lesser degree by sugar cane fields (ITESP, 1998a) and property is split among few large estates. Within the framework of the agrarian reform, approximately 60 000 families of former landless farmers have been settled in about 60 settlements. Newly settled farmers do not traditionally use forest products; however, the pressure on the remaining forest fragments is considerable during the first years of settlement, as forest resources often offer the first and only source of income and material for construction (ITESP, 1998b), fencing and cooking (Kageyama *et al*, 2000). Some people hunt within the forested fragments bordering with the settlements, and illegally exploit forest products, but the real impact is difficult to estimate.

Forest fragments are legally protected, and only sustainable practices are allowed (ITESP, 1998b). A major problem is the lack of awareness about the importance of conserving the forest and lack of knowledge about alternative management systems that can generate additional income for the settlers. Some species, such as *Copaífera langsdorffii*, appear to be manageable in a sustainable way. *C. langsdorffii* provides oil (Carvalho, 1994) used in the cosmetic industry and raw material for various other purposes (Lorenzi, 1992; Feirreira and Braz, 2001).

Another alternative land-use system suggested is the establishment of agroforestry systems that would connect natural forest fragments (stepping-stones or green corridors). Upon request of the local communities, the project has supported the implementation of demonstration plots, with forest tree species and medicinal plants mixed in agroforestry systems.

Communities in the *Araucaria angustifolia* forests of Parana

In southern Brazil and northern Argentina, the *Araucaria angustifolia* forests used to cover extensive areas. They played an important economic role, first for the erva mate (erva tea, *Ilex paraguariensis*) production and later for exploitation of *Araucaria angustifolia* wood. In the decades after the First World War most araucaria forests were cut down and their economic importance strongly diminished (Seitz, 2000). Nowadays, the contribution of forestry activities to the overall economy of the state is limited. According to the 1993 census, all forest activities together counted for about 3.4 percent of the total revenues of agricultural production. Only 0.7 percent came from wood and non-wood products (including charcoal) from native forests. Furthermore, only 1.75 percent of the agricultural labor force was active in forestry related jobs (IBGE, 1993).

Today, less than one percent of the araucaria forest ecosystems has remained intact (Sanquetta and Tetto, 1999; PROBIO, 2001), and can be found in the central south and southeast of the state (Yu, 1980; Higa, 2001). Census data from 1993 (IBGE, 1993) show that the extraction of wood and non-wood forest products in some regions where communitarian systems have been functioning, the forest cover spared is significantly higher than in other regions.

The small and medium sized landowners in this region used to work with an agroforestry system called "Faxinal". This typically includes a forest area or campos (natural grasslands), which is used for livestock and collection of forest products (Campos, 1998; Bittencourt, 2001b). In the last decade the number of faxinals decreased dramatically. The overexploitation of the araucaria tree led to a reduction in the availability of forest product and a related decrease in income, also due to the fall in the price of some secondary products derived from the forest (erva mate) (Bittencourt, 2001a). This in turn has triggered a process of conversion of land to agriculture in areas that are not suitable for highly productive crops. More recently, the pressure of immigration from other states has made livestock raising increasingly unsustainable.

An official registration of the existing faxinal system started recently. The registration introduces limitations in use but brings more security and stability to the community structure. Parallel activities that support the production of alternative products are taking place. However, although making progress in the marketing of its products, the increase in production and extraction raises the question whether this model is ecological sustainable (Bittencourt, 2001b).

Exploitation of *Araucaria angustifolia* is now illegal, but the legislation seems unsatisfactory, almost counterproductive. Due to this ban, planting is less attractive for small and medium sized farmers, who will be increasingly limited in their land use if covered with a protected species. Some promising income sources are the utilization of medicinal plants and tourism, but the commercialization of these products and the access to the market seem to be the main obstacles.

Mapuche communities in the *Araucaria araucana* forests of Argentina

In South-west Argentine, in the Andean mountains, *Araucaria araucana* forests form an important source of income for the local indigenous inhabitants, the Mapuches. There are about 30 communities in the Neuquén Province (Gallo, 2000b). The project works with two communities, Aucapán and Chiuquilihuin. They represent communities with relatively intensive use and medium intensive use of the forests respectively (20-30 percent of land forested in Aucapán, 50-60 percent in Chiuquilihuin).

The indigenous Mapuches used to depend on *A. araucana* (piñon) seeds for their basic diet, and piñons are still an important resource for the communities. No reliable numbers exists, but a study in Chili indicated that piñon could provide on average 13 percent of the alimentation (Ceballos in Gallo, 2000a). Seeds and derived products are sold on the markets of nearby towns or changed for other products. Quantities harvested for both consumption and sale vary with the annual variation in seed production, and accessibility of the area. In higher areas with more closed forests the collection is conducted in conjunction with the collection of fuel wood and grazing (Gallo, 2000a).

The harvest of seeds and other products is regulated through the legislation of Lanin National Park and the Neuquén Province Government. The cutting of the Araucaria is prohibited since 1991. The Mapuches are only allowed to use dead wood for fuel or for carving, and to collect up to 300 kg of seeds per family for consumption or commercial purposes. Regulations for non-local inhabitants are stricter (Gallo, 2000b). Other products collected from the forest are fuel wood, summer and winter forage, medicinal plants, and wild animals. The main source of income is livestock raising. Tourism is playing an increasing role. The intensity of use of their lands differ between Mapuche communities, mainly depending on the areas they have access to (Gallo, 2000c). However, both communities face an increasing degradation of their natural resources. The main problem is the lack of regeneration of *A. araucana*. Causes are overgrazing, trampling of natural regeneration and in some areas over-collection of the seeds. *A. araucana* is not only economically, but also culturally highly valuable, therefore it has to be preserved as part of the landscape (Gallo, 2000c).

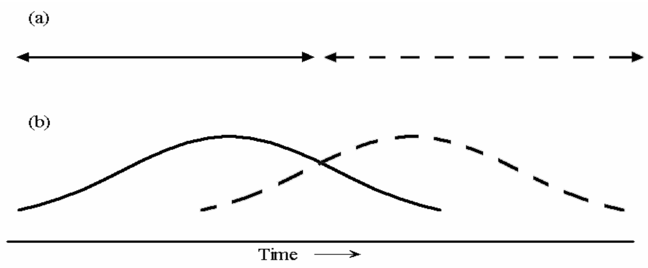
Two strategies have been suggested to achieve a more sustainable use of *A. araucana*. One is a more flexible system for determining maximal seed harvest levels per family. Seed production fluctuates strongly in time and space (Gallo, 2000a), and maximum harvest should be defined according to the quota and to the overall production of a specific year. Another strategy is based on regulating the access to grazing land, temporally fencing some areas to allow regeneration and restoration to take place. Local communities have shown interest, but initial costs (fencing, establishment of nurseries, capacity building) are high and cannot be easily borne by the community. Furthermore, earlier experiments with fencing of individual properties created social conflicts between communities (Gallo, 2000b).

Working with communities: striking the balance between research and development

There is a wide consensus that sustainable development should be based on local-level solutions derived from community initiatives (Leach *et al.*, 1997). This is seen as contributing to the empowerment of local communities and offering greater potential to meet local needs, while more effectively managing natural resources (Poffenberger, 1990; Murphee, 1993; Pretty and Shah, 1994; Chambers, 1997; Brosius, Tsing and Zerner, 1998; in: Cramb *et al*, 2000). Based on these ideas many international development agencies, non-governmental organizations (NGOs), and national governments have adopted participatory or community-based development approaches. This has also been one of the guiding principles of this project, whose objective was to produce base-line data to support a following phase (Figure 1) of elaboration of sustainable management alternatives to forest resources use, by managers and policy makers.

The participation of representatives of local communities in the planning phase proved to be crucial for the identification of priorities and the on-going re-adjustment of project work plans.

Figure 1. The black and dotted line represent research and development activities respectively. In (a) research activities are planned and carried out independently of development-oriented activities that implement and possibly test the research results. In (b) development and research activities are planned within one project and implementation of both types of activities is partly overlapping in time.



CONCLUSIONS

Some difficulties have been faced during the implementation of the project and these seem to be typically associated with most research projects oriented towards the elaboration of development strategies. A major challenge for a research project is the translation of research outputs into guidelines. Problems arise while extrapolating general guidelines from small, although representative, case studies, to apply them to larger geographical contexts. Baseline information is often missing and large efforts and costs have to be faced for their collection. Pressing needs and demands from local communities can be very difficult to conciliate with long-term conservation goals. Initial costs of adopting new management practices are high and revenues are uncertain and are often generated only in the mid- to long-term.

The formulation of sound guidelines for natural resource management could take a long time and the positive impact on the livelihood of local people could become significant only later. Ecological and economical required knowledge is not always available, and considerable research efforts are required. Sometimes the use of under-utilized alternative resources is limited by lack of access to the market and lack of extension activities, but local solutions are in most cases not sufficient to reach long-term conservation targets, and political interventions at higher level are required.

Furthermore, the environmental and social contexts are changing fast (population growth, immigration) and other highly variable factors can come into play (e.g., market changes), putting additional pressure on the sustainable use of forest resources in areas were traditional use systems are still in place. Some communities are politically strong but not knowledgeable enough to manage the natural resources made available to them, due to their lack of traditional acquaintance with certain management practices and species.

The BMZ project outcomes once again highlight the need to allow local people fully participate in the process of strategies and guidelines formulation, from the early stages of research studies. The present project has shown that, thanks to this involvement, additional benefits can be generated. Satellite initiatives stimulated by the original project and requested by local people could take off, better addressing local needs and having a greater positive impact on the livelihood of local people.

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CONSERVATION STRATEGY OF ENDANGERED FOREST PLANT GENETIC RESOURCES IN CUBA

by
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INTRODUCTION

The Republic of Cuba stretches over 110 860 km² of which 24,5 percent are forested, and home to 900 tree species, including 600 indigenous species. (Hechavarría, 1997). A number of native tree species are endangered and require urgent and active protection and restoration measures. This work aims at illustrating the conservation strategy for endangered species carried out by the Cuban Forest Research Institute.

TOOLS AND METHODS

The endangered species conservation strategy developed by the Forest Research Institute is based on, and carried out according to, the Cuban Ministry of Agriculture's Plan of Action, and supported by the 1999 Forestry Law (State Forestry Service, 1999).

The strategy details a number of technical steps, including:

- species prospection,
- phenologic studies,
- seed and / or fruit collection,
- raising seedlings in the laboratory and the nursery, and
- enrichment plantation.

Species prospection

On the basis of herbarium samples, target species are described, their natural distribution studied and verified in the field, and botanical samples taken and checked against collection samples.

Table 1. Summary of characteristics for 20 species studied.

Scientific name	Formation type	Endemic	State
Acacia daemon Ekm.et Urb.	Serpentine	X	A
Acacia rogii Leon.	Dry forest	X	A
Antirhea radiata (Griseb) Urb.	Tropical semideciduous moist forest		C
*Callycophylun candidisimun (*Vahl) DC.	Semideciduous		C
Cocotrinax borhidiana Muñiz	"Cuabales"	X	Ex
Garcinia aristata (Borhidi)	Semideciduous	X	A
Haematoxylum campechianum L.	Semideciduous in lowlands		C
Harpalyce macrocarpa Britt Will	"Charrascales"		C
Hidelgrardia cubensis (Urb.) Kostermans	Semideciduous	X	C
Juglans jamaicensis ssp jamaicensis C.DC	Semideciduous		C
Junniperus lucayana Britt	Coastal dry forest		A
Laurocerasus occidentalis L.	Dry Semideciduous		C
Licaria jamaicensis (Ness) Kostermans	Tropical moist forest		C
Magnolia cubensis Urb.*ssp acunae* Imch.	Tropical moist forest	X	A
Manilkara jaimiqui (Wr. Ex Griseb) Dubard *ssp wrightiana*	Semideciduous		C
Ochroma pyramidalis (Cab.) Urb.	Tropical moist forest, riverine	n.a.	n.a.
*Swartzia cubensis (*Britt et Wils.) Standl	Tropical moist forest	X	C
Terminalia eriostachya A. Rich	Semideciduous	X	C
*Trinax ekmaniana (*Burret)Borhidi et Muñiz	"Mogotes" (hills)	X	Ex
Ziziphus havanensis Kunth *var havanensis*	Coastal dry forests	X	A

[1] Forest Research Institute, Siboney, Ciudad Habana, Cuba

A: endangered; C: possible candidate; Ex: threatened of extinction

Phenologic studies

These studies are carried out to characterize target species in their natural distribution area and identify their phenologic phases and variations, and in particular their fructification behavior. These records allow the timely collection of reproductive material. Phenologic observations follow the methodology used by Hechavarría (1998).

Seed and / or fruit collection

Based on phenologic studies, physiologically mature fruits are collected, assessed and described in the laboratory. The description includes such criteria as external shape, fruit color, dimensions, internal and external patterns, number of seed per kg and seed health. Moisture content is assessed in fruits and seeds, and germination trials in different conditions are undertaken. (Alvarez *et al.*, 1991).

Raising seedlings in the laboratory and the nursery

The obtention of seedlings depends to a large extent on the effectiveness of the pre-germination treatments, confirmed by the results of statistical analysis. Once the most appropriate propagation method for each species has been identified, seedlings obtained in the laboratory are installed in the nursery, where their growth and development is monitored (height, number of first leaves and botanical description).

Enrichment planting

Gene pool enrichment aims at reestablishing the species in its respective environment and natural distribution area. An area is cleared and soil prepared in 1m circumference circles where 4 plants are installed, with a density of 625 circles per hectares, the objective being to plant 2 500 plants per hectares. The young plants are assessed at six months, and two years after plantation, and survival rates and height measured.

RESULTS

As a result of the prospection work, 50 tree species were identified *in situ* in 90 stands distributed in the western central and eastern regions of the country and in approximately eight different ecosystems, of which seven are endemic to Cuba. Once a species was recognized and verified, each sample tree was labeled, and its diameter at BH and total height were measured. Administrative and environmental factors were also recorded, such as the location of the area (municipality and province), coordinates, altitude asl, slope, topography, soil type, forest type, and climatic classification of the area.

The results of the phenological studies are shown in Table 2. Most species were propagated by seed.

Table 2. Results of phenologic studies.

Scientific name	Flowering period	Fructification period	Harvest
Acacia daemon Ekm.et Urb.	April	May	May
Acacia rogii Leon.	March-April	May	June
Antirhea radiata (Griseb) Urb.	July-September	August-September	October
*Callycophylun candidisimun (*Vahl) DC.	November-February	January-April	April-May
Cocotrinax borhidiana Muñiz	February-March	April-June	June
Garcinia aristata (Borhidi)	January-February	February-March	April
Haematoxylum campechianum L.	February-March	April	May
Harpalyce macrocarpa Britt Will	February-March	March- April	April
Hidelgrardia cubensis (Urb.) Kostermans	May-July	September-October	October
Juglans jamaicensis ssp jamaicensis C.DC	September-November	January-April	April
Junniperus lucayana Britt	July-September	October-Februrary	March-April
Laurocerasus occidentalis L.	May	July-December	Dec-January
Licaria jamaicensis (Ness) Kostermans	n.a.	n.a.	n.a.
Magnolia cubensis Urb.*ssp acunae* Imch.	February-March	March-June	June
Manilkara jaimiqui (Wr. Ex Griseb) Dubard *ssp wrightiana*	February	March-May	June
Ochroma pyramidalis (Cab.) Urb.	February-March	April-June	July
*Swartzia cubensis (*Britt et Wils.) Standl	April	March-September	September
Terminalia eriostachya A. Rich	March-June	July-November	November
Trinax ekmaniana (Burret)Borhidi et Muñiz	March- April	May-September	September
Ziziphus havanensis Kunth *var havanensis*	December-January	January-March	April

CONCLUSIONS

The *in situ* conservation technique carried out through enrichment and reintroduction of species was successful for most target species. Besides *in situ* restoration, some trees were also planted in botanical gardens, parks and other institutions with the objective of maintaining and extending the gene pool of their species, through *ex situ* conservation.

The conservation strategy carried out by the Cuban Forest Research Institute permitted the conservation of more than 40 endangered forest tree species, and improved seed and propagation techniques for 17 of them. These achievements will contribute to the recovery of valuable forest ecosystems and the reduction of genetic erosion.

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Extension manuals on forest seed and other reproductive materials

In 2002 and 2003, the FAO Forestry Department, in collaboration with the Danida Forest Seed Centre (DFSC), Denmark, commissioned a review of existing training and outreach information resources on forest seed collection, handling and use. A list of materials was drawn up and a number of extension manuals on forest trees and shrubs and crop trees were digitalized. The first electronic version of the review has been posted on line at the DSFC's internet site under the title: "*Training and Extension Resources on Tree Seed*". The site summarizes existing training and extension resources related to forest reproductive material. Its aim is to facilitate access to extension resources on tree seed and related topics, and make it easier for extension workers to produce new, appropriate resources customized to their needs.

The site can be accessed at: http://www.dfsc.dk/Extensionstudy/index.html.

All suggestions to improve it are welcome.

A FOUNDER PROJECT: MARKING THE DOMESTICATION BASELINE FOR FOREST TREES [1]

by
C.G. Williams[2], F.E. Bridgwater[3] and C.D. Nelson[4]

INTRODUCTION

One of the most apparent benefits of forest genomics programmes is to provide genotypic information on the original selections of tree improvement programmes worldwide. In many breeding programmes, branches from these selections were grafted onto seedlings and the grafted seedlings composed the first seed orchards for planting programmes. With advanced generation orchards or new vegetative propagation technology, these original orchards have become genetic archives. These archives conserve the original selections or founders of domesticated forests thus providing an opportunity for genotyping the entire population of founders. The window of opportunity, known as a Founder Project, is narrowing for obtaining DNA samples from founders because archives are being lost to pests, pathogens, extreme weather events, climate change, constricting budgets and increasing demands for arable land.

