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FOREST GENETIC RESOURCES

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TABLE OF CONTENTS

Cover Photo: Pine seedlings, Honduras (Photo: FAO)

All contributions for the next issue should be sent by 15 June 1999 to:

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NOTE FROM THE EDITOR

The management of forest genetic resources to ensure their conservation, improvement and sustainable use is a complex challenge, in which solutions will depend not only on the genetic variation and variation patterns of the species targeted for conservation and their intrinsic biological characteristics, but also on the degree of knowledge available on such species and their silviculture and management, the degree to which they are presently used and their importance and uniqueness in this regard, perceived threats and, quite decisively, on institutional capacities in countries directly concerned, including infrastructure and availability of funding.

As reported in the previous issue of Forest Genetic Resources (FGR No 25, 1997), FAO in collaboration with a number of partner organizations is supporting the organization of a series of country-driven, action-oriented regional forest genetic resources workshops. A brief report on the outcome of the first of these workshops, which covered countries of dry-zone sub-Saharan Africa, is given in the present issue. A similar workshop is planned to be held in the South Pacific in April 1999, as recommended by the meeting of the Heads of Forestry of Pacific Island Countries in September 1998. The South Pacific workshop will be organized in collaboration with the Australian-coordinated SPRIG project (South Pacific Regional Initiative on Forest Genetic Resources), the Secretariat of the Pacific Community (SPC), and a number of regional projects operating under the auspices of the SPC. Later the same year another workshop is planned for countries in Southern and Eastern Africa, to be organized in collaboration with the Southern Africa Development Community, SADC, as a result of discussions held during the Third Meeting of the SADC Technical Sub-Committee for Forestry Research, held in Botswana in October 1998.

The purpose of these and future workshops is to further the development of regional plans and programmes for coordinated action, founded on national priorities and needs, and based on common understanding of principles and mechanisms for the determination of priorities for species and specific conservation-related activities, such as conservation, field testing and improvement. Dialogue and incorporation of the views and aspirations of a range of interested parties at both national and regional levels is considered central to future success, as priorities will be dependent on value judgements which may differ widely among stakeholder groups. The overall aim is not to develop one single model of conservation applicable to all countries and all species, but to agree on concepts, principles, methodologies, priorities and options for concerted action at regional level. While national programmes and priorities will form the building blocks for regional strategies, streamlining of action and strengthening of regional collaboration is likely to help further develop and justify work also at the national level, and will undoubtedly compound the overall impact of such work. To the extent possible, regional plans and programmes should be, in turn, compatible with priorities and programmes in other geographical regions, with the ultimate aim of arriving at a coherent international framework for action in the conservation, enhancement and sustainable utilization of forest genetic resources.

This issue of FGR includes a number of reports from different countries and regions of the world, which cover various aspects of the management of forest genetic resources. Recognizing that conservation is not a limiting factor for development but a precondition for lasting well-being, these activities constitute important components of national conservation and gene management programmes, and contribute towards the sustainable and wise use of existing forests and forest resources. They also contributes, individually and in unison, towards global aims to safeguard and sustainably utilize forest genetic resources to meet present-day and future needs.

In relation to administrative matters, the previous issue of FGR included a detachable form for completion by readers, which will be used to up-date our mailing list. We would appreciate it if those readers who have not already done so could please complete this form or, alternatively, inform us by letter or e-mail of their interest in continuing to receive the news-bulletin on a regular (annual) basis. Please also note that contributions and brief articles of global interest for future issues are welcome. These should generally not exceed 2 000 words. The Secretariat maintains the right to edit material accepted for publication. Please address correspondence to:

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At the homepage, our readers can find general information on forest genetic resources, information on FAO's work in this field, links to other Internet sites on forest genetic resources and a list of FAO publications. The following FAO publications are available, on-line, in English, French and Spanish:

- ✓ Report of the 9th session of FAO Panel of Experts on Forest Gene Resources (1995)
- ✓ Report of the 10th session of FAO Panel of Experts on Forest Gene Resources (1997)
- ✓ *Forest Genetic Resources* No. 23 (1995), No. 24 (1996), No 25 (1997). No. 26 (1998) will be available from January 1999.

Issues of *Forest Genetic Resources* can also be accessed directly at the following address:

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MULTI-SITE PROVENANCE TRIALS OF *PINUS RADIATA* IN NEW ZEALAND[1]

by

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This article summarises the results from a New Zealand-wide series of 24 provenance trials of native provenances of *Pinus radiata* from the Californian mainland, USA with three local 'land-race' controls included. This coverage gave a clear picture of the adaptive profiles of three discrete native populations. Among them, Año Nuevo proved best adapted to the cold, snow-hazard sites, and Monterey to the warmest sites and infertile clay soils, while Cambria showed no distinctive adaptive advantage. The land-race controls had derived in varying proportions from Año Nuevo and Monterey, mostly the former, and showed some adaptive differentiation.

INTRODUCTION

A single provenance trial provides a snapshot of the comparative performances of the various provenances. Yet, by the very nature of differentiation among provenances, their relative performances could differ widely among the sites where the species might be used. With replication on a limited number of sites, such variation in relative performance may be evident, but its underlying pattern may not be clearly and unambiguously revealed. A thorough geographic coverage of potential planting sites is the ideal, but is costly. It is thus of interest to review a case history which illustrates the advantages, and some problems, of such a coverage in order to obtain a clear overall picture. This article covers such a case in an adaptation of a paper by Burdon *et al.* (1997).