MEASURING THE GENETIC CONSEQUENCES OF FOREST DOMESTICATION

The foremost reason for genotyping founders as part of a Founder Project is to provide a baseline for tracking genetic consequences of forest domestication. Genotypic information on the founders provides a baseline against which later generations or various breeding strategies can be tested for loss or increase in genetic diversity. Early generations of recurrent genetic improvement are expected to maintain high levels of genetic diversity, since population-level improvement conserves allelic diversity as a means of ensuring long-term adaptation (Williams *et al*., 1994; McKeand and Bridgwater, 1998; White *et al.*, 1993). In more intensive breeding programmes, genotyping founders allows for an estimate of the loss of genetic diversity that can occur the tradeoff between enhanced genetic gains and decreased genetic diversity. In those programmes that emphasize gene stewardship rather than maximum genetic gain, genotyping founders provides a baseline for monitoring effects of large shifts in breeding or production population size as a result of climate change, reduction in population sizes, use of vegetative propagules or selective seed collection.

IDENTIFYING DIAGNOSTIC ALLELES FOR TRACING GERMPLASM ORIGIN FOR EXOTIC SPECIES

Another application for a Founder Project is to determine the original provenance(s) of an exotic species or landrace. Again, a founder genotype database provides a baseline or a foundation for comparison. There are numerous exotic forest tree species for which provenance introductions are not known. In this situation, founders for the species within its indigenous range are first genotyped for hypervariable molecular markers. A search for diagnostic alleles at common frequencies is conducted and declared successful if a common allele appears in one provenance but not in another. These diagnostic allele patterns are determined in the indigenous range and then compared with the exotic populations in question. An example for *Pinus taeda* L. introductions in Zimbabwe is shown in Box 1.

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Box 1. The provenance origin of *Pinus taeda* in Zimbabwe

Pinus taeda comprises historically large, interconnecting populations, which extend along the United States Atlantic seaboard from Maryland to Florida and westward to central Texas. The Mississippi River Valley roughly delineates the eastern and the western parts of the species' range. A small founder genotyping dataset was developed with 36 nuclear microsatellite markers and 171 founders collected from grafted archives of natural stand selections made from 1950 to 1970 (Al-Rababah and Williams, 2002). These *P. taeda* founders represent the species in its natural range prior to intensive plantation establishment and domestication in the later 20th century. Similarly, a small set of Zimbabwe selections were assayed for the same microsatellites then compared with the founder dataset.

The first step is to find alleles that distinguish one provenance from another within the natural range of the species. Diagnostic or unique alleles within stands or subpopulations are often frequent with molecular markers than have large numbers (>10) of alleles per locus. Diagnostic alleles must occur in frequencies above 5 percent. Less frequent marker alleles may also be absent in one population and present in another population, but this is more likely due to sampling so these alleles are not treated as diagnostic.

The second step is to check for these diagnostic alleles in the exotic population in question. The provenance origin of *P. taeda* in Zimbabwe has been an open question for decades. By comparing eastern and western *P. taeda* sources, four marker alleles appear diagnostic (Table 1). The larger founder sample size in Table 1 shows that Zimbabwe population is an admixture of eastern and western sources although the diagnostic alleles reported in an earlier study (Williams *et al.*, 2000) changed with the fourfold increase in founder population size.

Table 1. *Pinus taeda* in Zimbabwe is still an admixture based on the larger survey (N =171) across the indigenous species' range.

Locus	**Allele**	**Zimbabwe**	**Western**		**Eastern**	
			BA	**WG**	**SC-FL**	**NE**
PtTX2037	9	0.042	0	0	0.071	0.017
PtTX2128	2	0.167	0	0	0.065	0.018
PtTX2146	9	0.136	0	0	0.068	0.034
PtTX2164*	10	0.136	0	0	0.091	0.204
PtTX3011	3	0.042	0	0	0.068	0
PtTX3030	1	0.111	0.125	0.024	0	0
PtTX3030	14	0.278	0	0	0.143	0.089
PtTX3037	4	0.042	0	0	0	0.086
PtTX3037	14	0.125	0	0	0.024	0.069
PtTX3037	27	0.083	0	0.014	0	0

The asterisk (*) represents the one diagnostic allele common to the smaller and larger sample sizes. Western regions are Bastrop County (BA) and Western Gulf (WG). Eastern regions are South Carolina to Florida (SC-FL) and Northeast (NE).

A shared founder genotyping database for *P. taeda* provides a resource where other investigators can compare founder genotypic data against their own exotic populations. Others can determine provenances for other countries planting *P. taeda* as an exotic plantation species. Sharing a founder genotype database at the international level reduces the amount of time and lab resources committed to redundant genotyping.

OTHER APPLICATIONS FOR A FOUNDER PROJECT

In those breeding programmes which have extensive advanced generation breeding, a Founder Project is useful for finding the right pedigrees for linkage map construction and for tracing haplotypes between populations and generations. If two molecular markers prove to be closely linked, then they delineate a segment of chromosome, defined as a haplotype. Each diploid individual has two haplotypes, one contributed by its maternal parent and one contributed by its paternal parent (Figure 1).

A Founder Project would provide a useful database for locating one or more copies of a particular haplotype to trace among a founder's descendants. The principal value to tracing haplotyping occurs if there are pedigrees for each founder in question. Tracing particular haplotypes in related pedigrees is quite relevant to tree breeders or ecologists if a given haplotype has been shown to be correlated with major phenotypic changes, adverse or beneficial (Gwaze *et al.*, 2003).

If the haplotype spans a chromosomal interval that includes one or more genes influencing the phenotypic trait in question then this type of haplotype is known as a quantitative trait loci or QTL (see review in Williams, 1998). Starting with the haplotype information already available in the founder genotype database saves precious time and lab resources otherwise spent searching for a pedigree suited to an important experimental question. Applications for a Founder Projects also extend to teaching, professional and practical training in breeding, conservation and ecological genetics of forest trees.

Figure 1. An example of tracing haplotypes from four unrelated founders through a three-generation pedigree.

Founder 1	Founder 2	Founder 3	Founder 4
$\frac{A_7 - B_2}{A_6 - B_2}$	$\frac{A_4 - B_2}{A_{14} - B_2}$	$\frac{A_{12} - B_2}{A_4 - B_5}$	$\frac{A_4 - B_5}{A_6 - B_1}$

Parent 12	Parent 34
$\frac{A_7 - B_2}{A_{14} - B_2}$	$\frac{A_{12} - B_5}{A_6 - B_1}$

Offspring

1	2	3	4	5	6	7	8
$\frac{A_{14} - B_2}{A_{12} - B_1}$	$\frac{A_{14} - B_2}{A_{12} - B_5}$	$\frac{A_7 - B_2}{A_6 - B_1}$	$\frac{A_{14} - B_2}{A_6 - B_5}$	$\frac{A_7 - B_2}{A_{12} - B_1}$	$\frac{A_7 - B_2}{A_{12} - B_5}$	$\frac{A_7 - B_2}{A_6 - B_1}$	$\frac{A_{14} - B_2}{A_6 - B_1}$

Note that each founder has two unique haplotypes or chromosomal segments. With recombination or crossing-over, each founder can contribute one of four haplotypes to the next generation. In this example, Founder 3 contributes a recombinant haplotype (A_{12}-B_5) and Founder 4 contributes a parental haplotype (A_6-B_1) to Parent 34.

GENOME COVERAGE AND CHOICE OF MOLECULAR MARKERS FOR A FOUNDER PROJECT

There is no ideal molecular marker for a Founder Project so the best strategy is to include several types of markers as funding permits: this might include microsatellites, isozymes, and polymorphic gene sequences. Including mitochondrial or chloroplast markers is quite vital for parental identification, for phylogeography studies and for measuring gene flow and population differentiation. The best marker systems for a Founder Project have the following properties:

- the marker's polymorphism corresponds to a known change in its DNA sequence,
- marker assays are low-cost,
- for nuclear markers, it is important that a marker score discern between homozygotes and heterozygotes.

This property is important because heterozygosity is the basis for measuring genetic diversity changes during domestication. This becomes especially important for highly heterozygous species that typically have multiple allele systems (see Box 2, Figure 2). Dominant marker systems such as RAPDs or AFLPs have no prominent role in founder genotype databases because neither heterozygosity nor multiple alleles can be discerned.

Box 2. An example of Founder Project showing a nuclear microsatellite.

Polymorphism levels of nuclear microsatellites tend to be very high for focal species (Echt *et al.*, 1996). The high number of alleles per locus offers a method of measuring allelic diversity with increased resolution. Marker PtTX4114 shows a nuclear microsatellite for *Pinus taeda* which has a multiple-allele intercross configuration (Figure 2).

The mating type configuration is multiple-allele intercross with four alleles. This means that there are four different heterozygote classes for the full-sib progeny. Ladder (M) shows two molecular bands sizes 120 and 105 bp, respectively. Lanes 1 to 4 show genotypes for four unrelated grandparents and Lanes 5 to 6 show genotypes for two unrelated parents descended from grandparents. Lanes 7, 8, 9 and 14 show the four different types of heterozygotes that occur with the mating of the original highly heterozygous founders (or grandparents in this pedigree).

Figure 2. Microsatellite marker PtTX4114 is shown for a founder genotype and its descendants for *Pinus taeda.*

M: molecular weight marker.

Marker PtTX4114 shows different alleles segregating among four different founders. In this advanced-generation programme, the founders were mated pairwise and their respective offspring, shown as parents (Figure 1) produced offspring. The four alleles in the founders and the parents were transmitted to the offspring. The four offspring heterozygotes can be seen by observing the offspring genotypes in lanes 7, 8, 9 and 14.

PUBLIC CURATORSHIP OF A FOUNDER PROJECT

Curatorship of a Founder Project should extend from database management to storage of voucher specimens. Many founders are archived in remote, unprotected areas so a voucher specimen from each founder should be archived in a safe place as an insurance policy. Long-term storage of freeze-dried leaf tissue and seeds tends to be more stable than DNA in the event that a founder is lost in the field. Voucher specimens ensure future availability of founder DNA for assaying new types of marker systems not yet available for use today.

Database management should be standardized so that genotyping records are easily retrieved. With time and added resources, phenotypic data can be combined with a Founder Project's genotypic data. This might include original descriptions of the founder, its offspring's measurements and breeding values as well as records on pest and pathogen attack. The goal is to provide a streamlined record of genotypic and phenotypic descriptions that will outlast a human career. Continuity of a database with founder genotyping and record keeping can be priceless in the event of political upheaval, extreme weather events, or financial shortfall.

Genotypic data from the founder projects should be made available for public use through Internet access and government database storage. This is a political obstacle for so many programmes in private and public sectors alike. One must ask whether it is better to have no genotype database resources for an important species rather than share resources. It is important to consider that forestry research and education worldwide has had a tradition of modest funding to the extent that cooperation and sharing have been a necessity. Sharing a founder genotype database is consistent with a tradition of shared genetic resources.

A founder genotype project in the public domain serves as a unifying framework for tree breeding, genetics, genomics and molecular technology. It can be viewed a foundation for other applications of markers into breeding programmes (Williams and Byram, 2001). A founder genotype database will no doubt raise some important questions about intellectual property that will require careful consensus-building among different organizations contributing DNA samples from founders.

Agricultural conservation programmes should be studied closely as examples of framework and infrastructure for long-term database maintenance. For example, the United State Department of Agriculture has a Germplasm Resources Information Network (GRIN) database that can be accessed via the Web and it now includes forest trees (http://www.ars-grin.gov/). A Founder Project for *Pinus taeda* is now underway at the USDA Forest Service's Southern Forest Genetics Institute. The plan is to post its founder genotype database on the Web but the level of detailed information permitted by founder contributors will ultimately determine its value to the larger forest genetics community.

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WOODY INVASIVE SPECIES IN THE WESTERN INDIAN OCEAN: A REGIONAL ASSESSMENT

by
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INTRODUCTION

Within the framework of biosecurity and forestry (Cock, 2003), the FAO's Forestry Department has set up a programme to investigate the invasiveness of forest trees. A global review, which identified considerable knowledge gaps in understudied regions, is reported in this issue of *Forest Genetic Resources*. (Haysom and Murphy). This paper is a summary of a regional survey on woody invasive species in the Western Indian Ocean (Kueffer *et al*., 2003). The study comprised the small island states and territories of the Comoros Archipelago (Union of the Comoros and Mayotte), Mauritius and Rodrigues, La Réunion and Seychelles. The objectives were threefold:

- Compilation of knowledge on the biology and management of woody invasive species in the region;
- Development of a rapid assessment method;
- Initiation of a national and regional network of stakeholders and experts.

In this study an invasive species is defined as an exotic species, with a 'fast' spreading rate, and a negative environmental or economic impact. For each country, a written standardized questionnaire was developed and discussed with all concerned experts.

MAIN INVASIVE SPECIES, INVASIVENESS AND IMPACTS

Study area

Two of the studied island groups are equatorial (Seychelles, Mayotte and the Union of the Comoros), and two are subtropical (Mauritius and Rodrigues, and La Réunion). All except the granitic islands of the Seychelles are of volcanic origin. The land mass ranges from 438 km² (115 islands of Seychelles) to 2 512 km² (La Réunion). With the exception of the Comoros archipelago the studied areas are very isolated (>1 500 km from nearest mainland). Between c. 0-5 percent (Mauritius, Rodrigues, Seychelles) to c. 20-30 percent (the Union of the Comoros, La Réunion) of relatively undisturbed native vegetation remains.

While the Union of the Comoros still lives mainly on a subsistence agriculture economy, the others have transformed their economies during the last few decades into service-oriented economies with an important tourist industry. This transformation stopped deforestation and made nature protection a national priority.

The studied region is a priority area for international conservation because of its high endemism (WIO biodiversity hotspot, Global 200 Ecoregion, Centre of plant diversity (WWF, IUCN)). Introduction of invasive species that followed the colonial era can be broadly categorized into four phases (not applicable to the Comoros Archipelago):

- Phase 1: before 1760, first settlements. Limited impact, introduction of alien animals.
- Phase 2: 1760-1830, permanent settlements. Main introductions of alien plant species, destruction of lowland habitats.
- Phase 3: 1830-1960s, fast population and economic growth. Main habitat destruction.
- Phase 4: after 1960s, post-colonial phase. Mainly accidental introductions and propagation of exotic ornamentals.

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Main invasive species

The invasive species compiled in the report were categorized into three groups: main invasives[5], non-consensus species[6], and potentially new invasives. Only invasives species that are most problematic in at least one country of the region are compiled in Table 1.

Table 1. The woody invasive species that are very problematic in at least one country of the Western Indian Ocean region.

Species	Comoros Arch.	La Réunion	Mauritius	Seychelles	Tropics
Acacia mangium	**			(*)	
Acacia auriculiformis	**	(*)			3
Alstonia macrophylla				**	
Ardisia crenata		*	**	*	1
Casuarina equisetifolia	(*)	**	(*)	**	3
Cinnamomum verum	*	(*)	(*)	**	2
Clidemia hirta	**	**	*	*	3
Hiptage benghalensis		**	**		2
Lantana camara	**	**	**	*	3
Ligustrum robustum subsp. *walkeri*		**	**		3
Litsea glutinosa	**	*	(*)	(*)	3
Paraserianthes falcataria				**	2
Psidium cattleianum	**	**	**	**	3
Ravenala madagascariensis		(*)	**	(*)	3
Rubus alceifolius	(*)	**	**		3
Schinus terebinthifolius		*	**		3
Solanum mauritianum	(*)	**	(*)		3
Spathodea campanulata	**	(*)	(*)	(*)	2
Syzygium jambos	**	**	**	**	2
Ulex europeaus		**	(*)		3

(*): potentially invasive or non-consensus, *: main invasive, **: most problematic invasive. 1: potentially invasive; 2: moderately invasive; 3: highly invasive according to Binggeli *et al.* (1998).

Compared to data on woody invasive species in the tropics as a whole (Binggeli *et al.*, 1998), the invasive woody flora of the region has a higher proportion of large trees (41 percent vs. 21 percent), whereas shrubs are underrepresented (30 percent vs. c. 60 percent). In terms of taxonomy, the families of the Leguminoseae (21 percent vs. 15 percent) and Myrtaceae (9 percent vs 3 percent) are over-represented, and the families of the Rosaceae (1 species vs. 15 percent) and the Pinaceae (0 vs. 4 percent) are underrepresented among the most problematic invasive species in the region.

Habitat invasibility

A large proportion of invasive species preferentially invade disturbed, open, secondary habitats. These habitats are mostly of low biodiversity value. More problematic are species that invade habitats with a generally high resistance to invasions (low invasibility) (see Table 2).

Table 2. Habitat types that show a high resistance to invasions (low invasibility), and the few exotic species that are able to invade them.

Habitat types	Description	Invading Species
Inselbergs (Seychelles)	Rocky granitic outcrops with a very high endemism and an abundance of exotics below 10% (Fleischmann *et al.*, 1996)	*Alstonia macrophylla*, *Cinnamomum verum*
'Padzas' Bad Lands (Comoros)	Denuded dry areas with very poor soils modeled by large-scale erosion.	*Acacia mangium*
Volcanic Flows (La Réunion)	Early succession stages on young volcanic flows. One filter may be that they are mainly colonized by wind-dispersed species (Strasberg, 1995)	*Casuarina equisetifolia*
Undisturbed Mountain Forests (all islands, except Rodrigues)	Mountain forests harbor most undisturbed closed canopy forests left in the region. They are invaded by species with a high shade-tolerance	*Ardisia crenata, Cinnamomum verum, Clidemia hirta, Fuchsia* spp., *Ligustrum robustum, Psidium cattleianum and Syzygium jambos*
High Altitude Ericoid Vegetation (La Réunion & Comoros)	Shrub and heather vegetation above c. 2000 m asl.	***Ulex europaeus*****,** mainly invaded by herbs and generally after fire

[5]mentioned by most of the experts consulted and in the literature
[6]rated as invasive only by a sub-set of the experts consulted and literature

The habitat specificity of invasive species may help to predict potentially invasive species in other regions. In bold in Table 2 are species that could become a problem in similar habitats.

Impacts

The impacts were broadly classified into environmental impacts on natural systems, and economic impacts on anthropogenic systems.

Environmental Impacts

Environmental impacts were classified into three biological levels: genetic effects, impacts on biological interactions, and ecosystem effects. For several exotic species the potential to hybridize with a native species has been shown, but in no case actual hybridization in the wild has been found so far.

The major environmental impact by invasive species perceived at present in the region is the reduction of the native regeneration through competition by exotic species. This becomes most apparent with thicket-forming species such as *Chrysobalanus icaco*, *Clidemia hirta*, *Lantana camara*, *Psidium cattleianum*, *Ravenala madagascariensis*, *Rubus alceifolius*, or *Syzygium jambos*.

A mutualistic relationship between exotic fruits (notably *Psidium cattleianum*) and exotic animals has been proposed for La Réunion and Mauritius. In Mauritius the following hypothesis has been formulated: fruit production of *P. cattleianum* in the austral winter when native fruit availability is generally low maintains high densities of pigs and monkeys. These exotic animals will then be at high densities at the end of the fruiting season of *P. cattleianum* when the main breeding season for native birds and the fruiting season for native trees begins. Monkeys cause significant damage to both native birds and trees. Pigs in turn disturb forest trees and ferns and may cause considerable damage to ground-dwelling invertebrates (J. Mauremootoo, pers. comm., 2003).

However, most endemic bird species seem to prefer or need native vegetation.

Leguminosae (e.g. several *Acacia* spp., *Paraserianthes falcataria*) and *Casuarina equisetifolia* are N-fixing species that have an ecosystem effect on nutrient cycling.

In the Mascarenes, exotic species generally prove to be less adapted to cyclones. Their higher vulnerability changes forest dynamics and increases the frequency of gaps. Gaps are often gateways for exotic invasions, and may increase soil erosion on steep slopes.

Casuarina equisetifolia is supposed to interrupt early successions on volcanic flows (Macdonald *et al.*, 1991).

Economic Impacts

Concerns over agricultural woody weeds were mainly mentioned in the Union of the Comoros (e.g. *Clidemia hirta, Lantana camara, Litsea glutinosa, Psidium cattleianum). Acacia nilotica* is a weed on rangeland in Rodrigues. Other agricultural weeds in the Mascarenes are for instance *Acacia mearnsii, Hiptage benghalensis, Homalanthus populifolius*, *Leucaena leucocephala* or *Rubus alceifolius*. In Seychelles creepers such as *Thunbergia grandiflora* or *Merremia peltata* are particularly perceived as very problematic weeds. Invasive species that are also agricultural weeds are an opportunity for awareness building, mainstreaming, and application of the existing legislation.

Besides agricultural weeds no major impacts on humans were mentioned for the region.

MANAGEMENT PRIORITIES IN THE REGION

Prevention

Preventive measures attempt to stop introductions of new potentially invasive species to a country, or further transport within the country (containment). Instruments for prevention at hand are:

- awareness building, that is best developed in the Seychelles by medias, 'Wildlife Clubs' and the Ministry of Environment;
- legislation and border control mechanisms, that are well developed within the framework of plant protection under the respective Ministries of agriculture by the plant protection unit of La Réunion for example;
- screening system for the identification of potentially invasive species, that is currently tested in La Réunion (Le Bourgeois *et al*., 2003; Kueffer *et al*., 2003);
- early detection mechanisms that the forestry service of La Réunion has institutionalized a mechanism for the early detection of exotic species in the field (Brondeau and Hivert, 2003; Kueffer *et al*., 2003).

Mechanical and chemical control

For the past 25 years the forestry service has, in many countries, been the main agency involved in the chemical and mechanical control of invasive species, first in forest plantations, later for nature conservation purposes. However, these experiences are rarely adequately documented.

They are not yet protocols for the documentation of control efforts that allow the assessment of their efficiency and negative impacts, as well as of the applicability of the method in other countries and habitats. The forestry service of La Réunion (ONF-Réunion) compiled its past control efforts and developed a method for their assessment (Hivert, 2003; Brondeau and Hivert, 2003; Kueffer *et al*., 2003). The ongoing INVABIO research project in La Réunion attempts to assess the impacts of mechanical control methods (Lavergne *et al*., 2003). Priorities for targeted species and areas have been set and the computerized information system developed by Hiebert (1996, 2001) has been tested (Cazanove, 1999).

Biological control

In La Réunion, two large-scale biological control research projects on *Rubus alceifolius* and *Ligustrum robustum* subspec. *walkeri* are about to finish (Le Bourgeois *et al*., 2003). Mauritius has a long history of past biological control attempts (for a review consult Fowler *et al.*, 2000). Biological control programmes are expensive. Regional collaborations on species that are problematic in all countries, such as *Psidium cattleianum*, are advisable.

Habitat restoration

Continuous efforts of habitat restoration started about 15 years ago. Important aspects are the depletion of the exotic seed bank, the restoration of a native canopy, the reduction of the exotic propagule pressure (i.e. seed rain). Best practice is often a combination of mechanical, chemical control and ecosystem management (e.g. the currently investigated introduction of giant tortoises on Ile aux Aigrettes in Mauritius). Often past restoration projects are not well documented.

Comparative studies between restored and non-managed sites in Mauritius indicate that the impact on the native flora and fauna is ambiguous (mainly positive, but for some taxa neutral or even negative). Targets for habitat restoration should be more clearly defined and negative and positive effects on the native fauna and flora monitored. Habitat restoration so far has been done on isolated small offshore or mainland islands (0.5 to 30 ha).

Social and institutional framework

So far, no formal interagency network (national or regional), and no formal invasive species database (national or regional) exist. Recently, national invasive species committees have been set up in Mauritius and La Réunion.

In all countries except the Union of the Comoros, the forestry sector is at the moment reorienting from production forestry to nature conservation and invasive species control.

In eco-tourism nature reserves, money generated from entry fees is partly used for habitat restoration (e.g. Ile aux Aigrettes in Mauritius; planned national park project in La Réunion; Cousin, Aride, Vallée de Mai in the Seychelles; Moheli Marine national park in the Union of the Comoros).

In the Seychelles, several luxury hotels do habitat restoration and rare species conservation on their islands.

CONCLUSION

This compilation of the most problematic woody invasive species of the Western Indian Ocean, the first of its kind in the region, should be used with caution. It is based on the contingent valuation of a few experts. However, it shows an extensive overlap of problematic species between the islands of the region and relates conflicts of interest. The following main controversial species have been identified:

- *Psidium cattleianum* (Goyave de chine, Goyavier, Cherry Guava). The fruits of *P. cattleianum* are very appreciated in several countries (Mauritius, La Réunion, and the Union of the Comoros).
- Horticulture industry: many invasive species are ornamentals. New ornamentals are probably introduced every year. The importation of potentially invasive ornamentals is currently not regulated.
- Erosion control: exotic species used in the past for erosion control became invasive (e.g. Casuarina equisetifolia, Chrysobalanus icaco). Currently, in the Seychelles Acacia mangium, a highly invasive species in the Comoros Archipelago, is planted for erosion control.

• Multi-purpose species in the Union of the Comoros: 70-80 percent of the population is still working in the agricultural sector where many invasive species are used.

It would be interesting to test the methodology in other region or eco-region and monitor at global level the phenomenon of invasiveness.

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The complete study (a set of five *Forest Health and Biosecurity Working Papers* in English and one document in French) is available in hard copy and on the Internet:

- **Kueffer, C., Vos, P., Lavergne, C.** and **Mauremootoo, J.** 2004. *Case Studies on the Status of Invasive Woody Plant Species in the Western Indian Ocean. 1. Synthesis.* Forest Health and Biosecurity Working Papers FBS/4-1E. Forestry Department, Food and Agriculture Organization of the United Nations, Rome, Italy.
- **Vos, P.** 2004**.** C*ase Studies on the Status of invasive Woody Plant Species in the Western Indian Ocean: 2. The Comoros Archipelago (Union of the Comoros and Mayotte).* Forest Health & Biosecurity Working Papers FBS/4-2E. Forestry Department, Food and Agriculture Organization of the United Nations, Rome, Italy.
- **Kueffer, C.** and **Mauremootoo, J.** 2004. *Case Studies on the Status of invasive Woody Plant Species in the Western Indian Ocean. 3. Mauritius (Islands of Mauritius and Rodrigues).* Forest Health & Biosecurity Working Papers FBS/4-3E. Forestry Department, Food and Agriculture Organization of the United Nations, Rome, Italy.
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SEED RESEARCH NETWORK ON AFRICAN TREES FOR CONSERVATION AND SUSTAINABLE USE

by
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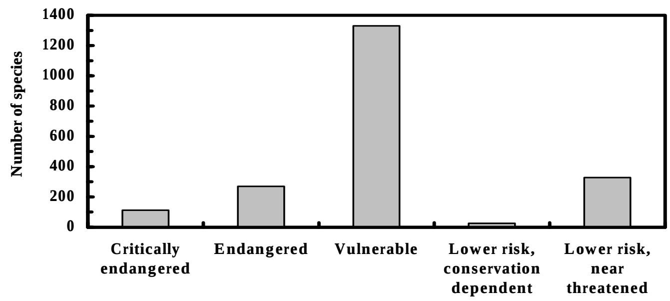
INTRODUCTION

Deforestation affects the daily life of millions of people. In sub-saharan Africa, forests are still disappearing at a rate of nearly one percent a year (FAO, 2003), despite the many reforestation and conservation programmes. Alarmingly, it is estimated that c. 2000 tropical tree species in this region are considered to fall into the categories of being 'near-threatened' to 'critically endangered,' as determined by IUCN (2002) and UNEP-WCMC (2001) (see Figure 1).

From a biodiversity perspective, this situation is partly exacerbated by the (over) use of only a handful of genera and families in most cultivated forests in sub-saharan Africa; for example, the *Fabaceae* (*Leguminosae*), *Meliaceae*, *Myrtaceae* and *Verbenaceae* (Schmidt, 2000; FAO, 2001). The attraction of these species groups has been fast growth and a relatively rapid economic return. But many of these species are exotic and the well-adapted natural resources have often been neglected. As a consequence, many species of local socio-economic importance are still under-utilized.

Clearly, efforts are needed to counteract species vulnerability as a result of the decline of their forest ecosystems. Raising trees and preserving their seeds are means of supporting reforestation, combating desertification, safeguarding the environment and conserving biodiversity. However, this is an enormous challenge that requires the planting of large numbers of adapted species. This also implies a need for careful selection of species for use and a great demand for quality seeds.

Figure 1. Estimated numbers of threatened tree species in sub-Saharan Africa by category of threat. The data were obtained from country reports from various sources (see IUCN, 2002, http://www.unep-wcmc.org/trees/Background/africa.htm)



REGIONAL INITIATIVES

Recognizing this short-coming, representatives of 18 countries, mostly from Western Africa (Table 1), gathered in Dakar in April 1997 to discuss the management and sustainability of tree seed programmes in the region (PRONASEF, 1997). The meeting proposed a regional approach for the sustainable management of forest genetic resources. The first technical workshop was held in Ouagadougou, Burkina Faso in 1998 and focused on the setting up of a regional collaborative programme on forest genetic resources for selected species (Ouedraogo and Boffa, 1999). Initially, the countries listed 302 highly important species with multiple uses. Ultimately, a species was selected if it was mentioned by at least 10 countries (Eyog Matig and Ouedraogo, 1999), to be included in the sub-Saharan Africa forest genetic resources (SAFORGEN) list for priority actions.

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A second regional group, of mainly the South African Development Community countries, supported by FAO, IPGRI, ICRAF and Danida Forest Seed Centre, met in Arusha, Tanzania in June 2000 for a sub-regional workshop on forest and tree genetic resources. Priority tree species and common issues amenable to regional co-operation on conservation activities were identified by nine countries (Table 1). Ten important native species to this region were acknowledged as a top priority for consideration by at least two of these countries (Sigaud and Luhanga, 2000).

Table 1. Countries that participated in SAFORGEN technical workshops in Burkina Faso and in Tanzania

Countries at the Ouagadougou workshop (1998)	Countries at the Arusha workshop (2000)
Benin, Burkina Faso, Cameroon, Cape Verde, Central African Republic, Chad, Congo, Côte d'Ivoire, Gabon, Guinea, Kenya, Madagascar, Mali, Mauritania, Niger, Senegal, Sudan, Togo	Botswana, Malawi, Mauritius, Mozambique, Namibia, Swaziland, Tanzania, Zambia, Zimbabwe

In consolidating these two regional programme lists, 59 species were identified for urgent attention for in and ex-situ conservation effort. In addition, three genera (Combretum, Entandrophragma and Terminalia) were also cited for attention (Ouédraogo and Boffa, 1999; Sigaud and Luhanga, 2000; Table 2). The species fall into four key groups, based on socio-economic and ecological criteria: (1) producing edible fruits, (2) forage species, (3) species mostly used as timber and for amenities, and (4) species used for crafts and other non-wood products.

In parallel to these discussions and developments, sub-Saharan African countries - in collaboration with various international and national agencies - got together (see IUFRO workshops in Kenya, 1992; Madagascar, 1994; Senegal, 1997; Burkina Faso, 1992; 2001) to emphasize the potential role that seeds could play in the preservation and regeneration of forest genetic resources.

COLLABORATIVE TREE SEED RESEARCH

More effective use of the seeds of these selected species is highly desirable, but is still hindered by a shortage of knowledge of their seed biology (development, storage and germination). During the last two decades, numerous symposia and workshops have been held on tropical forest seeds, and several proceedings of the International Union for Forest Resources Organizations (IUFRO) have been produced with special reference to tree seed problems (see Kamra and Ayling, 1987; Turnbull, 1990; Some and De Kam, 1993; Olesen, 1996; Marzalina *et al.*, 1999). Concurrently, technical books on tropical forest seeds have been produced (FAO, 1985; Albrecht, 1993; Tompsett and Kemp, 1996; IPGRI/DFSC project, 1996; Poulsen *et al.*, 1998; Schmidt, 2000). Nonetheless, there is still a relative dearth of information on tropical tree seeds, in general. For example, in a compendium of information on the seed storage behavior of c. 7 000 species published recently, only 0.2 percent of those listed are tropical tree seeds (Hong *et al.*, 1998). Although the seed biology of a small number of species (*Khaya anthotheca, Khaya senegalensis, Lannea microcarpa, Pentadesma butyracea, Sclerocarya birrea, Trichilia emetica, Vitellaria paradoxa, Warburgia salutaris* and *Ximenia americana*) on the SAFORGEN list has been investigated since 1996, as part of a project on "the handling and storage of recalcitrant and intermediate tropical forest tree seeds" [IPGRI/Danida Forest Seed Centre (DFSC), see Ouedraogo *et al.*, 1996, 1999], the majority remain under-researched.

Because most of the species have high levels of diversity and their areas of distribution cross national boundaries, co-operative actions have been agreed to avoid redundant effort and to promote complementarity. Indeed, national tree seed programmes (e.g. in Burkina Faso, Ethiopia, Kenya, Madagascar, Niger, Senegal, Sudan, Tanzania, Togo and Zimbabwe), which have been established in African countries in the last 20 years, attempt to do this (Eyog Matig and Ouedraogo, 1999). However, it is still the case that the institutes require technical and other support. For example, strengthening of research capacity in such institutes is a key to adequate, longer-term availability and provision of quality seeds. In addition, there is a need to exchange information more efficiently between partners in tree conservation and sustainable use programmes (Eyog Matig and Ouedraogo, 1999; Sigaud and Luhanga, 2000; Proceedings Ouagadougou Workshop, 2002, in press and pers. comm.).

Table 2. SAFORGEN priority list of forest tree species identified by > 10 countries as highest priority for management and conservation actions in 27 sub-Saharan countries. Species produce edible fruits (fruit) and African timber (timber). Some are important forage species (forage), and amenity and fuel-wood species (non-wood products). Species names authorities come from TROPICOS, from the Missouri Botanical Garden: http://www.mobot.org or IPNI (The International Plant Names Index): http://www.ipni.org/index.html.