Pinus radiata, the species concerned, is by far the main commercial forest tree in New Zealand. Now occupying nearly 1.5 million ha, this introduced species represents about 90% of the country's plantation forest estate. An intensive breeding programme began in the early 1950s, starting from local, New Zealand 'land-race' stocks arising from seed importations made during about 1860-1880, rather than awaiting provenance trial results. Preliminary provenance testing, from plantings made in 1955 and the mid-1960s, and some other lines of evidence, showed that the decision to start breeding from the local stocks was basically correct, but that further importations and testing of native population stocks looked worthwhile. This was because the local NZ stocks were clearly based on a very incomplete and unbalanced sample of the native range, while the Monterey population, which was evidently very under-represented in the land-race ancestry, seemed likely to have adaptive advantages for some sites. Accordingly, a joint Australia-New Zealand seed collecting expedition was made, with the help of some FAO funding, to the native stands in mainland California in early 1978 (Eldridge 1978, 1979). The distribution of the seed was handled by CSIRO Division of Forest Research, Canberra. The large majority of it was used in Australia and New Zealand for establishing both provenance trials and gene resource plantings, but some was distributed to a number of other countries for provenance testing. Results of the New Zealand provenance trials are covered here, but reference is made to some other trials, especially those in New South Wales, Australia.

[1] Received July 1998. Original in English.

THE TRIALS

Seedlots

Collection was from the populations at Año Nuevo (Lat. 37° N), Monterey (36½° N) and Cambria (35½° N) on the Californian coast, USA. In all, 13 local subdivisions of these populations were sampled with seed from 20-70 trees. For the trials, the seed from each of these subpopulations was bulked into a single composite lot. Three broadly-based local 'land-race' lots were included as controls, from Kaingaroa Forest (Lat. 38½° S) in the volcanic plateau of the central North Island, the Nelson area in the north of the South Island (41½° S), and the far south of the South Island ('Southland') (*ca* 46° S).

Trial sites and assessment

Trials were planted in 1980 on 23 sites, with one more trial in 1983. The test sites were spread almost throughout the country, including all regions where the species is grown on a significant commercial scale. Some of the sites were chosen as being extreme, representing difficult soils, or high rainfall, or severe coastal exposure, or frost and/or snow hazards, in order to probe the adaptive limits of the material. At six sites 6-tree x 6-tree plots ('large plots') were used, to obtain some indication of crop performance, 6-tree row-plots being used elsewhere.

The main assessment was made at varying ages, 5½-11 years from planting, in order to catch trials with differing growth rates at similar mean top heights (mostly 7-10 m). Traits assessed on individual trees usually included: survival; (as applicable) cause of mortality or other failure to produce an assessable stem; breast height stem diameter; predominant height; scores for stem straightness, branch cluster frequency (the species varying widely in degree of polycyclism or 'multinodality'), and degree of stem malformation; and stem acceptability. At eight sites bark thickness was recorded on a sample of trees. Where significant, levels of needle cast attributed to *Cyclaneusma minus* and *Dothistroma pini* respectively were scored, as were cases of wind or snow damage and any other noteworthy disorder. For the large-plot trials stem basal area per ha was calculated.

A follow-up assessment, primarily for stem diameter, was made at seven sites in 1995, and included the two sites not covered in the first main assessment.

In addition, a comparative study was made of monoterpene composition in oleoresin collected from near shoot tips on one site at five years from planting.

Statistical analysis was done site by site for comparing: local subpopulations within the main native populations, the main populations with each other, native populations with the local controls, and the controls with each other. From these results, it was decided to synthesise the overall picture by calculating relative performance (RP) figures (Burdon, in press) at each site, setting each trial mean to 100, and examining the pattern of RP values.

RESULTS

At most sites, marked provenance differences were evident. However, the pattern of differences varied widely among sites, revealing obvious provenance x site interaction. Some of the sites clearly fell into definable categories, which shared common geographic features and showed common and distinctive patterns of relative performance among the populations. Some key results for the site categories, which were admittedly drawn up on a somewhat subjective *post hoc* basis, are summarised in Table 1. Some other selected results are shown in Table 2.

Table 1. Relative Performances of provenances as at first main assessment, averaged by site categories for stem diameter and large-plot basal area

Site category	No. of sites	Provenance			
		Año Nuevo	Monterey	Cambria	New Zealand
Diameter					
Infertile clays	3	92	105	102	99
Coastal dunes	2	97	102	100	103
Volcanic plateau	4	97	102	93	106
Central	5	98	100	96	105
Southern S. Island	6	99	100	96	104
Basal area					
Infertile clays	1	68	121	109	94
Coastal dunes	1	96	103	99	102
Volcanic plateau	2	91	101	96	116
Southern S. Island	2	126	89	57	127

Table 2. Overall provenance mean Relative Performance values for other traits.

Trait	No. of sites	Provenance			
		Año Nuevo	Monterey	Cambria	New Zealand
Dothistroma resistance	3	108	104	71	122
Uprooting resistance[2]	5	133	91	84	100
Snow break resistance	3	106	94	86	125
Total snow resistance	3	124	90	81	104
Branching frequency	18	92	100	98	114
Stem acceptability	14	99	96	96	112

Native material

The most striking features of the results are:

- The inferiority of the Año Nuevo population on the infertile, phosphorus-deficient clays, two of which were in the Northland Peninsula, and one near Nelson, NZ. Associated with this was the relatively poor performance, compared with elsewhere, of the New Zealand material, which overall has derived mainly from Año Nuevo with the balance of its ancestry coming from Monterey. For stem basal area per hectare, at the one such site where it was measured, Monterey outperformed Año Nuevo and the New Zealand material by 76% and 33% respectively.

- The superiority of Año Nuevo in the Southeast of the country, particularly on the higher-altitude, snow-hazard sites. This pattern paralleled the different rates at which the populations assumed

[2] Including uprooting by snow

adult morphology, with Cambria which showed the most persistent juvenile characteristics performing worst on these sites.