Species	**Main uses**	**Species**	**Main uses**
Acacia nilotica (L.) Willd. ex Delile	Non-wood	*Grewia bicolor* Juss.	Forage
Acacia raddiana Savi.	Forage	*Irvingia gabonensis* (Aubr.) Baill.	Fruit; Non-wood
Acacia senegal (L.) Willd.	Forage; Non-wood	*Isoberlinia doka* Craib & Stapf	Timber
Adansonia digitata L.	Fruit; Forage; Timber; Non-wood	*Khaya anthotheca* (Welw.) C. DC.	Timber
Afzelia africana Sm.	Forage; Timber	*Khaya ivorensis* A. Chevalier	Timber
Afzelia quanzensis Welw.	Timber; Non-wood;	*Khaya senegalensis* (Desr.) A. Juss.	Forage; Timber
Aningeria altissima (A. Chev.) Aubrév. & Pellegr.	Timber	*Lannea microcarpa* Engl. & Kr.	Fruit
Anogeissus leiocarpus (DC.) G. & Perr.	Timber	*Lophira alata* Banks ex C. F. Gaertn.	Timber
Aucoumea klaineana Pierre	Timber	*Maerua crassifolia* Forsk.	Forage
Baikiaea plurijuga Harms	Fruit; Forage; Timber;	*Milicia excelsa* (Welw.) C.C. Berg	Timber
Balanites aegyptiaca (L.) Del.	Fruit; Forage;	*Nauclea latifolia* Blanco	Non-wood
Bauhinia rufescens Lam.	Forage;	*Parinari curatellifolia* Planch.	Non-wood
Borassus aethiopum Mart.	Fruit; Non-wood	Parkia biglobosa (Jacq.) R. Br. Ex G. Don	Fruit
Borassus flabellifer L.	Fruit	*Pausinystalia johimbe* (K. Schum.) Pierre ex Beille	Non-wood
Carapa procera DC.	Fruit	*Pentadesma butyracea* Sabine	Fruit
Cola nitida (Vent.) Sch. & Endl.	Fruit	*Prosopis africana* (G. & Perr.) Taub.	Forage
Colophospermum mopane (J. Kirk ex Benth.) J. Léonard	Timber; Non-wood	*Pterocarpus angolensis* DC.	Forage; Timber
Combretum aculeatum Vent.	Forage; Timber	*Pterocarpus erinaceus* Poir.	Forage; Timber
Combretum sp.	Timber	*Pterocarpus lucens* Lepr.	Forage
Commiphora africana (A. Rich.) Engl.	Forage	*Ricinodendron heudelotii* (Baill.) Pierre.	Fruit; Non-wood
Dacryodes edulis (G. Don) H. J. Lam.	Fruit	*Sclerocarya birrea* (A. Rich.) Hochst.	Fruit; Forage; Non-wood
Dalbergia melanoxylon Guill. & Perr.	Fruit; Timber	*Spondias mombin* L.	Fruit
Daniellia oliveri (R.) Hutch. & Dalz.	Timber	*Sterculia setigera* Del.	Non-wood
Detarium microcarpum G. & Perr.	Fruit; Timber	*Tamarindus indica* L.	Fruit
Diospyros mespiliformis Hochst. ex A. DC.	Fruit; Timber	*Terminalia* sp.	Timber
Entandrophragma sp.	Timber	*Trichilia emetica* Vahl.	Non-wood
Faidherbia albida (Del.) A. Chev.	Forage; Non-wood	*Triplochiton scleroxylon* K. Schum.	Timber
Garcinia afzelii Engl.	Non-wood	*Vitellaria paradoxa* Gaertn.	Fruit; Non-wood
Garcinia epunctata Stapf	Non-wood	*Warburgia salutaris* (Bertol. F.) Chiov.	Fruit; Non-wood
Garcinia kola Heckel.	Non-wood	*Ximenia americana* L.	Fruit
Gnetum africanum Welw.	Non-wood	*Zizyphus mauritiana* Lam.	Fruit; Non-wood

DARWIN INITIATIVE RESEARCH EXERCISE ON COMMUNITY TREE SEEDS (DIRECTS)

Action to specifically address some of the issues raised above is underway through a Darwin Initiative project (2003-2006) supported by the Department of Environment, Food and Rural Affairs (DEFRA, United Kingdom Government). The project aims to increase seed biology knowledge for all 59 species (from 22 families), and some additional species in three genera (Combretum, Entandraphragma and Terminalia), over a three year period. This will be achieved in collaboration with 40 scientists from institutes from about 15 African nations. Already two regional research workshops have been held in Burkina Faso (August 2003) and Ethiopia (September 2003) for scientists from nine (Benin, Burkina Faso, Cape Verde, Côte d'Ivoire, Ghana, Mali, Niger, Nigeria and Togo) and six (Botswana, Ethiopia, Kenya, Malawi, Tanzania and Uganda) countries, respectively. These workshops followed a United Kingdom planning meeting in the United Kingdom in July 2003 which was attended by 13 countries. Partners will establish a network web presence, will publish co-authored research papers and cascade their experience to others in their institutes. The group will present their findings at a final research workshop in Kenya early in 2006. The project will be supported at a technical level by both Millennium Seed Bank Project and IPGRI staff.

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GENETIC IMPROVEMENT OF HAWAII'S PREMIER HARDWOOD, *ACACIA KOA* [1]

by
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Koa (*Acacia koa* A.Gray) is an endemic leguminous tree of the Hawaiian Islands. It is one of the most prestigious timber species in Hawaii, best known for its exceptionally fine wood. The wood has excellent working properties, ranges widely in rich colors (yellow to deep purple), and often shows exceptional figures of grain. Koa is legendary and symbolic in Hawaiian culture. It was famous for building canoes and surfboards, and is now widely used for instruments, crafts, furniture, and utensils (Whitesell, 1990; Sun, 1996). Genetic improvement is deemed essential for expanded use in plantations of this highly variable tree (Brewbaker, 1996).

INTRODUCTION

Koa is one of 1 200 species in the large leguminous genus, *Acacia,* a member of the thornless, phyllodinous subgenus *Heterophyllum* (Guinet and Vassal, 1978; Whitesell, 1990). It was originally classified into three species and several varieties by different authors, but only the species *A. koa* is now recognized (Wagner *et al.*, 1990). Koa is a tetraploid, with a chromosome number of 2n=52 (Atchison, 1948; Carr, 1978; Shi, 2003). No variation in chromosome structure and number within the species has been found.

Koa is an important component of Hawaii's ecosystems. It is one of Hawaii's few endemic nitrogen-fixing species, and nurtures soils through its rhizobial root system and leaf littering. It is commonly associated with ohia (*Metrosideros polymorpha*). Koa forests have protected Hawaii's watersheds historically, and they are important habitats for many insects and birds (Whitesell, 1990). The tree once thrived on all Hawaiian Islands, but populations were reduced drastically by animal grazing, fire, land clearing, logging and insect pests. Between 1963 and 1978, stock volume of commercial koa dropped from 34.1 to 7.1 x 10^5 m^3 (Nelson and Wheeler, 1963; Metcalf *et al.*, 1978). Few "superior" trees can be found in wild koa forests today (Brewbaker *et al.*, 1991).

Koa forests presently occur on the major Hawaiian Islands - Kauai, Oahu, Molokai, Maui, Hawaii - at longitudes of 154° to 160° W and latitudes of 19° to 22° N. It grows on volcanic soils of all geologic ages and degrees of development (Whitesell, 1990), but appears to perform poorly on highly acid soils. Koa is concentrated at elevations between 600 to 1800 m, and thrives in a belt between 800 and 1600 m (Whitesell, 1990; Sun, 1996). Koa wilt is implicated in the failure to survive at lower elevations (Shi, 2003). Most koa is found in high rainfall areas receiving 1900 to 5100 mm rainfall annually, and does not thrive in drier areas.

Germplasm collection

Germplasm collections of koa were initiated by Brewbaker and his students at the University of Hawaii in the 1960s and have continued to the present time. Accessions were usually collected from single trees, occasionally as bulked seeds from several mother trees. Since 1990, the collection has been expanded by former UH (University of Hawaii) student Nicolas Dudley, forester for HARC (Hawaii Agriculture Research Center), whose collection is focused on low-elevation provenances.

The germplasm collection is summarized in Table 1. It currently comprises 547 accessions housed by the two institutions, including some advanced-seed accessions from outstanding trees or families in performance trials. All accessions have been germinated and transplanted into trials on the islands of Oahu and Hawaii as the basis for evaluations and genetic improvement.

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Table 1. *Koa* germplasm collection

Institution	Island	Number of families
UH	Oahu	29
	Kauai	132
	Hawaii	75
	Maui	18
	Advanced seeds	100
HARC	Most from Oahu and Kauai	75
Total		**547**

HARC (Hawaii Agriculture Research Center)
UH (University of Hawaii)

Genetic variation

Phenotypic variations are great among koa trees in natural populations, where the majority of trees are of poor form. However, these represent a complex of genetic and environmental influences. Large numbers of feral ruminant animals and pigs have damaged Hawaii's natural ecosystems over the past two centuries, and koa is a highly digestible legume. Many koa populations have been damaged by hurricanes and tropical storms, and others affected by soil acidity, waterlogging, plant competition and drought. Many traits vary widely in these natural populations (Daehler *et al*., 1999).

Clones occur in koa as a result of root-sprouting, however, and these often display genetic differences in tree form and morphology. Our replicated trials of seedlings derived from single mother trees provide the best evidence of genetic diversity. Genetic differences in these trials are evident in bole form, fluting and limbiness, growth rate (diameter and height), phyllode and pod shapes, seed size and arrangement, wood properties and resistance to koa wilt (Sun, 1996; Shi, 2003). Wood color and figure vary widely among individual koa trees, including the highly valued "fiddleback" figure. One variety, koaia, is not arboreal but shrubby, and reportedly has denser wood than other koas (Felling, pers. commun.).

Isozymic surveys of koa populations also revealed genetic variations in enzyme loci (Brewbaker, 1977; Conkle, 1996). Brewbaker noted variation among esterase and peroxidase loci intimating that outcrossing was the breeding system, while the six isozymic loci studied by Conkle had an average of three to seven alleles per locus. The calculated heterozygosity of these genes was 0.42, suggesting high genetic diversity. Self-pollinations by Sun (pers. commun.) also confirm that koa is largely or entirely outcrossed due to self-incompatibility.

Research on koa

Research on koa began in the nineteenth century, and focused on botany, ecology, forest management and reforestation (Whitesell, 1990). Later studies involved insect pests and diseases, phenotypic diversity and methods of propagation. With the erosion of koa resources, genetic improvement of koa became an issue of interest (Brewbaker, 1977; Brewbaker *et al*., 1991; Skolmen *et al*., 1991). Early koa plantations date back to 1910 on public and private lands. These were established from bulked, non-selected seeds from various sources (Skolmen *et al*., 1991). Very little genetic improvement of koa took place before the 1990s. An exception is the USDA Forest Service study that identified 52 "superior" trees with straight boles (Skolmen, 1977). A small progeny trial was planted at Keanaolu on the Island of Hawaii with seeds and clones derived from these trees (Skolmen *et al*., 1991). Genetic variations were not quantified, and no further selection took place (Sun, 1996).

Progeny trials

A genetic improvement programme for koa was started in 1990 based on seeds collected since the 1960s by Brewbaker and students. Since 1991, progeny trials have been planted annually at Hamakua (650 m elevation) on the Island of Hawaii. Trials usually consisted of about 50 families (half-sib seeds from single mother trees) in two replications of ten trees per rep planted at a spacing of 1 x 1.5 m. Four early trials were duplicated at Maunawili (160 m elevation) on the Island of Oahu, using the same experimental design, with more recent HARC trials in the region of Opaeula on Oahu. Two seed orchards at Hamakua have been established in recent years based on seeds of selected high-performing families. Plantings at Hamakua comprise 12 replicated yield trials (planted annually), one demonstration orchard, and two seed orchards. Trials were planted into herbicide-managed grass pastures, irrigated as needed and protected from weed competition for the year of establishment. Ruminant animals were excluded, but pig damage has occurred. Research has focused on: evaluation of growth rate, tree form and quality, survival rates and resistance to koa wilt and seed production of improved varieties based on selected families.

Progeny trials prove that koa is a fast-growing species under these experimental conditions, averaging 1.5 m height increment annually the first 5 years. Canopy closure could be achieved in six months. The narrow spacing we use (1 x 1.5 m) encouraged straighter boles and less forking than trees growing in open canopies. Average DBHs at age of four years ranged from 6.8 to 9.5 cm. Some families achieved heights >15 m and DBHs of >40 cm after 12 years.

Significant differences in growth occurred among families, with 90 percent of the families assessed as “genetic junk” (Brewbaker, 1996). Diversity within the half-sib families was often impressively small, suggesting some inbreeding within provenances. Genetic variance components for DBH ranged from 32.7 to 70.3 percent of total phenotypic variance for four trials at age of four years. High mortality caused by koa wilt disease precluded accurate estimations of heritability among older trees. Families from the Islands of Oahu and Kauai generally performed better than those from the Islands of Hawaii and Maui. However, superior families were identified from all Islands.

A seed orchard established in 1999 started flowering in 2002. This seed orchard consisted of single-tree plots of 15 superior families selected from early progeny trials. The seed from this seed orchard has been designated ‘UH Koa Comp 1’, and samples of seeds have been disseminated to foresters for evaluation of growth and resistance to koa wilt disease.

Breeding for resistance to koa wilt

Many pathogens and insects can impact on koa forests, but few are able to kill mature trees (Brewbaker *et al.*, 1991). However, the koa wilt disease kills mature trees in natural forests and in plantations, and has raised deep concerns among foresters. This poorly understood disease injures trees of all size classes and occurs on all islands (Anderson, *et al*., 2002). Koa wilt was found by Gardner (1980) to be caused by the pathogen *Fusarium oxysporum* f. sp. *koae.* Early symptoms of the disease include leaf chlorosis and defoliation. Major branches or the entire crown of an affected tree can then wilt and die (Anderson, *et al.*, 2002).

Koa wilt is epidemic in the progeny trials at Hamakua and Maunawili. Data from 11 of the annual trials planted at Hamakua are summarized in Table 2. Each year around 10 percent of trees in the trials die, largely due to wilt disease. Genetic variations in tolerance to the wilt have been evident. Certain families have shown exceptional tolerance to the disease in repeated plantings, while many do not survive. An almost linear regression occurs when survival is plotted against time (R^2 = 95 percent).

Table 2. Individual and average survival rates of the trials of Hamakua at different ages.

SET no.	# of family	Overall survival rate (%), at the age (years) of											
		1	2	3	4	5	6	7	8	9	10	11	12
91-1	48	88.2	77.0	46.5	43.1	40.4	-	-	-	16.2	8.4	7.8	7.2
93-1	15	67.5	58.6	55.4	49.8	-	-	24.0	22.0	18.1			
94-1	45	68.0	-	-	-	-	-	22.8	19.7	17.9			
95-1	53	96.0	-	-	74.7	39.9	27.0	27.4	24.5				
96-1	59	-	-	37.7	28.1	28.8	25.4	22.5					
96-2	8	-	-	73.3	-	42.0							
97-1	80	72.4	-	50.1	43.0	38.6	32.2						
98-1	27	81.5	-	41.3	30.7	29.7							
99-1	66	58.7	47.9	40.0	34.5								
00-1	47	76.1	54.5	46.3									
01-1	48	54.4	41.5										
Avg.		73.6	61.8	48.8	43.4	36.6	28.2	24.2	22.1	17.4	8.4	7.8	7.2

Family selection for resistance to wilt disease has been conducted based on survival data of this type. Thirty families with the highest survival rates at the age of for or five years have been identified. They will be further examined for resistance at multiple locations in Hawaii, and incorporated into seed orchards.

Vegetative propagation

Early studies of vegetatively propagating koa met with limited success. Skolmen (1977) conducted an extensive study on vegetative propagation. Stem cuttings of juvenile seedlings and air-layers of juvenile shoots successfully produced roots, but no success was achieved from cuttings of older trees. Rooting ability varied from tree to tree, indicating the involvement of genetic factors. Grafting and root cuttings were not successful. Callus induction in tissue cultures was successful, and shoots could be regenerated from the callus (Skolmen, 1977). Only a few mature clones survived. Meristematic multiplication from young koa seedlings seemed promising in a study by Nagai and Ibrahim (1996), but also has not provided techniques suitable for large-scale cloning.

In recent studies of Shi (2003), propagation of koa cuttings was very successful from juvenile seedlings. Variations in rooting ability were observed among families tested. Rooting ability declined quickly as trees aged, most losing rooting ability when trees developed phyllodinous leaves. Cuttings failed to respond to auxin treatments. Etiolation treatments on young shoots of trees entering mature stage seemed very promising. Cuttings survived much longer, and rooting frequencies were increased in some families. Cuttings of a few mature trees from the Island of Hawaii rooted well after plant hormone treatments, confirming genetic variation in rooting ability. Vegetative propagation can play an important role in forest tree breeding (Zobel and Talbert, 1984). A successful vegetative propagation method could enable koa breeders to establish clonal plantations or to exploit self-sterility in the production of hybrid trees.

Future priorities

Early evaluation is desired for the koa composites derived from Cycle 1 selections from the UH and HARC trials. A high priority is to identify field resistance to koa wilt, a difficult and widespread pathogen of many crops. More research is needed on koa's wood quality and its heritability, notably of the highly-figured koa prized by craftsmen. Proof is needed of the presence of a self-incompatible system in koa that could be the basis for hybrid tree production. Any exploitation of improved germplasm will rely on improved management methods, as unimproved plantations of koa often succumb to the stresses imposed by weeds, animals, diseases and insects. The high value of this prized tree and the devastating loss of high-value tropical hardwoods underscore the importance of this continued research.

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INTERNATIONAL SPECIES AND PROVENANCE TRIALS OF DRY-ZONE *ACACIA* AND *PROSOPIS* SPECIES: RESULTS FROM THE 1990-1994 ASSESSMENTS.

From 1983-1987 seeds of 281 provenances of 43 species of dry-zone *Acacia* and *Prosopis* were collected in 11 arid and semi-arid countries: Argentina, Chile, India, Israel, Mexico, Niger, Pakistan, Peru, Senegal, Sudan and Yemen. FAO and the Danida Forest Seed Centre (DFSC), Denmark, were involved in coordination, collection, seed storage and distribution. Seeds were distributed and field trials of sub-sets of the seedlots were established by 40 institutes and projects in 22 countries from 1983-1989. Although the project was officially terminated in 1987, an evaluation of a selection of trials was thought necessary to gain some initial knowledge of the productivity of the species and provenances included. Assessments were carried out by national institutions during 1990-1994, on 26 trials in 6 countries (Brazil, Burkina Faso, India, Pakistan, Senegal and Sudan). DFSC assisted in data analysis and the compilation of results at global level.

Although replication of provenances across trials was limited, the results suggested, for example, in Senegal, some provenances of *A. tortilis* and the provenance of *A. senegal* had large number of stems, which may be an advantage in the production of livestock fodder. For dry weight production, the best provenances were found in *P. juliflora*, *A. nilotica* and *A. tortilis*. Species with a low production were *A. aneura*, *A. holoserica*, *A. senegal* and *P. chilensis*. More information on results from the various trials in the six countries can be obtained from a series of field assessment reports which have been produced by the DFSC (for each of the 26 trials), and can be viewed at the FAO Forestry web site (*Forest Genetic Resources* -> *Species* -> *Acacia & Prosopis*) or directly to the DFSC link http://www.dfsc.dk/pdf/Aridzone%20trials/index.html

PRELEMINARY *AZADIRACHTA INDICA* (NEEM) TRIALS IN AMHARA REGION, NORTHERN ETHIOPIA

by
Solomon Gebreyohannis[1]

INTRODUCTION

Neem has been introduced to almost all tropical and subtropical regions (Schumutterer, 1998), but is still rare in Ethiopia, where it is found only in one place, Metema, in the northwest of Amhara National Regional State (ANRS), in the north of the country. The origin of the seed is undocumented, but the tree appears to grow well. Cultivating neem in other dry and degraded areas of the Amhara region has been suggested (Vietrneyer, 1992), but this will entail the establishment of provenance trials (which would include the local provenance), and the identification of the most adapted provenances according to the plantation objective (soil conservation, provision of natural pesticide to farmers, etc). Before new germplasm is imported for testing, knowledge of neem seed handling, treatment and cultivation in the nursery and in plantation is necessary. The present paper reports on the first introduction of the local neem provenance to three sites in Amhara in 1999. Seedlings behaviour was assessed and basic conclusions drawn for the future establishment of provenance trials.

METHODOLOGY

Seed collection and storage

Neem seeds were hand picked from the ground in Dire Dawa. They were depulped and washed by hand. Seed collection was done during the late fruit ripening season (July-August). The seeds were half sun dried and stored in a light sieved cloth *("Netella").*

Site selection and location

The three sites, Belesa, Kemise and Woldiya are located at 12º 25' 12" N and 38º 02' 24" E; 10º 38' 40" N and 39º 38' 40" E; and 11º 45' 36" N and 39º 33' 36" E respectively.

Table 1. Site conditions

Annual Average				
Sites	Elevation(m)	Rainfall(mm)	Mean monthly temp.(ºc)	Soil type
Belesa	1900	1030	20-25	Clayey eurthric regosol
Kemise	1450	950	19.36	Silty clay euthric regosol
Woldiya	1800	1053	15-20	Black cotton chromic vertisol

Site management and design

In the nursery, seedlings were raised on 10 cm high beds. Pits were dug at 10 cm x 5 cm spacing and 3 seeds inserted in a pit. Planting was done in the surroundings of the nursery site with two replications. Each block had two lines and 25 seedlings per line. Pits (30 cm x 30 cm in depth & width) were open 15 days before planting, at spacing of 1 m x 1 m, according to a complete block design.

Data recording and analysis

In the nursery, after sowing, seedlings were assessed every 2 weeks. After 4 months, 25 randomly selected seedlings, according to the methodology suggested by Wood and Burley (1991), were outplanted in the field. At the planting site, survival rate, height and number of leaves were recorded every 15 days for 8 months.

A X^2 test was used to assess the significance of differences in germination and survival rates between sites. A T-test checked significant differences in height and number of leaves between two sites; and a F- test was used to discriminate the three sites.

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RESULTS AND DISCUSSION

In the nursery, germination and survival rates were significantly different between the three sites at α=0.05 (table 2). Since seedlings at Woldiya appeared damaged at month seven since germination, data on three sites was analyzed at the age of six months and significant differences found. At the end of the year, results at two sites (Belesa and Kemise) also showed significant difference (T-test at α = 0.05).

Table 2. Germination and survival rates and length of dormancy in nursery sites.

Sites	Germination energy (%)	Survival rate (%)	Dormancy period[1]
Belesa	93.67	85.41	22
Kemise	40.14	88.39	16
Woldiya	11.00	63.34	24

[1]Dormancy in number of days elapsed between sowing and germination.

In both nursery and plantation, eurithric regosols (found at Belesa and Kemise) appeared more favorable to neem than black vertisols (found at Woldiya).

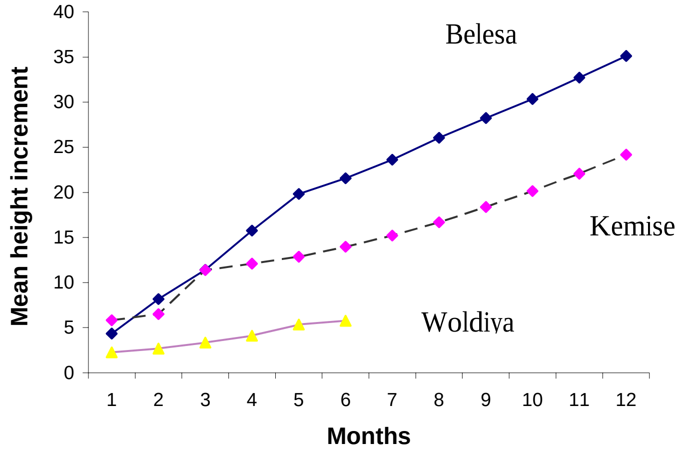
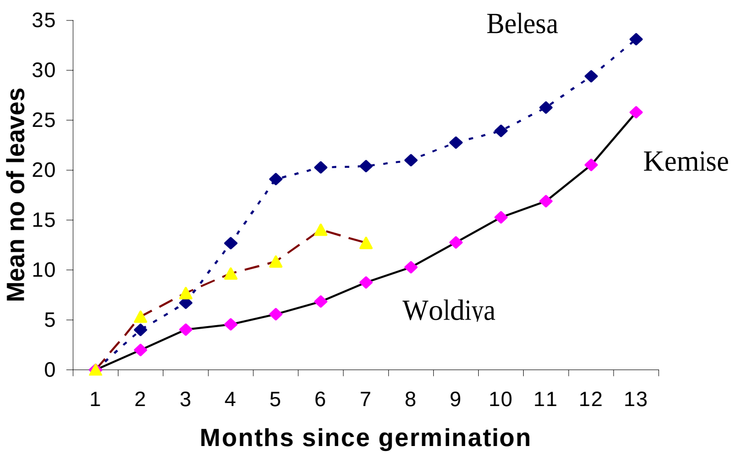


Fig. 1. Growth rate in planting sites.

Fig. 2. Number of leaves in planting sites.



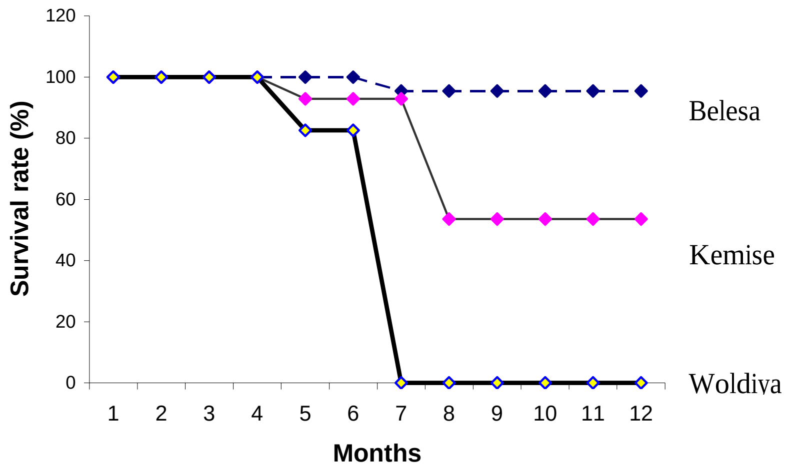


Fig. 3. Survival rates at planting sites

CONCLUSION AND RECOMMENDATION

The study shows that neem seed processing, treatment and handling can be done relatively easily in Ethiopia. Sites Belesa and Kemise show the most interesting potential for further neem introduction and testing. The study widens the limits of neem cultivation usually recommended (Vietrneyer, 1992) (elevations lower than 1200 m and average annual rainfall below 400 mm), although adult plant behavior will need to be assessed before final conclusions are drawn. In the limits of the study, seven-month old neem seedlings have successfully grown at 1900 m a.s.l. and under 1000 mm annual rainfall. In these conditions, heavy clay soils appear unsuitable for the local provenance. In future experiments, it will be necessary to test the behavior of the local provenance against other known provenances, as was done in Tanzania (Iversen *et al.*, 2002).

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Note from the Editors: the publications of the International Neem Network, including technical guidelines on seed collection and exchange and seed sources description, have been digitalized and are available on line at www.fao.org/forestry/site/5313/en.

SILVER FIR (*ABIES ALBA*) RESOURCES IN ALBANIA AND THEIR CONSERVATION

by

G. Zeneli[12], M. Dida[2], F. Ducci[4] and D. Habili[2]

INTRODUCTION

Silver fir (*Abies alba* Mill.*)*, an ecologically significant tree species native to many European mountain forests, is currently one of the most economically important conifers in Albania. It occupies an area of about 16060 ha and represents 9.3 percent of conifer forests. It is one of the tallest trees growing on the mountain regions of the country. Natural Silver fir forests comprise pure forests and forests mixed with other conifers, such as black pine (*Pinus nigra* Arn.), or broadleaf trees such as beech (*Fagus sylvatica* L.) and maple (*Acer pseudoplatanus* L.) (Habili, 1985). Silver fir populations show very high variability in Albania, as in most the species' distribution range. This variation is correlated with the changes in physiographic conditions. Despite high levels of intrapopulation genetic variation, increased use of the forests, climate change and disease outbreaks undoubtedly affect the species' resources and requires intensified genetic conservation. The first measures for the protection of targeted samples of Silver fir genetic variability are being implemented.

DISTRIBUTION

Forest resources in Albania cover approx. 1.028.060 ha or 35.7 percent of the national territory (Anonymous, 2000). Silver fir shows the highest average annual increment among forest trees (2.92 m^3/ ha) compared with other economically important trees as beech (2.14 m^3/ ha) or black pine (1.45 m^3/ ha).

On the basis of physical, climatic and geographical characteristics, the country can be divided into four main regions (Mitrushi 1966). Silver fir forests are found in three of the four regions (the Western lowland region excepted). The natural distribution range includes (Map 1 and Table 2) (Habili 1985; Dano 1996):

- the northern mountain region (Albanian Alps) between 42º 10' N - 42º 34' N and 19º 41' - 20º 04' E. Only one percent of the species' distribution range falls in this zone. Silver fir grows mainly on slopes facing east and northeast or in valleys where the climate is relatively milder. Long winters with severe freezing days are main limiting factors. Silver fir stands have the lowest increment and are not as developed as other areas.

- the central mountain region between 42º 12' N and 20º 03' - 20º 51' E. The largest area of fir forest is found in this zone (74 percent) where in most cases it forms mixed forests with beech (*Fagus sylvatica*), black pine (*Pinus nigra*), maple (*Acer pseudoplatanus*), and sometimes oak (*Quercus* spp). In this region, Silver fir shows tolerance to low temperatures and low annual rainfall, and is able to survive in several microclimates (Puke, Bulqiza, Mirdite, Mat, Tirane, Elbasan and Librazhd).

- the southern mountain region between 39º 46' N - 40º 20' N and 19º 31' - 20º 45' E. The majority of the pure Silver fir forests are located here, although the tree only covers 25 percent of the total area. Most stands are located on slopes facing southeast or northwest and are under the influence of the Adriatic Sea. The fact that Silver fir here achieves its maximum growth indicates its adaptability to drought conditions under a xerophytic ecotype.

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In summary, stands of fir extend from Sotire - Koshovice, in the South (latitude 39° 46') to the northern borders of the country with Serbia & Montenegro (Vermosh - latitude 42° 38'); Llogara in the Western part (longitude 19° 31') to the Eastern part in Drenove - Bozdovec (longitude 20° 51') (Dano, 1996; Dano and Proko, 1998).

The altitudinal distribution varies greatly throughout the range. In the northern mountain region, because of frequent late frosts in spring, the species' altitudinal range is limited to below 1500 m a.s.l. although, in rare cases, it grows up to 1800 m. Because of climatic limitations, the altitudinal limit in the central mountain region is more or less the same as in the Alps (1400 to 1600 m). The situation is different in the southern region, where it can be found from 450 m to 1700 m a.s.l. (Habili, 1985).

Table 1. Distribution of Silver fir (*Abies alba*) forest in Albania (Anonymous 2000)

DISTRICT	SURFACE Area (HA)			STANDING VOLUME (000/m3)		
	PURE	MIXED	TOTAL	PURE	MIXED	TOTAL
Bulqize	10	0	10	1	0	1
Delvine	0	220	220	0	74	74
Devoll	0	280	280	0	53	53
Diber	320	720	1040	22	172	194
Elbasan	10	320	330	1	58	59
Gjirokaster	1230	530	1760	195	113	308
Gramsh	100	710	810	24	296	320
Kolonje	450	1760	2210	122	368	490
Korçe	880	390	1270	55	159	204
Kukes	110	460	570	16	97	113
Librazhd	0	480	480	0	123	123
M. e Madhe	10	30	40	2	3	5
Mat	10	260	270	7	85	92
Mirdite	120	700	820	60	232	292
Permet	1230	430	1660	429	101	530
Pogradec	110	520	630	10	91	101
Puke	520	1210	1730	140	334	474
Skrapar	80	20	100	19	6	25
Tepelene	110	170	280	22	19	41
Tirane	0	20	20	0	7	7
Tropoje	320	20	340	172	11	183
Vlore	560	630	1190	154	109	263
Sum	6180	9880	16060	1451	2511	3952

ECOLOGY

Silver fir attains its best development in areas where there is comparatively high humidity, cold temperatures and high rainfall. A sheltered situation is adequate for its development. Both severe late frosts in spring and strong dry winds in winter jeopardize its growth and it is not found in regions with a marked continental climate (Habili, 1985). The major factor shaping its distribution is the amount of annual rainfall (1000-2 100 mm).

In regions with a temperate climate (eastern and northern mountain zone) with annual rainfall of 1800 to 2500 mm, the petrographic origin is not a limiting factor. The tree can grow on different bedrocks from magmatic to ultabasic formations. On the other hand, in the southern and southeastern parts of its range, which are characterized by long and dry summers, fir requires deep soils rich in $CaCO_3$.

Silver fir can achieve its optimum growth in soils derived from limestone or dolomite limestone. In areas where fir is associated with beech (*Fagus sylvatica*), the soil pH is acid to neutral, while in its associations with black pine (*Pinus nigra*), oak (*Quercus* spp) and maple (*Acer pseudoplatanus*) soil acidity ranges from 6.7 to 7.7. Fir prefers loamy or metamorphic soils with elevated hydric potential of deduction, but it grows well even on clay soils. Deep rich soil of sandy loam gives the best growth (Habili, 1985). Table 2 gives climatic and soil data for three major locations (Dano, 1996).

Within the range of distribution, Silver fir is more scattered and associated with other trees including both conifers and broadleaf trees. Pure forests account for 18 percent of its total area while the percentage of Silver fir compared with other trees in mixed forest is variable depending on local conditions.

In mixed forests Silver fir is found with other conifers as black pine (*Pinus nigra* Arn.), Norway spruce (*Picea abies* L. (Karst) (one association in Valbona - Northern Albania) or with broadleaf trees such as European beech (*Fagus sylvatica* L.), oak (*Quercus* spp) or *Ostrya carpinifolia* L (Paparisto *et al*, 1988). Based on climatic conditions, Silver fir achieves its optimum growth in the phytoclimatic zone Fagetum (hot subzone) and Castanetum (cold subzone). In particular cases, it can be grow in the cold subzone of Lauretum (Habili, 1985).

Table 2. Climatic and soil characteristics of Silver Fir locations in Albania (Dano, 1996)

CHARACTERISTICS	**PHYSIO - GEOGRAPHIC ZONE**		
	NORTHERN	**CENTRAL**	**SOUTHERN**
Bedrock	**Flysh and dolomite limestone**	**Flysh and dolomite limestone**	**Limestone**
Soil type	Clay	Clay	Loamy clay
Elevation (m)	1000-1500	900-1500	1100-1600
Mean annual temperature (°C)	6.1-9	6.9-8.2	8.7-13
Mean temperature July (°C)	15.3-15.9	14.7-18	18-22
Mean temperature January (°C)	-2.4	-1.8	3.5
Minimum absolute temperature (°C)	-20	-12	-9.2
Atmospheric humidity (%)	65-70	50-70	50-700
Annual rainfall (mm)	2650	1300-1800	1000-2200
Snow thickness (m)	1.5-2	0.5-1	0.40- 0.60
Frost days	110-150	100-125	-

Map 1. Natural distribution of *Abies alba* in Albania

(Source: Habili, 1985)

TAXONOMY AND SPECIATION OF ALBANIAN FIRS

The taxonomy of Albanian firs still raises many questions. Hypotheses concerning the alleged occurrence of *Abies alba* Mill., *Abies cephalonica* Loud. and *Abies borisii regis* Mattf., either based on morphological and anatomical criteria (Mitrushi, 1955; Mitrushi, 1966; Habili, 1985), ecological surveys (Dano, 1996; Dano and Proko, 1998; Misiri, 1999), isosyme analyses (Misiri, 1999) or biochemical characters (Zeneli *et al*, 2001) are often contradictory because studies are generally based on single traits. Albanian fir populations show high variability in connection with their microclimatic niches (Habili, 1985; Dano, 1996; Dano and Proko, 1998).

Margraft (1932) was the first to study and describe the variations in Albanian fir populations and on the basis of morphological traits, recognized three species: *Abies alba*, *Abies cephalonica* and *Abies borisii regis.*

Referring to Margraft, Svoboda (1953) classified Albanian fir stands into two climatic types; fir populations north of the Shkumbin river were included in a "Illyrica" climatic type, while fir populations south of the Shkumbin river were referred to a "Macedonica" type. Mitrushi (1955) mentioned the same three species as Margraf, although later (1966), he only recognized two species, namely *A. alba* and *A. borisii regis.*

An extensive study of morphological and anatomical characters on samples collected over the Albanian distribution range (Habili, 1985) showed considerable variation between and within populations. Some traits appeared to vary along latitudinal and/or longitudinal gradients. Habili (1985) concluded that in some southern populations morphological features of *A. cephalonica* could be found, but the author excluded this species from Albania: *A. cephalonica* grows up to 38º 50' (Mattfeld, 1930), while Albania lies between 39º 38'- 42º 39'N.

Even *Atlas Florae Europea* (1988) displays contradictions on fir species distribution in Albania. While on map No 152 the distribution of *A. alba* covers all the national territory, on map No 154 firs in southern Albania are referred to as *A. borissi-regis.* Misiri (1999) concluded that southern firs are different from those in the central and northern regions and inherit a number of features of *A. cephalonica* , therefore belonging to *A. borisii-regis.*

More recently, Zeneli *et al* (2001) investigated fir terpene variation in needle oil and cortical oleoresin from different geographical regions. It was found that the terpene composition of the Drenova population (southeast) is as different from northern Albania populations as from the Greek fir reported by Fady *et al.* (1992). The geological characteristics of the Bosdovec-Drenova mountains are very varied (flysh and phyllites dominate) and a few populations of Silver fir may have been able to constitute glacial refuge. The existence of central resin channels in a radial section of fir trunk is reported as a characteristic of the Drenova fir, helping to differentiate it from other provenances (Habili, 1985).