- The greater susceptibility of Cambria to needle cast, especially Dothistroma needle blight. This disease clearly depressed diameter growth where it was prevalent, particularly at the 15-year assessment.

Other features of the native-population comparisons included: generally least transplanting mortality in Año Nuevo and most in Cambria; a tendency for relatively even performance on coastal sand dunes; Cambria showing the straightest stems; and, interestingly, the Año Nuevo showing a markedly stronger tendency to become less 'multinodal' on the colder and more southerly sites.

Local differentiation for performance in the native populations was generally weak, although the subpopulations at the fringes tended to be slightly less vigorous. However, at 15 years the northern outlier of Cambria, by Pico Creek, was showing appreciably lower inside-bark diameter and thicker bark than the two other subpopulations. The two subpopulations from the inland fringes at Año Nuevo showed anomalous monoterpene composition (Burdon *et al.* 1997) which is suspected to have resulted from genetic drift associated with known past re-colonisation.

Land races

The New Zealand 'land races' were generally superior, the main exceptions being growth and survival relative to Monterey and Cambria on infertile clays, and resistance to uprooting by snowfalls relative to Año Nuevo. This superiority appears to reflect a combination of release from the neighbourhood inbreeding in nature and responses to natural and silvicultural selection in the adoptive environments. A striking feature was a shift to more 'multinodal' branching in the Kaingaroa material. Also of note was some superiority of the Southland lot in the southern parts of NZ, particularly on snowy sites. From bark thickness data, and monoterpene composition (Burdon *et al* 1997), the New Zealand material showed 60% or so of Año Nuevo ancestry overall, the balance being Monterey. For both Kaingaroa and Southland the proportion was two-thirds or so, and for Nelson slightly under one-half.

DISCUSSION

Lessons for breeding in New Zealand

The results strongly indicate that an increased contribution from the Monterey population could be of value for producing improved stocks with better adaptation to warm sites in New Zealand, especially those with infertile, phosphorus-deficient soils which occupy a major area of land that is already planted or potentially available for planting. Even though phosphorus fertiliser is easily applied, and routinely so on many such sites, there are indications that it would still not remove the adaptive advantage of Monterey material. With such an improvement in adaptation, commercial afforestation could well be extended on to land that is now avoided because of its low quality, even after fertilisation.

By contrast, however, the Monterey population seems to offer little, if anything, in the way of adaptive advantages for the far south of New Zealand. Cambria, despite its tolerance of the infertile clays and resistance to *Phytophthora cinnamomi* when planted in Western Australia, has shown no clear adaptive advantage for New Zealand conditions. However, the advent of some new disease or pest might change the situation. Moreover, the results do not address the less predictable advantages that might accrue from completely new combinations of genes resulting from hybridisation among populations.

It is of note that the pattern of results agrees well with that obtained by Johnson *et al.* (1997) in New South Wales, Australia, and by Falkenhagen (1991) in South Africa, but has added the major dimension of the superior tolerance of Año Nuevo to cold, snow-hazard sites and has compared local 'land races' with native provenances.

One aspect not covered by this study was the promise shown by the Guadalupe Island population (Low & Smith 1997). This distinctive Mexican population (*P. radiata* var. *binata*) is now being trialed as F1 hybrids with improved New Zealand stock on a limited commercial scale. The hybrids show superior stem straightness and wood density from the Guadalupe parentage, combined with the superior growth rate of the mainland-origin parents. They evidently have most of the adaptive advantages of the New Zealand parentage, but their full site tolerances are still unproven. Hopefully, however, they may have superior resistance to winter cold and/or exposure. The one other native Mexican population, from Cedros Island (*P. radiata* var. *cedrosensis*), is not being pursued as a commercial prospect in New Zealand.

There remains the issue of the longer-term *ex-situ* management of the native-population material from USA and Mexico. The technical ideal is to maintain pure *ex-situ* populations in New Zealand and, in parallel, to promote intercrossing that will generate completely new gene combinations in the various hybrid generations (Burdon 1988). That way, conservation of 'pure' populations can be practised, so maintaining any existing co-adapted gene complexes, and yet provision is still made for arriving at new gene combinations that may be co-adaptive in the exotic environments. However, conserving pure populations in the field with adequate genetic bases can be compromised by risks of pollen contamination, unless controlled pollination is done (Eldridge 1997). Systematic controlled crossing is very costly, and even maintaining spontaneous hybrid swarms can involve both logistical challenges and opportunity costs. To be sure of doing things properly, therefore, makes heavy demands on funding, technical skills and political will.

Nevertheless, a firm commitment exists in New Zealand to maintaining pure Guadalupe Island material by controlled crossing between select individuals (Low & Smith 1997). This will serve to capture the advantages of F1 hybrids with local mainland-origin stock in production populations, and meets an ethical obligation posed by the progressive extinction of this native island population by introduced goats.

Lessons for provenance testing in general

Overall, quite a complex picture has emerged very clearly from the series of trials. This was obtained without any elaborate statistical analysis of provenance x site interaction, although such analysis (e.g. Ades & Garnier-Géré 1997) is well worth pursuing.

The complementarity of the information provided by the various trials was crucial. Some of the key differences in site tolerances were revealed by a relatively few trials, although different trials revealed different features of the tolerances. In some cases, the provision of one type of information, e.g. on resistance to climatic damage or disease resistance, can virtually obliterate other types of information, e.g. on growth potential or inherent tree form. Some trials were inevitably less informative, through giving inherently imprecise results, or through weaker expression of provenance differences, although the latter still represents very valid information. Usually, some trials will be effectively lost, or their information weakened, through mishaps; in the present case one trial received two inadvertent thinnings. One trial which was installed primarily to test frost resistance was largely unsuccessful, because of complications arising from a combination of boron deficiency and winter waterlogging, but the particular information could be pieced together from results of other studies (Burdon 1992). Yet we suffered no total losses of trials.

We had the advantage of the extreme importance of the species allowing us to establish numerous trials. Against that, the diversity of sites on which it is grown in New Zealand, combined with the lack of a strict genecological pattern, demanded an elaborate empirical coverage. Moreover, the large-plot trials would be a luxury in the early phases of a testing programme.

The existence of only five discrete native populations makes *P. radiata* in one sense a very simple case. However, its great economic importance can make subtle differences in performance important. At the same time, the coverage of local differentiation both in the native populations and within New Zealand, by leading to the testing of a total of no fewer than 16 distinct seedlots, should make our experience quite broadly applicable.

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FAO/IPGRI/ICRAF WORKSHOP ON THE CONSERVATION, MANAGEMENT, SUSTAINABLE UTILIZATION AND ENHANCEMENT OF FOREST GENETIC RESOURCES IN DRY-ZONE SUB-SAHARAN AFRICA

by

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Thirty-five participants took part in the above workshop held at the Centre National des Semences Forestières, Ouagadougou, Burkina Faso, 22 - 24 September 1998. National experts from 15 countries attended, as well as representatives from the organising institutions (FAO in collaboration with IPGRI and ICRAF) and 6 other international, regional, bi-lateral and national agencies. The objective of the workshop was to assist countries in the Sahelian sub-region of Africa to assess the status of their forest genetic resources and to prepare a regional plan of action. During the workshop delegations presented reports on the national status of their forest genetic resources and discussed a draft synthesis report covering the sub-region (compiled beforehand on the basis of 12 individual national reports). Based on the discussions, a sub-regional plan of action on forest genetic resources was prepared and recommendations made for immediate follow-up and implementation.

BACKGROUND

The Leipzig Conference (June 1996) adopted a Global Plan of Action for the Conservation and Sustainable Utilization of Plant Genetic Resources for Food and Agriculture. However, for a number of reasons, forestry was specifically excluded from this plan. As a first step toward developing a Global Plan of Action for Forest Genetic Resources and following recommendations made in March 1997 by the Committee of Forestry, FAO's highest governing body on forestry issues, FAO has initiated action to help plan and co-ordinate a series of regional and sub-regional workshops on forest genetic resources. This is a collaborative process in close linkage with national and international partners.

The overall goal of these workshops, on the conservation, management, sustainable utilization and enhancement of forest genetic resources, is the development of dynamic, country-driven and action-oriented regional and sub-regional plans. Plans are developed to help ensure that forest genetic resources are conserved and sustainably utilized as a basis for local and national development, providing food security, poverty alleviation, environmental conservation, economic and social advancement, and the maintenance of cultural and spiritual values. These action plans must be compatible with national, regional and international strategies in other areas that together contribute to overall sustainable development. Where they exist, national forest genetic conservation programmes will constitute the building blocks of regional and sub-regional action plans. It is therefore acknowledged that regional plans and programmes will vary according to national needs and priorities, as well as local biological, social and economic environments. The aim is not to develop one single

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model for conservation, but the elaboration of a framework for coordinated action at the sub-regional or regional levels that enhances and supports action at a national level (for background information, see Forest Genetic Resources No. 25, 1997, p. 15-19).

THE OUAGADOUGOU WORKSHOP

In 1997 FAO, IPGRI and ICRAF joined forces to begin organizing a workshop on the conservation, management , sustainable utilization and enhancement of forest genetic resources in sub-Saharan dry-zone (Sahelian) Africa.

As a first step, two consultants from the sub-region (namely Mr. Bernard Kigomo, Kenya Forestry Research Institute and Mr. Albert Nikiéma, Centre National des Semences Forestières, Burkina Faso) were contacted to assist countries in collating available information on forest genetic resources. They travelled to 13 selected countries for direct discussions between November 1997 and February 1998. The consultants covered (respectively): (i) six English-speaking countries of East and West Africa; and (ii) seven French-speaking West-African countries. Other countries that could not be visited were informed of the process and invited to contribute. The consultants visited interested parties in individual countries and proposed the identification of focal points for the elaboration of national reports to be presented at the workshop. They also discussed the format and content of these reports, in order to cover all aspects related to forest genetic resources and to facilitate the elaboration of a regional synthesis later.

In March 1998, IPGRI, in collaboration with FAO, the Danida Forest Seed Centre, CIRAD-Forêt and other partners, organized a regional training course on the conservation and sustainable use of forest genetic resources for French-speaking countries of western and central Africa and Madagascar. Several national focal points were present. The training course, the first of its kind in the region, covered all fields related to forest genetic resources and emphasized the need for country-driven concerted action at national and regional levels[5].

In preparation for the workshop, IPGRI-consultant O. Eyog Matig (Cameroon) prepared a draft regional synthesis, based on the 12 country reports received by mid-August 1998.

The workshop itself was held at the Centre National de Semences Forestières, Ouagadougou, Burkina Faso, 22 - 24 September 1998. The objective of the workshop was to assist countries in the Sahelian sub-region to assess the status of their forest genetic resources, elaborate and propose priority actions, and make recommendations for immediate follow-up and implementation.

Thirty-five participants took part in the workshop, with national experts from 15 countries[6], as well as representatives from the organizing institutions (FAO in collaboration with IPGRI and ICRAF) and 6 other international, regional, bi-lateral and national agencies (CIRAD-Forêt, Danida Forest Seed Centre, IRAD-Cameroon, UNEP, IUCN and IUFRO). National experts presented country reports summarizing the status of forest genetic resources, indicating priority species, listing key issues and providing recommendations to tackle the major constraints identified. A draft regional

[5] Participants at this training course recommended the development of a regional research programme for forest genetic resources in Sub-Saharan Dry-Zone Africa (SAFORGEN), initially composed of four pilot networks, namely: fruit and food tree species; fodder tree species; African timber and wood species; and African non-timber forest products. It was recommended that IPGRI facilitate the development of this programme in collaboration with FAO, ICRAF and other participating regional and international organizations.