To explain the patterns of variation of fir in Albania, it is necessary to consider the migration routes during the last glaciation. One often assumes the existence of a refuge in the Balkan Peninsula (Schiefele, 1970). The southern migration of *A. alba* before and during the last Ice Age and contacts with *A. cephalonica* in small refuges probably led to the development of *Abies borisii regis* hybrid populations. The introgression between the species may have been secondary, i.e it may have originated, to a large extent, from the natural hybridization of preexisting species *A. alba* and *A. cephalonica* (Mitsopoulos and Panetsos, 1987). Frequent contact between the two species during the Pleistocene could have contributed to the particular morphology of southeastern ecotypes of *A. alba*, including Albanian populations. (Fady and Conkle, 1993). After the end of the glaciation, fir has migrated northwards from the Balkan Peninsula (Southern Bosnia, Macedonia) (Horvat-Marolt and Kramer, 1982).

Another introgression zone has been in the Slovenian Alps, where Silver fir from the southern Balkans met populations from central Italy during their migration along the East Alpine route (Konnert and Bergmann, 1995). Silver fir may have been subject to genetic impoverishment during the re-migration from the refuges where it survived the glaciation period.

The present range of Silver fir in Albania and the existence of introgression (hybrid) zones appear to be the result of different migration routes after the end of the last glaciation from the Balkans and Central Italy (Konnert and Bergmann, 1995). Various factors, such as geographic isolation, gene flows, selective harvesting, soil mosaic, climatic and altitudinal variations, as well as forest fires, may have contributed to the present complex genetic structure.

In conclusion, it can be assumed that two *Abies alba* ecotypes, instead of two taxa, can be found in Albania. The first ecotype grows in Korca, Koshovica, Gjirokaster, Permet and Leskovik, while the second ecotype covers the mountains of Korca to the northern part of the country (Habili, 1985; Dano, 1996; Zeneli *et al.*, 2001).

CONSERVATION

Abies alba has an extensive natural range and shows considerable morphological and physiological variation especially in its southern limit (Habili, 1985; Mitsopoulos and Panetsos, 1987; Wolf *et al.*, 1994). Climatic changes are alleged driving forces in its expansion and regression phases. In Albania several populations are severely threatened by increased harvesting; forest fragmentation, climate change and insect and disease outbreaks. These threats highlight the urgent need for conservation and sustainable management of fir resources, and protection of appropriate amounts of genetic variability.

The first measures aimed at conserving Silver fir genetic resources are being implemented in the country. Parts of the Albanian territory have designated as protected areas (Vangjeli *et al.*, 1997) and will play an important role in *in situ* conservation:

- the Forest Management Unit of Kardhiq (Southern Albania), where Silver Fir forms mixed forest with oak species is now a Strict Nature Reserve/Wilderness Area (Category I IUCN);
- fir stands at Hotova (approx. 2000 ha) are under a National Park (Category II in IUCN's classification);
- Sotira, which represents the southern extension of fir in Albania (approx. 980 ha) has been designated a natural monument (Category III of IUCN);
- Shelegura (approx. 980 ha) is now a Habitat/Species Management Area (Category IV IUCN).

Seed stands have also been classified. They cover an area of 569 ha and are distributed in three major regions (from 39°49'00" to 42°35'00" N and 19°34'10" to 20°25'00" E), including 57 ha in the northern mountain region, 175 ha in the central mountain region and 337 ha in the southern mountain region. Seed orchards have already been established in two areas and may be extended to other ecogeographic zones, pending the availability of resources. Developing science-based conservation strategies and maintaining minimum viable populations will represent other important challenges towards the conservation of Albanian fir genetic resources.

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CONSERVATION AND USE OF *TRIPLOCHITON SCLEROXYLON* IN MOIST WEST AFRICA

by
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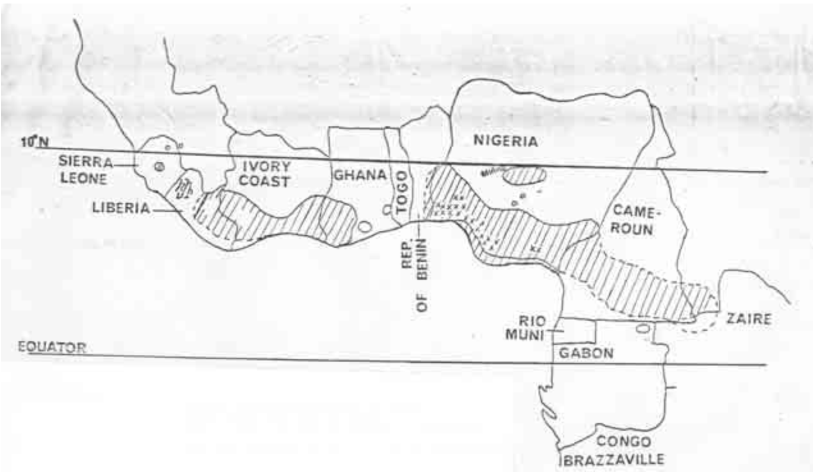
INTRODUCTION

Triplochiton scleroxylon K. Schum (Sterculiaceae) is a large, deciduous African forest tree. It is distributed in the semi-deciduous moist forests from Sierra Leone to Congo. The highest concentration of the tree is associated with altitudes below 500 m, mean annual rainfall from 1 100 to 1 800 mm, a seasonal and two-peaked rainfall distribution, average temperatures 20-35 °C and well drained ferruginous soils (Hall and Bada, 1979). It may sometimes be found in the dry forest zone, where it occurs in clusters, either within the dry forests or at its boundaries with the moist forest. Trees found in the dry forest zone have smaller leafs, narrower crowns and shorter bole lengths (Jones, 1975). Within the natural range, three sections are generally recognized, namely: Sierra Leone to Togo, Benin to Nigeria and Cameroon to Congo (Hall and Bada, 1979; Figure 1).

Figure 1: Approximate range of *Triplochiton scleroxylon* in West Africa



Where cross hatching is bounded by a broken line, the location of *Triplochiton scleroxylon* is debated.

Triplochiton scleroxylon is an important timber tree and in the FAO database REFORGEN[iii], 12 countries list it as a priority species. The tree is native to 11 of the countries listed, while the last country, Solomon Islands, use it as an exotic. In 8 of the 12 countries the species is used in plantations. Côte d'Ivoire lists it as endangered and 4 countries report either *in situ* or *ex situ* conservation programmes. Three countries have mentioned tree selection or improvement programmes on the species.

OVER EXPLOITATION

The species has been exploited in all the countries within the native range to such a degree that most natural forests have become depleted; selective logging has also probably eroded the native gene pools (Ladipo *et al.*, 1992) and continued exploitation from natural forests is increasingly difficult due to the scarcity of the resource. It used to be the commonest export timber of the countries bordering the Gulf of Guinea, comprising nearly half of all timber production by volume, but in Nigeria it has been almost eliminated from the forest due to over-exploitation (Lowe, 1997).

PLANTATIONS

T. scleroxylon has been tested for cultivation in plantations because it is fast growing (Table 2), self pruning and well established in the timber marked (FAO, 2002). There are however pest problems affecting the species. Leading shoots are often killed by aphids. Almost annually (in August-September), heavy defoliation by the caterpillar of *Anaphe venata* occurs, although increment loss is not apparent (FAO, 2002).

Stumps of *T. scleroxylon* are also liable to severe or fatal termite attack if soil is not moist at the time of planting (Taylor, 1962).

The species has been used both for plantation establishment and in enrichment planting in Ghana and Nigeria. Lamb (1967), in FAO (2002), inspected line-planting in Ghana and Nigeria and he reported that *T. scleroxylon* was one of the species that grew fast enough to become established successfully. He noted also the benefit of side shade provided by line planting for early growth. Igboanugo (1990) also observed that medium shade enhanced growth more than dense shade and full light. These practices are believed to be contributing to curtail foliar insect infestation and enhance growth.

Table 2. Estimated Mean Annual Increment (MAI) in Ghana for selected species.

Species	Good site		Poor site	
	Zone	**MAI (m3/ha/yr)**	**Zone**	**MAI (m3/ha/yr)**
Heritiera utilis	WE	10	ME	6
Triplochiton scleroxylon	ME	20	MS	12
Terminalis superba	MS	18	FST	12
Gmelina arborea	ME	20	MS	12
Tectona grandis	MS	12	FST	6
Cedrela odorata	MS	18	FST	12
Ceiba pentandra	MS	18	S	12
Pinus spp.	MS	22	FST	12

FAO (2002) - FST: forest savanna transition, ME=moist evergreen,
MS= moist semi-deciduous, S: savanna, WE: wet evergreen

SEED AND GERMPLASM PROCUREMENT

T. scleroxylon has irregular seed years with unpredictable quantities (Jones, 1975 and 1976) and furthermore the seeds are short-lived and cannot be relied upon for supplying plantation requirements (Foli and Ofosu-Asiedu, 1977; FAO, 2002). This has stimulated considerable research into vegetative propagation techniques and juvenile leaf cuttings have been propagated successfully (Leakey *et al.*, 1982; Leakey, 1985; Leakey and Mohammed, 1985).

Lowe (1997) mentioned that based on his experience in Nigeria, and despite the success and comparative ease of the methods used to propagate *T. scleroxylon*, he never observed this method being used in routine management. Peprah (1999) also mentioned that vegetative propagation techniques, which would have allowed the establishment of clonal trials to identify the extent of genotypic variation, have not been fully utilized in Ghana.

TREE SELECTION & IMPROVEMENT PROGRAMMES

According to information stored in REFORGEN, three countries, Cameroon, Côte d'Ivoire and Nigeria, have tree improvement programmes for *T. scleroxylon* including provenance, progenies and clonal trials. Siaw (2001) reports that Ghana has carried out provenance trials and according to Ladipo *et al.* (1992) clonal evaluations have resulted in better understanding of genetic variability and an overall gain in stem volume of over 30 percent has been achieved for *T. scleroxylon*. Studies on the early growth have included the relationship between branching frequency and apical dominance, as well as measurements of photosynthesis, as aids to early selection of desirable genotypes. Developments from these research efforts have enhanced reforestation, particularly in Côte d'Ivoire and Nigeria.

Unwin (1920) described *T. scleroxylon* growing in the forest canopy as being slightly shade bearing at first and becoming light demanding as it matures. In this case it might be possible that due to physiological ageing, cuttings from mature trees may exhibit a different response to light intensity than plants obtained from seeds.

DISCUSSION

Unreliable seed supplies and pest management problems have been major obstacles to larger utilization in plantation; the situation may worsen since dwindling the resource in natural forests threatens future seed supply, in both quantitative and qualitative terms. Nevertheless, vegetative propagation methods seem to be a short-term way to overcome the problem of supplies of good planting material and provide new options for tree selection and improvement programmes.

Plantation forestry relying on vegetative (clonal) propagation requires the conservation of a comprehensive and representative gene pool, storing material from all known sources of genetic variation within the distribution range. Such long-term gene banks actually condition the long term of any intensive tree planting programme. Selection and marking of plus trees followed by establishment of provenance trials in a number of sites which at the same time could act as tree improvement programmes and as a part of a conservation programmes should be initiated.

For such a programme to be successful, government agencies need to work with local communities to protect selected stands and relevant institutions need capacity building in vegetative propagation methodology. Considering the cross boundary pattern of the distribution area, reproductive materials should be exchanged between countries in the region.

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PROGRESS IN COUNTRY AND REGIONAL ASSESSMENTS OF FOREST TREE GENETIC DIVERSITY

by
F. Patiño[1]

Several international organizations and programmes have in the past decade supported the preparation of status assessments and action plans on forest tree genetic resources, and assisted countries in identifying their main issues and priorities in forest genetic diversity, through the organization of eco-regional workshops. Workshops have been held for North American Temperate Forests (1995), Boreal Forests (1995), Europe (1995), Sahelian Africa (1998), South Pacific islands (1999), Southern and Eastern Africa (2000), Southeast Asia (2001), Central America, Cuba and Mexico (2002), Asia (2003) and Central Africa (2003) (Table 1). Documents prepared during these workshops (methodologies, country assessments, regional syntheses and action plans) have been published by the organizers and most reports are available on the Internet. Updated quantitative data on forest tree species and populations, and information on national institutions, will be compiled in the World-Wide Information System on Forest Genetic Resources (REFORGEN). This paper summarizes the outcomes of two sub-regional workshops convened with FAO support in Central America and Central Africa in 2002 and 2003 respectively, and outlines tentative future developments in this field.

DEVELOPMENTS IN CENTRAL AMERICA, CUBA AND MEXICO

The Regional Workshop on Forest Tree Genetic Resources for Central America (including Cuba and Mexico) was held at CATIE, Turrialba, Costa Rica, in November 2002. The workshop gathered experts from nine countries (Belize, Costa Rica, Cuba, El Salvador, Guatemala, Honduras, Mexico, Nicaragua and Panama), and five agencies (FAO, CATIE, IPGRI, IUFRO and DFSC). A list of priority forest tree species was drawn by the participants (Table 1).

Table 1: List of priority forest tree species in Central America, Cuba and Mexico

No	Priority species	Number of countries*	Countries**
1	*Cedrela odorata*	9	1, 2, 3, 4, 5, 6, 7, 8, 9
2	*Swietenia macrophylla*	7	1, 2, 3, 5, 6, 7, 8
3	*Calophyllum brasiliense*	7	1, 2, 3, 5, 6, 7, 9
4	*Tectona grandis*	7	1, 2, 3, 4, 5, 6, 9
5	*Pinus caribaea hondurensis*	7	1, 3, 5, 6, 8, 9
6	*Ceiba pentandra*	6	1, 2, 3, 4, 5, 6
7	*Gmelina arborea*	6	1, 2, 3, 5, 6, 7
8	*Bombacopsis quinata*	5	2, 3, 6, 8, 9
9	*Cordia alliodora*	5	1, 2, 3, 4, 6
13	*Gliricidia sepium*	5	1, 3, 4, 6, 8
11	*Eucalyptus camaldulensis*	5	3, 4, 6, 8, 9
12	*Swietenia humilis*	5	2, 4, 5, 6, 8
13	*Hymenaea courbaril*	4	2, 3, 6, 8
14	*Leucaena leucocephala*	4	1, 3, 4, 6
15	*Myroxylon balsamum*	4	1, 2, 4, 5
16	*Pinus oocarpa*	4	4, 5, 6, 8
17	*Pinus tecunumani*	4	1, 5, 6, 8
18	*Tabebuia chrysantha*	4	4, 5, 6, 7
19	*Dalbergia retusa*	4	2, 6, 8, 9
20	*Carapa guianensis*	4	1, 2, 3, 8
21	*terminalia amazonia*	4	1, 2, 6, 7

*: number of countries in which a given tree species is regarded as priority species; ** 1, Belize; 2, Costa Rica; 3, Cuba; 4, El Salvador; 5, Guatemala; 6, Honduras; 7, Mexico; 8, Nicaragua; 9 Panama.
Source: FAO 2004 (*in press*), based on the work of Francisco Mesén.

Participants pointed out that, during the last decade, the field of forest genetic resources has changed dramatically in a majority of countries, at policy, institutional and technical levels. While deforestation and encroachment are still comparatively high, a majority of public-owned tree seed centers face financial constraints and have difficulties to integrate high-profile national and regional efforts on biological diversity conservation.

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There is in most countries a need to redefine the very concept of forest genetic diversity, and to market the expertise and capacity of the forest geneticists in areas associated with natural forest management, biodiversity restoration and other environmental issues. Costa Rica is showing innovative approaches to seed certification, biodiversity investment schemes and access and benefit-sharing from the use of, or investigations on, genetic resources, most of them derived from natural forests.

As a follow-up to the workshop, national status assessments have been completed, printed and posted on the internet. A regional synthesis and action plan is being finalized.

DEVELOPMENTS IN CENTRAL AFRICA

A regional workshop on forest and tree genetic resources for Central Africa was held in Pointe Noire, Congo, 14-15 October 2003. The workshop, organized by FAO in collaboration with the African Timber Organization (OAB), IPGRI, ICRAF and IUFRO, was attended by participants representing countries of the Congo Basin (Cameroon, Democratic Republic of the Congo, Congo and Sao Tome & Principe), international organizations and national agencies. Country-based information had in addition been received from the Central African Republic and Gabon.

Participants presented preliminary status reports that will be updated and finalized in collaboration with national stakeholders concerned. A regional status synthesis, discussed by participants, will incorporate these updates. Most countries reported difficulties in assessing and monitoring forest cover, and even greater problems in evaluating the state of forest tree genetic diversity. With the exception of Congo, where planted forests represent a significant share of wood production, and where long-term tree selection and breeding programmes are in place (mainly on hybrid eucalypts), forests are mainly natural or semi-natural, and the main challenge facing geneticists is the integration of genetic elements in the management of natural forests.

While forest management plans are being drawn at increasing rate, only few of them take into account basic information on the biology, reproductive behaviour, phenology, fruiting habits and periodicity of priority species that may be available locally. Information is more then often scattered and not accessible to forest managers. Three main domains of applications were identified for possible future action: seed sources identification, supply and demand; definition of tree provenances and genecological zonation; and domestication of fruit trees and medicinal species. The scarcity and unavailability of scientific and technical information on the main tree species was considered a major bottleneck in forest management planning and monitoring, and there exist opportunities for forest geneticists to work with forest and natural resources managers.

At policy level, a proposed plan of action on forest tree genetic diversity is planned to be integrated into the regional COMIFAC programme on forests. Most country status reports are still in the stage of development and revision. When finalized, they will be published and posted on line, and will be used to update the World-wide information system on Forest Genetic Resources REFORGEN.