[6] Benin, Burkina Faso, Cameroon, Chad, Côte d'Ivoire, Eritrea, The Gambia, Guinea, Kenya, Mali, Mauritania, Niger, Senegal, Sudan and Togo.

synthesis was presented, discussed and amended. Experts identified the need for, and agreed to prepare, a sub-regional Plan of Action on forest genetic resources, for which the following three main objectives were specified with related activities (the main points are underlined):

1. Improved management and utilization of forest genetic resources.
   - Resource assessment
   - Conservation, including protection
   - Sustainable utilization
2. Enhancement of availability of superior germplasm
   - Seed supply and demand
   - Selection and improvement of priority species
3. Enhancement of institutional capacity
   - Awareness raising
   - Institutional strengthening
   - Training
   - Exchange of experience, know how and information.

Experts recommended that FAO, in collaboration with IPGRI, ICRAF, and other international, regional, bilateral and national partners, should: (a) finalize the synthesis report on the state of forest genetic resources in the Sahelian sub-region, (b) finalize the sub-regional Plan of Action on forest genetic resources prepared by the meeting, (c) promote the implementation of the sub-regional Plan of Action through appropriate mechanisms; and (d) facilitate the organization of similar action-oriented, country-driven workshops in other sub-regions of Africa.

Experts recommended the establishment of a regional research oriented programme for forest genetic resources in Sub-Saharan Africa and expressed their willingness to take part in this regional structure acting as a focal instrument for future action. Participants indicated high expectations of IPGRI's new Sub-Saharan Africa Forest Genetic Resources Programme (SAFORGEN) as an implementing mechanism. A satellite meeting was held to discuss the scope, objectives, functioning and funding of SAFORGEN. When operational, the programme would be a useful platform to carry out several of the research activities listed in the sub-Regional Plan of Action on forest genetic resources for Sahelian Africa.

A reference document, incorporating the synthesis report, the plan of action and the recommendations of the workshop is currently being finalized by FAO in collaboration with IPGRI and ICRAF. This will be published in 1999.

ACTION TAKEN TO DATE IN OTHER REGIONS OF THE WORLD

Similar developments are being planned for other sub-regions or eco-regions in the world, pending the identification of additional funding and suitable partners. However, the methodology and process followed will differ by region, according to the biological, social and economic environment, as well as national needs and priorities.

Positive replies have been received from, and action initiated by, several sub-regional partners in the Pacific (including the South Pacific Regional Initiative on Forest Genetic Resources, the Samoan Forestry Division, the Secretariat of the Pacific Community/Pacific Islands Forests and Trees Support Programme, and the South Pacific Regional Environment Programme) for holding a workshop on the Pacific Islands in Apia, Samoa, April 1999. Contacts are being initiated in Eastern and Southern Africa within the framework of the Southern African Development Community, Forestry Sector Technical Coordination Unit, which has expressed its interest in facilitating the organization of a workshop in this region.

This flexible country-driven process, which was noted and welcomed by the XI World Forestry Congress in Antalya, Turkey (October 1997) and the IUFRO Consultation on Forest Genetics and Tree Improvement in Beijing, China (August 1998), complements other initiatives presently being undertaken at national and global levels. These include the elaboration of Biodiversity Status and Action Plans developed in the framework of the Convention on Biological Diversity, and the exchange and sharing of technologies, know-how and information being implemented through the Clearing-House Mechanism. Information and data gathered during this process (including regional syntheses) will be made available on the internet at the FAO homepage on forest genetic resources: (http://www.fao.org/waicent/faoinfo/forestry/fogenres/homepage/content.htm).

TERMINOLOGY IN FOREST GENETIC RESOURCES

Following recommendations made by the Tenth Session of the FAO Panel of Experts on Forest Gene Resources (1997), FAO and IUFRO have joined forces to develop a glossary of terms frequently used in the field of forest genetic resources. The objectives of the glossary are to record and document a limited number of established, widely used terms and definitions and allow a comparison to be made between the various conceptual uses and the meaning given to these terms by a range of agencies and organizations in different countries. Thus, rather than providing one single definition, the glossary will aim at providing, for any given term, a range of definitions and meanings, developed by various groups with specific objectives. The glossary will reflect the diversity of users, uses and complementary approaches to defined terms. This work is carried out by IUFRO's SylvaVoc programme (Mrs. Renate Prüller), the newly created IUFRO Task Force on Forest Genetic Resources (chaired by Francis Yeh, University of British Columbia, Canada) and FAO.