OPTIONS FOR THE FUTURE

The outcomes of these workshops outlined major trends at global level. International priorities in forest genetic resources have changed from an early focus on support to countries in genecological studies and seed collection underpinning species and provenance research of a few major timber species in the 1960s and early 1970s, to the wider management of genetic resources of a range of trees and shrubs for a great number of purposes and end uses, in a variety of national and local contexts. Such a shift, due largely to changes in the perception of the place and role of forests and trees in national development, has been accompanied by increased attention in all countries to native species. At the policy level, national and international agendas are increasingly dealing with issues related to intellectual property rights and patenting of genetic applications, access and benefit sharing in the use of genetic materials, and regulations over biotechnology products and processes, such as genetic engineering. These developments are often lead by, and under the umbrella of, agreements in other sectors, including trade and economics, agriculture, and the environment, rather integral parts of forestry-led initiatives.

Furthermore, the number of instruments related to forests, forestry and plant genetic diversity have recently greatly increased in response to increased environmental awareness and related national and international programmes. As institutions and expertise in developing countries have gradually become stronger, international action has over the past decade increasingly stressed institutional networking rather than providing direct support, and FAO and other international and bilateral institutions have focused their action to building technical partnerships with national institutions in developed and developing countries.

There is a need to ensure close collaboration between instruments, including cross-sectoral links. At the national level, forest geneticists will need to be able to address cross-cutting issues, some of which only loosely related to the traditional field of forest genetic resources, and increasingly work in interdisciplinary teams. For FAO, it is also important to keep abreast of new developments, reflect on changes in the international environment, anticipate trends at regional and global level, and provide neutral, up-to-date and balanced information to member countries.

Globally, increased movement of people, goods, services, information and know-how, contribute to a constant change in demands on forests, wood and non-wood products and environmental services, and to shifts in the boundaries in, and priorities of, the forest genetic resources sector. The availability of up-to-date information, as stressed *i.a.* in the forest work programme of the Convention on Biological Diversity, is essential for the decision maker, the manager and the scientist. What type of forest resource or function will be used, for which purpose, by which customer, in which region, over which period, are important parameters that will condition the perception of forest genetic resources as well as the degree of attention given to this issue.

Table 1. Summary of processes & outputs of regional workshops on forest tree genetic diversity, 1995-2003

Eco-region/	International organizers	National organizer	Number of countries/ territories covered	Country status on FGR	List of national priority species	Regional summary or synthesis	Regional action plan or recommen-dations
Temperate North America (1995)	North American Forestry Commission	USDA Forest Service U. California	3		+	+	+
Boreal Forests (1995)	FAO	Canadian Forest Service	20		+	+	+
Sahelian Africa (1998)	FAO, IPGRI, DFSC, ICRAF, IUFRO	CNSF, Burkina Faso	15	+	+	+	+
Pacific Islands (1999)	SPRIG, AusAID, FAO, SPC, SPREP, IUFRO	Samoa Forestry Division	18	*	+	+	+
Eastern & Southern Africa (2000)	SADC, FAO, ICRAF, IPGRI, DFSC, IUFRO	Forestry Division, Tanzania	9	+	+	+	+
South East Asia (2001)	FORGENMAP, APAFRI, DFSC, FORSPA	Thai Royal Forestry Department	8	+	+	+	+
Central America (2002)	FAO, IPGRI, IUFRO	CATIE, Costa Rica	9	+	+	+	*
Central Africa (2003)	FAO, ATO, UNDP, IPGRI, ICRAF, IUFRO	Direction des forêts, Congo	6	*	+	+	*
South Asia (2003)	APFORGEN, IPGRI, APAFRI, FAO, DFSC	FRIM Malaysia	13	+	+	+	+

* : work in progress; +: work completed

Note: in Europe, the European Forest Genetic Resources Programme (EUFORGEN) has been coordinating country-based action on forest tree genetic diversity since 1994.

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FOREST GENETIC RESOURCES IN BUENOS AIRES PROVINCE, ARGENTINA: CHARACTERIZATION, CONSERVATION AND PROPAGATION

by
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BACKGROUND AND ISSUES

Argentina is situated in the Southern cone of the American continent, covers 3.761.274 km² and hosts approximately 35 million hectares of native forests (as by 1984 - Merenson, 1992). In 1915, the forest cover was more than 30 percent of the national territory (SAGP&A, 1998). Today, forest cover is estimated at 12.7% of the total land area (FAO, 2003).

The Province of Buenos Aires covers 308.000 km², at an average latitude of 37-38º L.S in the neo-tropical region, and hosts about 1500 native plant species. The number of extinct species due to overgrazing, intensive agriculture or urban settlements is not known. Thirty six percent of the Buenos Aires province area is used for agricultural purposes, 53 percent for livestock raising, while 11 percent has no use, although it practically does not harbor any remaining pristine forests.

The native forests of Buenos Aires province are strictly confined to the coastal strip of Rio de la Plata (marginal forests and "Talares" of *Celtis tala* Gill ex Planch) and to the Western region (Caldén forests) (Parodi, 1939) (see Figure 1). When the city of Buenos Aires was founded, in 1590, its surrounding areas hosted forests of *Celtis tala* and white algarrobo *(Prosopis alba)* (Cozzo, 1992). The exploitation of forests for firewood was so intensive that the resources were exhausted at the beginning of the 19th century. Today, these relic woodlands are known as "Talares" and "Monte Blanco".

Figure 1: Location of natural forests (Talares) in Buenos Aires Province

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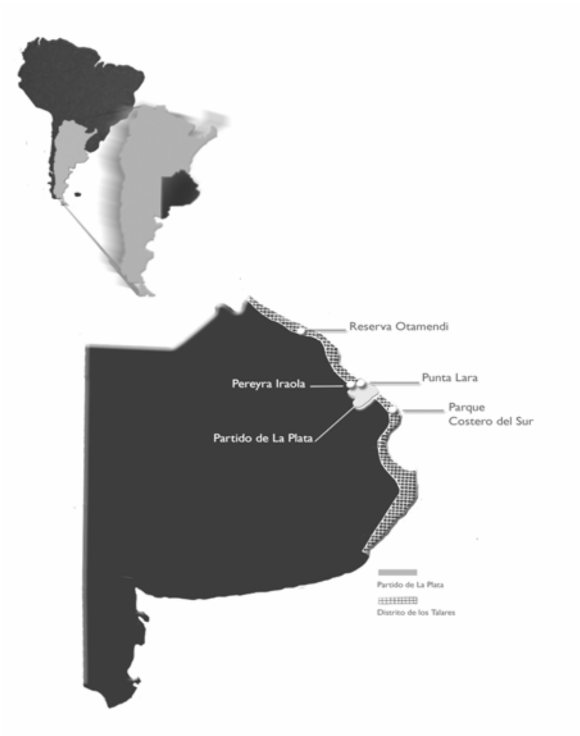

DESCRIPTION OF THE TALARES AREA

The administrative district of Talares spans the slopes of the Parana river and the province's coastal area up to the Samborombón Bay. (Figure 1). The climax vegetation was represented by white algarrobo (*Prosopis alba)*, and tala (*Celtis tala)*. Current tree species include *Celtis tala* (tala), *Scutia buxifolia* (coronillo), *Jodina rhombifolia* (sombra de toro), *Schinus longifolius* (molle), *Sambucus australis* (sauco), *Phytolacca tetramera* (ombusillo) and *Sapium haematospermun* (curupí). The *Celtis tala* forests underwent an intense degradation process due to the expansion of urban settlements, livestock raising and firewood exploitation (Parodi 1939). The current status of conservation shows that protection of *Celtis tala* forests is considered a priority due to their high biodiversity and fragility.

The unique characteristics of the Talares lead to the creation, in 1984, of the Biosphere Reserve "Parque Costero del Sur" (MAB-UNESCO), now considered a natural and cultural heritage site. This reserve consists of a group of natural interphases, with exceptionally rich flora and fauna. Its area stretches over 26.581 ha, of which 73% is covered by different grasslands, 9% by talares, 9% by scrublands and 1% by riparian forests. The remaining eight percent is covered by cultivated areas (Goya et al., 1992). Most of the area is privately owned and productive activities are not regulated. The area could be managed as a reserve if the administrators would balance economic and conservation interests (Arturi M., 1997).

There is little information on the biology of native tree species, the different purposes they could be used for and the genetic variation between and within the species. This lack of knowledge could lead to irreversible loss of genetic diversity even before any study on variability is made. The implementation of *in situ* and *ex situ* conservation strategies for native trees is considered absolutely necessary.

A NATIVE FOREST SPECIES GERMPLASM BANK IN BUENOS AIRES PROVINCE

The Faculty of Agricultural and Forestry Sciences of La Plata National University has proposed the creation of a Germplasm Bank for the conservation of native forest genetic resources. To implement this initiative, the active involvement of concerned agencies (including the Environmental Policy Secretariat of the Buenos Aires Province, and the Experimental Centre of Vegetative Propagation (C.E.Pro.Ve.) of the Faculty of Agricultural and Forestry Sciences) was obtained. The Centre has been working in plant propagation since 1983, mainly with forestry species, through conventional methods (macro propagation, seed technology) and biotechnology. The project was declared a provincial level project; it is supported by the Buenos Aires Province

Chamber of the Senate, and the Secretariat of Natural Resources and Sustainable Development of the Presidency.

The objectives of the germplasm bank are to:

- increase the number of accessions per species
- increase the number of tree and shrub species
- carry out molecular characterization of selected individuals and populations
- join forces with government agencies to develop *in situ* conservation schemes in protected areas
- obtain additional reproductive material to establish field tests and exchange it with other scientists.

ACTIVITIES

Since 1999, data on target species have been collected in a number of natural areas, including the restricted Natural Reserve Otamendi, the provincial Park Pereyra Iraola, the Punta Lara reserve and the Biosphere Reserve "Parque Costero del Sur" (Fig. 1), following a methodology proposed by Painting *et al.* (1993). Trees and seed-producing stands have been selected and marked, while material has been collected (Table 1) for the herbarium.

Most of the samplings are used to develop propagation protocols and seed analysis tests. The on-going project first phase studies the following species:

Acacia caven (espinillo)
Parkinsonia aculeata L. (cina-cina)
Erythrina crista galli L. (seibo)
Celtis tala Gill. ex Planch(tala)
Scutia buxifolia (coronillo)
Sesbania punicea (Cav.) Benth (acacia mansa)
Caesalpinia gilliesii (Hook.) Benth (barba de chivo)
Gleditsia triacanthos L. (acacia negra)

The following multiplication techniques are used:

- macro propagation (rooting of branches, roots, grafts)
- micro propagation (organogenesis, micro-grafts, embryogenesis somatic and meristem cultivation).

Complete plants have been obtained using these techniques. Cloned individuals are conserved in *ex situ* banks.

Seeds are being collected for conservation, after physiology studies have been carried out (feasibility and germination tests) out according to FAO/IPGRI gene bank methodologies. The facilities and the experienced personnel allow the Centre to operate as a Certifying Centre of Forestry Species Seeds, thus facilitating seed exchange with other institutions.

In addition, woody indigenous species including tala (*Celtis tala*), espinillo (*Acacia caven*) and cina cina (*Parkinsonia aculeata*) originating from Pereyra Iraola and Punta Lara Parks have been planted in the Ecological Park of La Plata Municipality (Buenos Aires) with the aim of evaluating growth and behavior.

Table 1: General information on forest tree accessions collected in the Talares (from 1999 to 2002)

Species	**Local name**	**Use**	**Number of samples**	**Number of collection sites**
Acacia caven	espinillo	Wood, medicines, ornamental, perfumes	28	7
Parkinsonia aculeata	cina-cina	Wood, honey, medicines, ornamental	33	10
Erythrina crista galli	seibo	Wood, medicines	35	8
Celtis tala	tala	Wood, animal and	12	6

		human food		
Scucia buxifolia	coronillo	Wood	5	3
Sesbania punicea	acacia mansa	ornamental	5	1
Caesalpinia gilliesii	barba de chivo	ornamental	3	2
Gleditsia triacanthos	corona de Cristo, acacia negra	Urban forestry, mucilage, honey, fodder, medicines	2	1

CONCLUSIONS AND FUTURE PROSPECTS

As mentioned above, the forest resources of the Northeastern region of Buenos Aires province are under significant threat and require urgent action to halt the perceived loss of genetic diversity. In spite of the on-going destruction of the native forests, the National University of La Plata and the provincial government of Buenos Aires have started a unique *ex situ* germplasm conservation programme of native forest species. Similar projects exist in other provinces of Argentina, i.e. the *Prosopis* Bank in Cordoba province, but, considering the size of the country, such efforts are still scattered and limited. It is hoped that in the near future more resources will be devoted to protecting and sustainably managing the unique genetic heritage of native Argentinean forest trees.

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A Review and Evaluation of Comparative Trials of Conifer Species in the Mediterranean

In the early 1960's, several coordinated activities took place between countries of the Mediterranean Basin, towards the establishment of comparative trials of forest tree species, provenances and progenies. In particular, at the 8th Session of *Silva Mediterranean* in Dubrovnik, 1962, participating countries agreed to set up a coordinated project for the selection of seed stands of Mediterranean conifers, which was later followed by seed collections, exchange and establishment of field trials. Several other bilateral and multilateral forest seed exchanges followed, with ad-hoc support from FAO, IUFRO and other international and national organizations.

In April 2002, countries participating in the 18th Session Committee on Mediterranean Forestry Questions *Silva Mediterranea* decided to review the results and outcomes of these seed exchanges, starting with Mediterranean conifers. A significant amount of field trials on conifers were established in the framework of the FAO/*Silva Mediterranea*/IUFRO network.

The French Ministry of Agriculture, FAO and IUFRO have expressed their willingness to support the evaluation work, in close collaboration with national institutions concerned. The objective of the work is to identify, evaluate, review and synthesize the results of comparative trials of conifer species established around the Mediterranean Basin that have followed international seed exchanges (starting with *Cedrus* spp., *Pinus brutia* and *Pinus halepensis*). Special emphasis will be given to the compilation of grey literature, unpublished assessments and evaluations, with other documented publications, so as to provide the international community with a regional overview of this important undertaking.

The French National institute for agronomic research (INRA) has started to compile a list of trials from information available in the archive of *Silva Mediterranea.* This preliminary list will be circulated to *Silva Mediterranea* member countries and countries where Mediterranean conifers have been tested (including Australia and the USA). An internet page, at the FAO Forest Genetic Resources site, will provide details of the progress of the work.
For more information, please contact: michel.bariteau@avignon.inra.fr.

CONSERVATION STATUS OF NATURAL POPULATIONS OF *EUCALYPTUS UROPHYLLA* IN INDONESIA & INTERNATIONAL EFFORTS TO PROTECT DWINDLING GENE POOLS

by
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INTRODUCTION

Eucalyptus urophylla naturally occurs on volcanically derived soils on seven islands in eastern Indonesia (Timor, Flores, Wetar, Lembata (Lomblem), Alor, Adonara and Pantar) at altitudes that range from 180 m to 3000 m (Figure 1). It is one of the most commercially important forest species as an exotic in the world. It is often crossed with *E. grandis* to produce hybrid progeny that are well adapted to tropical conditions and the hybrids are more disease resistant than the *E. grandis* parent.

To broaden the genetic base of *E. urophylla* for plantation forestry, organizations like the Commonwealth Scientific and Industrial Research Organization (CSIRO), Australia and the Centre Technique Forestier Tropical (CTFT, now CIRAD-Forêt), France have collaborated with the Indonesian government over the last three decades to make research seed collections of the species in natural stands on the seven islands (see Martin and Cossalter 1975 a-b; Martin and Cossalter 1976 a-e, Eldridge et al. 1994, Gunn and McDonald, 1991). The Brazilian government and private industry have also made small seed collections of *E. urophylla* in Indonesia, most notably in the 1970s and 1980s (Moura, 1983).

From 1996 to 2003, a new series of explorations and seed collections were made in natural stands of *E. urophylla* by research staff of PT Sumalindo Lestari Jaya, a private Indonesian forestry company and CAMCORE, North Carolina State University, USA, an international tree conservation and domestication programme. The collections were conducted with the assistance of the Forestry Research Institute, Kupang, Timor (Nusa Tenggara Timur).

The objective for these new collections were to assess the conservation status of *E. urophylla* across its natural distribution and to sample mainly untested populations that recently became assessable with the opening of new roads on the islands (Hodge et al. 2001). The goal was to distribute the genetic material to the CAMCORE membership for establishment of *ex situ* conservation banks and progeny tests. The conservation status of each population was assessed during exploration and seed collection and categorized according to rules developed by the International Union for Conservation of Nature and Natural Resources (IUCN) as either Low Risk (LR), Vulnerable (V), Endangered (EN) or Critically Endangered (CR) (see Farjon and Page, 1999).

RESULTS AND DISCUSSION

The collections were the most comprehensive made of the species to date.
In the seven years of seed collections, 62 populations and 1104 mother trees were sampled on the seven islands where *E. urophylla* is known to occur (Table 1, Figure 1). Explorations to the neighboring islands of Solor, Besar and Palue yielded no new sighting of the species. New populations were identified on most of the seven islands of known occurrence as the accessibility and local knowledge about the location of eucalypt populations were better than that available to previous collectors.

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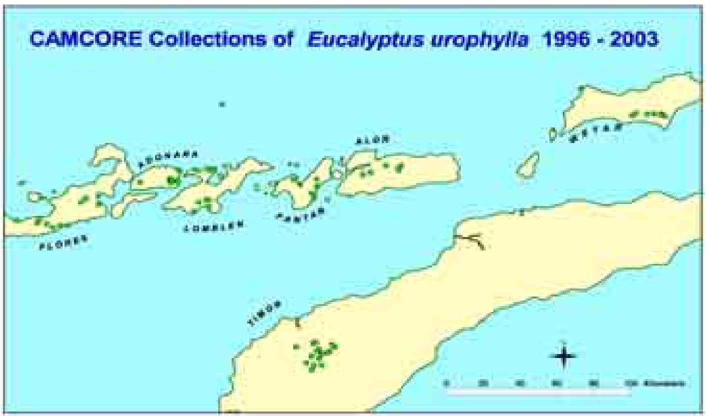
Of the 62 populations visited, the conservation status of 39% of these was classified as low risk, 24% as vulnerable, 20% as endangered and 5% as critically endangered. Populations identified as “low risk” all came from Wetar and Timor.