The terms selected for inclusion in the glossary are:

- Biological diversity
  - agrobiodiversity
- Biotechnology
  - genetic engineering
  - genetic markers / molecular markers
- Conservation
  - *in situ* conservation
  - *ex situ* conservation
  - genetic conservation
- Genetic variation
- Genetic diversity
- Genetic resources
  - germplasm
  - value of genetic resources
- Management of genetic resources
- Tree improvement
  - domestication
- Vegetative propagation
  - micropropagation
  - macropropagation

THE ECOLOGY AND CONSERVATION OF *PINUS JALISCANA*[1]

by

W. S. Dvorak[2], J. A. Pérez de la Rosa[3], M. Mápula and V. J. Reyes[4]

INTRODUCTION

Pinus jaliscana Pérez de la Rosa is a closed-cone pine in the Oocarpae subsection that occurs from 19° to 20° N latitude in tropical and subtropical areas of the mountains of western Jalisco, Mexico. It was first identified in the early 1980s by Pérez de la Rosa (1983) and five provenances of the species have been located growing from 800 to 1650 m altitude [El Tuito, La Bulera, Las Tarimas, Los Lobos Milpillas/Saucillo]. The boundaries of its known distribution roughly form a triangle of approximately 300,000 ha, the interior of which has not been adequately explored because of the mountainous terrain and lack of roads (Figure 1). Recently, several additional taxonomic descriptions of *P. jaliscana* have been published by Perry (1991) and Farjon and Styles (1997). Both contributions suggest that the extent of the geographic distribution and the abundance of *P. jaliscana* are still poorly defined. Furthermore, little is known about its ecology, wood properties, need for conservation, or its potential for plantation forestry in the tropics and subtropics.

In 1998, the Central America and Mexico Coniferous Resources Cooperative (CAMCORE), North Carolina State University, in collaboration with the Botany Department, University of Guadalajara (UG), Jalisco, Mexico and the Forest Genetics Centre (CGF), Chapingo, Mexico, began exploration of *P. jaliscana* in the States of Jalisco and Nayarit with a view to the development of *in situ* conservation strategies. Seed collections of 40 mother trees were also made in the most accessible populations to establish *ex situ* gene conservation plantings and genetic tests.

Nine locations of *P. jaliscana* were visited in the field reconnaissance, four of which, to our knowledge, are new reported sightings: La Concha, El Sauz, Las Trojes, and Monte Grande (Table 1, Figure 1). In this paper, we combine new information generated by the CAMCORE/UG/CGF explorations and seed collections, with existing taxonomic descriptions, to develop a more detailed account of the ecology and conservation status of *P. jaliscana*.

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Table 1. Location of the exploration and seed collection sites of Pinus jaliscana in Jalisco, Mexico, and the present conservation status of each

Provenance	Latitude/ Longitude	Altitude (m)	Annual Rainfall (mm)	Size (ha)	Conservation Status
La Bulera	20° 45' N 104° 57'W	700-1100	1600*	1000+	low risk
Milpillas	20° 44' N 104° 53'W	1195-1410	2000*	<20	highly endangered
Los Lobos	20° 24'N 105° 04' W	1020-1460	2000*	1000+	low risk
El Tuito	20° 21' N 105° 12' W	840-1460	1900	1000+	low risk-vulnerable**
La Concha	20°16' N 105°03'W	900-1800	1500	500+	vulnerable
Monte Grande	20° 15'N 104° 49' W	1255-2000	2100*	375	vulnerable
Las Trojes	19° 51' N 104° 35'W	970-1300*	2000*	25	vulnerable
El Sauz	19° 49'N 104° 35'W	1000-1300	1935	250	vulnerable
Las Tarimas	19° 48' N 104° 37'W	1010-1220	1935	15	endangered

* Values estimated

** Wood is being extracted in one section of El Tuito (vulnerable), in other areas stands are intact with little pressure from human activities (low risk).

DISTRIBUTION AND ECOLOGY

Description of the species

Pinus jaliscana is a medium to large tree 15 to 25 m in height and 40 to 80 cm diameter breast height. It is easy to recognise in the field because of the bright yellow green (lemon) color of it needles and its distinctive upraised branches. The needles, which are mainly in fascicles of 5, are the most slender in the closed-cone pine group (Perry 1991), and when touched have a "softness" that is more characteristic of the white pines.

Occurrence

Based on our recent field reconnaissance, *P. jaliscana* occurs between 19° 48' and 20° 45' N latitude and 104° 35' and 105°12' W longitude in western Jalisco. No occurrences of *P. jaliscana* were found north of this location in the Sierra de Vallejo, Nayarit and the second author has not found it south of this latitude in prior explorations. The altitudinal range of the species is now confirmed from 700 m (at La Bulera) to 2000 m (Monte Grande). However, most of the *P. jaliscana* trees are found from 750 to 1400 m elevation and become scarce above or below this altitudinal range (Farjon and Styles 1997). At its lowest occurrence the species is a constituent of a semi-deciduous, pine-oak, forest ecosystem and at it highest occurrence it is part of a mountain mesofile forest community.

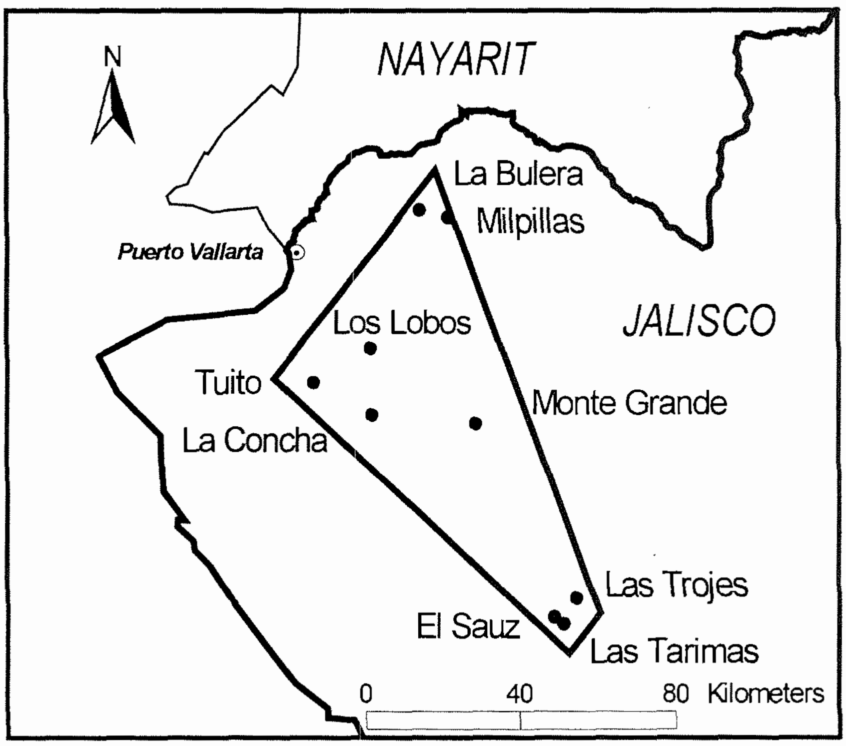

Figure 1. *Map showing the nine locations with P. jaliscana which were visited.*

Climate

The climate at a typical *P. jaliscana* site such as El Tuito, where meteorological information is the most complete, is classified as "Aw2 (w) (i') rainy tropical savanna" under the Köppen system with an average monthly temperature of more than18°C (Garcia 1988). Better meteorological information is now available than in the past and indicates that most *P. jaliscana* sites receive more than the 1000 to 1500 mm annual precipitation often reported. The average rainfall at El Sauz, El Tuito, Las Tarimas, is approximately 1900 mm with less than 30 mm of precipitation per month for six to seven consecutive months from November to May (Garcia 1988). Annual rainfall may be above 2000 mm at the high elevation sites like La Concha and Monte Grande (Table 1).

Species Association

Pinus jaliscana is found in both pure and mixed stands with *P. oocarpa* and *P. maximinoi* H. E. Moore and rarely with *P. devoniana* Lindl. (syn. *P. michoacana* Mart.) and *P. douglasiana* Mart. (Pérez de la Rosa 1983). It is most abundant in steep ravines or canyons where it is the dominant pine species at elevations between 750 and 1300 m. It seems particularly well adapted to mezic conditions on the northern or north-western aspects of canyons and watersheds where air temperatures and evapotranspiration are lower, moisture supply more readily available, and the humidity higher than on exposed southern and eastern aspects. Even though the two closed-cone pines, *P. jaliscana* and *P. oocarpa* occur sympatrically, there was no evidence that hybridization or introgression was occurring between the two.

On valley bottoms near streams, *P. jaliscana* co-exists with broadleaf flora in what can best be described as a micro-tropical rainforest environment. The associated broadleaf species vary from one canyon or watershed to another depending on the altitude, moisture availability and frequency of fires. On slopes several hundred meters above the valley bottom, *P. jaliscana* and associated broadleaf species become less abundant and are gradually replaced by *P. oocarpa* on the drier exposed slopes. Even when conditions appear suitable for *P. jaliscana* on slopes above 1500 m, the species is often replaced by *P. maximinoi*. We assume that *P. jaliscana* thrives best under tropical conditions and becomes less competitive when night-time temperatures are often cool. More study is needed to better define plant associations in these unique ecosystems.

Role of natural and man-made fires

Periodic fires are essential for the survival of *P. jaliscana* to eliminate competitive broadleaf species and aggressive weed growth. Recent man-made intervention has resulted in more fires than would be expected naturally, and their high frequency is killing both young pine regeneration and large mature pines and oaks. Frequent burning in natural stands is one of the greatest dangers to the future survival of the species.

Diseases

Pinus jaliscana seems highly susceptible to the cone rust, *Cronartium conigenum*. The plant parasite, *Cladocolea* sp. was common on *P. jaliscana* at only one site, El Tuito. CAMCORE is screening seedlings of *P. jaliscana* in North Carolina to determine their resistance *to Cronartium quercum* f. sp. *fusiforme* (fusiform rust) and to *Fusarium subglutinans* f. sp. *pini* (pitch canker).

SOILS

Pinus jaliscana appears to need disturbed mineral soils to grow and proliferate. Historically, the disturbed mineral soils have been generated from stream sediments deposited by floods during the short but intense rainy season. More recently, the loose soil piled along logging roads during their construction has served the same purpose. It is here that the natural regeneration of *P. jaliscana* is the most prolific and vigorous and outcompetes that of other pine species.

On ravine and canyon bottoms, *Pinus jaliscana* is primarily found on well drained fluvial sediments (Entisols/Regosols) that may be as much as 3 m in depth.

A compacted surface organic (O) horizon of 2 to 8 cm depth is present at some (but not all) locations and was best defined at La Bulera where *P. jaliscana* occurs in a tropical rainforest environment with abundant broadleaf flora. The top (A) mineral horizon of the valley soils ranges from greyish-white, sandy clay loams to yellow coarse sands that are so loosely compacted that a soil probe can be manually pushed 40 cm deep into the ground with little effort. The fluvial sands are strongly acidic with soil pH 4.8 to 5.2. The subsoil (B) horizon ranges from greyish-white, sandy clay loams to yellow-brown, sandy clays and are extremely acidic with soil pH of 4.0 to 4.3.

On the steep slopes above the valley bottoms where *P. jaliscana* and *P. oocarpa* occur together, soils are more shallow and clayey. The A-horizons are often greyish- white, sandy clays 40 to 50 cm in depth and are underlain by yellow-brown or less frequently, red clays (Ultisol/Acrisols) 50 to 100 cm in depth. These yellow-brown and red clay soils are easily weathered and erosion is great especially at the Tuito collection site.

On the north-western slope at Milpillas, a degraded *P. jaliscana* and *P. oocarpa* stand was also found on an eroded red Ultisol. These clay soils (pH 4.8) are little different in physical and chemical properties than those that occur throughout Central America and support *P. caribaea* var. *hondurensis*, *P. oocarpa* and low elevation populations of *P. tecunumanii*. The amount of clay in these soils was sufficiently high at Milpillas to be used by local farmers for making bricks. We assume that the presence of *P. jaliscana* on these moderately drained, eroded red soils with high clay content is a rare occurrence and indicates that the availability of soil moisture and high humidity dictates the distribution of the species rather than the soil physical properties.