Table 1. Location of the *Eucalyptus urophylla* populations sampled and their conservation status. LR= low risk, V=vulnerable, E= endangered, and CR=critically endangered

Year	Island	Latitude	Longitude	Elev Range (m)	No. of Trees	Conservation Status
96	Adonara	08° 16' S to 08° 21' S	123° 03' E to 123° 18' E	494 - 1000	142	CR, V
97-99	Alor	08° 14' S to 08° 18' S	124° 30' E to 124° 45' E	320 - 1300	100	CR, E, V
98-01	Flores	08° 31' S to 08° 41' S	122° 15' E to 122° 47' E	220-980	221	CR, E
96-00	Lomblen	08° 16' S to 08° 34' S	123° 24' E to 123° 32' E	540 - 980	137	V, E
97-00	Pantar	08° 20' S to 08° 28' S	124° 03' E to 124° 12' E	380 - 840	97	E
97-01	Timor	09° 31' S to 09° 43' S	124° 04' E to 124° 19' E	1100-1655	299	LR
02-03	Wetar	07° 51' S to 07° 53' S	126° 15' E to 126° 28' E	409 - 750	118	LR

The detailed table of *E. urophylla* populations explored by the mission is available from W. Dvorak.

Figure 1. Geographic range of *Eucalyptus urophylla* and the location of the 62 populations sampled by the Sumalindo/CAMCORE collections.



The Wetar provenances are protected because of their geographic isolation and by the fact that the human population pressure on the island is still minimal. The Timor populations appear well conserved because most are within the boundaries of Mt. Mutis Forest Park.

The conservation situation is much different on the other five islands. All the *E. urophylla* populations sampled on Pantar and Flores are either endangered or critically endangered (Table 1). These include the well-known populations on the slopes of Mt. Egon and Mt. Lewotobi, Flores, such as Ile Nggele and Hokeng, respectively. The newly discovered population Koangao, Flores, is being converted to cassava plantations and will be lost in the next several years. Stands on Adonara, Lomblem and Alor range from vulnerable to critically endangered. The disappearance of important eucalypt populations is primarily the result of land conversion to agriculture and the establishment of more economical short-rotation crops like macadamia nut trees. It is realistic to assume that in 25 years time, all that will be left of the *E. urophylla* genetic base in Indonesia will be on the islands of Timor and Wetar.

Difficult challenges exist on how to conserve populations of *E. urophylla*, either *in situ* or *ex situ* for the long term. *Eucalyptus alba* occurs on the fringes of or within most *E. urophylla* populations and there must be regular gene flow between the two species. Questions about what represents a “pure species” remains. Socio-economic question can be asked about why small landholders in Indonesia should conserve *E. urophylla in situ* when other land use alternatives generate more income. *Ex situ* conservation efforts are made difficult because of contamination of pure lines of *E. urophylla* with pollen of other eucalypt species such as *E. grandis.* Furthermore, the long-term conservation of large number of populations is prohibitively expensive for many organizations.

CAMCORE has established more than 100 provenance/progeny trials of this genetic material in Argentina, Brazil, Colombia, Mexico, South Africa and Venezuela. An initial assessment of 32 trials of 23 populations and 434 families was made in 2001 and reported on by Hodge et al. 2001. A more complete analysis will be made in 2004.

CAMCORE intends to address these challenging conservation issues by conducting a comprehensive molecular assessment of the species that complements the allozyme work of House and Bell (1994). We envision that new molecular techniques will allow us to better examine questions about migration and genetic structure of the species. Our hope is to relate marker information to provenance results so that priorities can be identified for *in situ* conservation approaches in Indonesia and better define practical strategies for *ex situ* conservation.

This conservation and testing effort exemplifies the benefits of international cooperation. PT Sumalindo Lestari Jaya, co-sponsor of the project, does not plant *E. urophylla* commercially as is true for eight other CAMCORE industrial members. Yet all organizations in CAMCORE contributed some funds for the explorations and seed collections of *E. urophylla* and pay for all the field establishment, maintenance, and assessment of *ex situ* conservation plantings and genetic tests.

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COMPARISON BETWEEN SEED PRETREATMENTS OF THREE ENDEMIC *NOTHOFAGUS* OF MEDITERRANEAN CHILE[1]

by
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INTRODUCTION

The mesomorphic zone of Chile is one of the country's 27 biodiversity "hot spots". It hosts, among others, a forest ecosystem unique in the world: the Roble-Hualo forest type, also known as maulino forest, stretching between 35° 05' and 36° 50' S. This forest is the only *Nothofagus* formation growing in a typical Mediterranean climate, in a zone that hosts the highest number of endemism and rare endangered species of the country. It is also a centre of high variability for *Nothofagus,* and several species including ruil *(Nothofagus alessandri* Espinosa), huala (*Nothofagus leonii* Espinosa) and hualo (*Nothofagus glauca* (Phil.) Krasser) can be found. The genus Nothofagus belongs to the family Fagaceae. In Chile, this family is composed by 9 species and one natural hybrid *N. leonii* (a natural cross between *N. obliqua* and *N. glauca).*

This ecosystem is under various threats. Long summer draughts (rain falls in form of heavy precipitations during the few winter months) contribute to the fragility of these relic stands. On the other hand, anthropic pressures (land use conversion to shifting agriculture, charcoal and firewood production and the substitution of natural stands by exotic plantations) tend to fragment and encroach on the forest. Only 0.05% of this ecosystem is represented in the State's National System of Wild Protected Areas (SNASPE).

Species restoration programmes, including the establishment of gene banks, *ex situ* conservation stands or assisted regeneration in protected areas, are sometimes necessary, and rely on the availability of *Nothofagus* reproductive materials of appropriate genetic, physiological and physical quality in appropriate quantities. Basic knowledge of seed collection, treatment, handling and storage is a prerequisite to operational programmes. The study summarized in this paper aimed at finding the most appropriate pretreatment for *Nothofagus alessandri*, *Nothofagus leoni,* and *Nothofagus glauca* seed to obtain the highest capacity and germination energy. It will also analyze other specific aspects in order to:

- determine whether the application of pretreatment gives better results than no pretreatment (controls);
- analyze results of germination through the application of 2 chemical compounds that have shown favorable results in other species of *Nothofagus*. These compounds are giberelic acid (GA_3) and Tiourea at different levels of concentration and different periods of exposure.

METHODOLOGY

The analysis was carried out in the Chillán Seed Centre; seed was harvested during the 2002 season, in the National Reserve of Los Ruiles (35° 49' S), Chanco, VII region. 50 seeds were sampled with 4 repeated applications for each treatment, and the seeds were distributed on a random base. The seeds were raised in germinators. Although treatments differed slightly between species, the main factors studied were:

- Stratification in wet sand at 2-4ºC for 2 to 8 weeks (treatments E);
- immersion in Tiourea (from 2 to 6 days) at different concentrations (from 05% to 1.0%) (T); and
- immersion in giberelic acid GA3 for 2 to 3 days (at concentrations between 200 and 600 ppm) (G).

Two variables were calculated:

- Relative germinative capacity (RGC): = % of germinated seeds out of total number of viable seeds

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- Average time (AT) which measures the germinative energy (GE), and the average time that seeds take to germinate.

RESULTS AND CONCLUSIONS

Nothofagus glauca

- The treatment with low concentration giberelic acid (200 ppm) was the most appropriate to improve both RGC and AT, although all pretreatments lead to better results than controls without pretreatment.
- The most appropriate treatments to increase the germinative capacity were immersion in giberelic acid at 600 and 200 ppm (giving a success rate of 72%). The best results in terms of average time variable were obtained by a 6 week stratification associated with a 3 day immersion in giberelic acid at 200 ppm (13.3 days).

Nothofagus alessandri

- Best results was obtained through six-week stratification, giving a relative germinative capacity (RGC) of 72.7% and a 58.0 % germinative energy (GE) on day 16.
- The average germination time was 16 days. Only if 2 pretreatments were applied, would 70% have germinated during that time.

Nothofagus leonii

- The best pretreatments consisted in immersion in giberelic acid at 200 ppm, giving a RGC of 87.5% and a GE of 83.3%, followed by higher giberelic acid concentrations (400 ppm). for 2 days, with 85.4% of relative germinative capacity and germinative energy.
- The average germination time was 16 days.

These results are the first step towards the finalization of comprehensive seed collection and handling protocols for each individual species, with the final objective to produce the highest amount and the best quality of plants for future *ex situ* conservation activities. They will hopefully contribute to a better protection, management, conservation and use of the unique Mediterranean *Nothofagus* forests.

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TEN YEARS OF INTERNATIONAL COLLABORATION ON FOREST GENETIC RESOURCES IN EUROPE

by
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INTRODUCTION

In October 1994, the European Forest Genetic Resources Programme (EUFORGEN) was established to promote conservation and sustainable use of forest genetic resources and coordinate international collaboration in this area among European countries. In the early 1990's, two Ministerial Conferences on the Protection of Forest in Europe (MCPFE) had initiated and endorsed the establishment of EUFORGEN. The Programme is financed by participating countries (currently 32) and coordinated by the International Plant Genetic Resources Institute (IPGRI) in technical collaboration with the Food and Agricultural Organization of the United Nations (FAO). The EUFORGEN Steering Committee, composed of national coordinators nominated by the participating countries, has the overall responsibility of the Programme.

EUFORGEN has been operating through species-oriented networks which have brought together scientists and managers to exchange information, discuss needs and develop conservation methods for priority tree species. Countries' financial contributions to the Programme are used for the overall coordination of the activities, including Network meetings, publications and dissemination of information while Network members in participating countries carry out agreed activities with their own resources as in-kind inputs.

In May 2004, the EUFORGEN Steering Committee endorsed the continuation of the Programme into Phase III (2005-2009). This paper provides a short update on the recent outputs of EUFORGEN and describes its planned future efforts.

RECENT OUTPUTS

During Phase II (2000-2004), EUFORGEN operated through five Networks, namely 1) Conifers; 2) Mediterranean Oaks; 3) Noble Hardwoods; 4) *Populus nigra* (European black poplar), including work on white poplar *P. alba*); and 5) Temperate Oaks and Beech. The last Network was called 'Social Broadleaves' until 2002. A total of 17 EUFORGEN Network meetings were held during Phase II and participants from 41 countries participated in these meetings. The Networks have produced a considerable amount of technical information on forest genetic resources in Europe and developed strategies and recommendations for genetic conservation of a large group of tree species growing in different forest ecosystems throughout the continent.

The main objective of the conservation strategies is to ensure continuous evolution of European forest trees. *In situ* conservation efforts are given a first priority but it is emphasized that *in situ* and *ex situ* conservation measures should be used in a complementary manner, according to threats and species-specific needs for genetic conservation. During Phase II, the Noble Hardwoods Network has developed conservation strategies for black alder (*Alnus glutinosa*) (Krstinic et al. 2002), walnut (*Juglans regia*) (Fernándes-Lópes et al., 2002) and elms (*Ulmus* spp.) (Collin, 2002). The *Populus nigra* Network produced a technical bulletin on the *in situ* conservation of black poplar (Lefèvre et al. 2001) and the Mediterranean Oaks Network has also finalized a similar bulletin for cork oak (*Quercus suber*) (Varela et al., 2004).

One of the major achievements of the EUFORGEN Networks is development of technical guidelines for the genetic management of forest tree species. These practical guidelines present commonly agreed

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recommendations based on the available knowledge of the species and they are targeted specifically at field managers. So far a total of 16 guidelines have been published and 15 new ones are expected by the end of 2004[2]. Technical guidelines also include revised distribution maps of the target tree species. The development of these maps has involved several partners in North Africa and West Asia.

Standardized descriptors are commonly used in *ex situ* gene conservation activities (they are used *i.a.* for documentation and exchange) but they are also needed for *in situ* conservation. The Networks have made efforts to develop standard descriptors, as a first step towards the identification of minimum genetic conservation requirements for target species in the long term. In 2000, the *Populus nigra* Network finalized a standardized list of descriptors for black poplar stand inventories. Other Networks had already developed similar descriptors for inventories of various species during Phase I (1995-1999).

The Networks have significantly contributed to the *ex situ* conservation of forest genetic resources in Europe. Several members of the Noble Hardwoods Network participated in an EU-funded project on elms (*Ulmus* spp.), which established a core collection with more than 850 clones. Nearly half of the clones are also cryopreserved in liquid nitrogen (Collin et al. 2004). European elms are seriously threatened by the Dutch elm disease (*Ophiostoma novo-ulmi*) and this project made an effort to strengthen their *ex situ* conservation. The *Populus nigra* Network had earlier established another core collection for black poplar which includes material from more than 20 countries; efforts have been made to receive new entries from outside Europe (inc. Algeria and China). Development of a core collection for white poplar is underway and the Network has also established a population collection for black poplar. The latter was created following an EU-funded research project which analyzed genetic diversity of black poplar along European rivers (van Dam and Bordács, 2002). Black poplar is threatened by habitat alteration for agriculture, urbanization of floodplains and hydraulic engineering of rivers that have destroyed natural populations in many parts of Europe (Lefèvre et al., 2001).

The Mediterranean Oaks Network facilitated the exchange of cork oak genetic material within another EU-funded research project. Acorns were collected from seven countries (Algeria, France, Italy, Morocco, Portugal, Spain and Tunisia) for 17 field trials, which were established in all these countries (except Algeria) (Varela, 2000). This network of trials holds a unique collection of cork oak genetic material as it contains material throughout the species' natural range in the Mediterranean basin.

During their meetings, the Networks have also addressed global issues, such as the use of exotic tree species in forestry and climate change. European forestry is mostly based on native species but exotic trees, in particular North American conifers, have a considerable role in such countries as Iceland, Ireland and the UK. It should be noted that the number of exotic forest trees that have become invasive in Europe is low, compared to other regions of the world (Haysom and Murphy, 2003). The Conifers Network addressed the issue of conserving and using exotic conifer species in Europe at its meeting in Scotland, UK in October 2003. The discussions highlighted the role of exotic conifers not only in wood production but also in environmental protection. Some exotic conifers were reported to show adaptation to their new environment and this may lead to the emergence of 'landraces'. The participants stressed that this locally adapted genetic material should be conserved and that this issue should receive more attention in the future.

The Mediterranean Oaks Network discussed the effects of climate change on the Mediterranean forests in Macedonia in November 2003. Participants noted that forest trees have always been exposed to changes in environmental conditions and that the evolutionary principles under which forest trees cope with these changes are the same even if the speed of change is faster due to human-induced climatic change. Acclimation, seed dispersal, existing additive variance in important traits, mutation rates in these traits, speed of evolution and mating pattern were highlighted as important factors which determines how trees react to climate change. Droughts are expected to be more prolonged in the Mediterranean Basin, thus increasing the occurrence of forest fires. In Portugal, for example, some 450,000 hectares or approximately 12 percent of the forest area were burnt in 2003 (Varela, pers. comm.) and the likelihood of such catastrophes is expected to increase in other Mediterranean countries as well.

[2] Technical guidelines, and more detailed information about the Programme, are available at www.euforgen.org

BROADER IMPACTS

The international collaboration through EUFORGEN has supported the development of or strengthened national programmes and policies for management of forest genetic resources in many European countries. However, still less than 30 per cent of European countries have well-established national programmes on forest genetic resources while approximately in one third of the countries these programmes exist informally (Koskela et al., 2004). Currently, most European countries are increasingly developing national forest programmes (NFPs) encompassing the whole forest sector. However, while NFPs address biodiversity management, they tend to highlight species and habitat conservation and overlook genetic issues. There is a need to strengthen the role of forest genetic resources in biodiversity management and highlights its importance in NFPs.

EUFORGEN has created a platform for both formal and informal collaboration and exchange of information on forest genetic resources in Europe. EUFORGEN Networks have facilitated identification of research needs and development of various research projects. Results have been disseminated through the Networks once the research projects have been completed. EUFORGEN has also been asked to contribute to the development of new European policies and other measures, such as the new Council Regulation on genetic resources in agriculture (EC No 870/2004) and forest biodiversity indicators, for example. Furthermore, EUFORGEN has facilitated the development and implementation of other efforts on forest genetic resources in Europe (including bilateral projects and training courses).

Outside Europe, IPGRI and FAO have used EUFORGEN as an example for similar regional initiatives on forest genetic resources, namely the Asia Pacific Forest Genetic Resources Programme (APFORGEN) and the Sub-Saharan Forest Genetic Resources Programme (SAFORGEN). EUFORGEN has provided advice and experience with networking to these programmes, as well as relevant contacts for them in Europe.

FUTURE CHALLENGES

During the new phase of EUFORGEN, the challenge is to translate the various recommendations and guidelines into practice. This means a stronger incorporation of genetic issues into national forest programmes, which provide the framework for implementing forest-related policies at country level. At operational level, there is a need to increase awareness among field managers on the role of forest genetic resources in sustainable forest management. Information management has also been identified as an area where improvements can considerably support the implementation efforts and monitoring of forest genetic resources.

EUFORGEN will continue to develop common action plans, which aim at sharing responsibilities for forest genetic resources conservation in Europe. The plans are an effort to create pan-European networks of primarily *in situ* conservation units of target tree species throughout their entire distribution ranges. This effort involves obtaining geo-referenced data for further analyses and action. *Ex situ* conservation units outside the species' natural distribution ranges should be included if they contribute to dynamic gene conservation. Common action plans can help identify gaps and overlaps in gene conservation efforts at both national and pan-European level. Subsequently, countries can assess which gene conservation units under their responsibility are the most valuable ones from the pan-European perspective and can prioritize the use of their human and financial resources.

The Steering Committee decided to re-organize the EUFORGEN network structure and merge the current five species Networks into three new ones: 1) conifers, 2) broadleaved tree species with scattered occurrence and 3) broadleaves with a continuous range. New thematic structures, namely a Forest Management Network and an Information Working Group, will be established to complement the work of species-oriented networks. With these thematic tools, EUFORGEN will better promote the implementation of the recommendations presented in the technical guidelines and support the integration of gene conservation issues into national forest policies and programmes. Furthermore, the Programme will focus on developing protocols to evaluate the genetic effects of different management practices and identifying genetically appropriate management practices in collaboration with forest managers and policy-makers.

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