REPRODUCTIVE BIOLOGY

Flowering time, cone maturation, and seed dispersal

The first phase of explorations and seed collections occurred from January 18 to 23, 1998 and our second field reconnaissance from April 9 to 20, 1998. Female strobili were past the receptive stage and male strobili were not shedding pollen for either *P. jaliscana* or *P. oocarpa* during the January visit. Generally, the flowering time for *P. oocarpa* throughout southern Mexico and Central America is from late December through March. We assume, based on the stages of development of both female and male strobili, that the flowering period for *P. jaliscana* is primarily in November, the first month of the extended dry season in western Mexico. However, more flower phenology studies need to be conducted to confirm this. The degree of cone maturity varied from site to site. It appears now that the optimum cone collection time may be in March.

Cones and seeds are distributed throughout the canyons by local squirrel populations. Wind, stream, and animal seed dispersal vectors must all be considered when studying *P. jaliscana* migration patterns.

Seed yields

Mature cones have from 80 to 120 scales (Pérez de la Rosa 1983, Farjon and Styles 1997) but only 60% of these appear fertile. This is because the cones open from the apex and the scales near the base remain closed, quite similar to *P. patula* (Perry 1991). Our assessments of mature cones suggest that the maximum average seed potential for *P. jaliscana* is approximately 120 seeds. An average of only five filled seeds per cone were found in the sample of 2,582 cones examined in our seed collections in natural stands giving a seed efficiency rate of 4%. The number of filled seeds per cone and number of seeds per kg found for *P. jaliscana* are very similar to the values obtained for trees from high elevation populations of *P. tecunumanii* (Dvorak and Lambeth 1993). Seed yields per cone are expected to improve by making collections in March rather than late January. There is an average of 93,000 seeds per kg.

WOOD PROPERTIES

The wood of *Pinus jaliscana* is used locally for construction and also for charcoal to fire brick kilns. Even though local sawmills do not single it out for any special purpose (Farjon and Styles 1997), they do recognize that the wood of *P. jaliscana* is whiter than *P. oocarpa* and is less resinous. The resin is also more transparent than that of *P. oocarpa*.

Our examination of 12 mm bark to pith wood cores of 10 *P. jaliscana* trees sampled in natural stands indicated that the transition between juvenile and mature wood occurred between 8 and 10 years of age. The juvenile core is very distinctly white and has annual rings that are sometimes poorly defined. The mature core is yellowish-white with very pronounced annual rings. The weighted mean specific gravity (unextracted) of 10 trees that averaged 35 years of age was 0.546. The juvenile and mature wood had specific gravity of 0.464 and 0.573, respectively. These values were 5% to 8% lower than those found for trees of *P. tecunumanii* at the Mountain Pine Ridge, Belize (Dvorak and Wright 1994) but were approximately the same as those found for *P. greggii* Engelm. in central Mexico (Murillo 1988), sampled at approximately the same age in natural stands.

CONSERVATION STATUS

We believe that a number of additional stands of *P. jaliscana* still exist in the isolated canyons of western Jalisco within the triangle of its present-day known occurrence. These unique microsites serve as the last refuge for what was probably once a larger geographic distribution of *P. jaliscana*. The species appears naturally to be on the decline and its rate of loss has been accelerated in the last 200 years by man's activities.

The discovery of new populations by CAMCORE/UG/FGC and the prospect of finding more suggests that *Pinus jaliscana* is not in danger of extinction nor is it necessarily threatened throughout its natural distribution. The Bulera, El Tuito, and Los Lobos populations are greater than 1000 ha in size, much larger than most populations of pines that CAMCORE has sampled in southern Mexico and Central America. The *P. jaliscana* population of La Bulera is remarkably intact, and even though El Tuito and Los Lobos have been fragmented by agriculture and grazing, areas exist which still have adequate tree stocking with good natural regeneration.

The population of *P. jaliscana* that is most endangered is Milpillas; it will probably be lost in the next 5 to 10 years (Table 1). The Milpillas stand apparently was never very extensive. The only remaining trees are close to the main road and are being harvested for charcoal. Las Tarimas is also threatened. Most of the remaining trees have been protected from woodcutters by the steep and isolated ravines in which they grow. However, continual over burning in the ravines has destroyed large old trees along with natural regeneration. Seed collections were made at Milpillas and Las Tarimas in 1998 for *ex situ* conservation.

The provenances of El Sauz, La Concha, Las Trojes, and Monte Grande have been fragmented by agriculture and cattle ranching and are vulnerable to continued pressures by man (Table 1). Additional collections of research quantities of seed are planned in these high graded populations in 1999. The seeds collected will be distributed to agencies in Brazil, Mexico, Colombia, South Africa and Zimbabwe for *ex situ* gene conservation and genetic testing through CAMCORE.

Much opportunity remains for *in situ* conservation programs at El Tuito, Los Lobos and La Bulera because of the relatively large size of the populations, and the density and high quality of the trees. *In situ* conservation efforts will be difficult in the other six provenances because of pressure from humans, and their future appears to rest on the success of *ex situ* conservation efforts.

Molecular marker projects are planned at North Carolina State University in the near future to better study how genetic diversity is structured in the *P. jaliscana* populations. Because the spatial distribution and abundance of *P. jaliscana* differs at each location and is influenced by the amount of moisture, broadleaf competition, frequency of fires, and other human disturbances, understanding the patterns of gene flow and pollen exchange among canyon populations will be important in determining how the species evolved and how to best conserve it.

POTENTIAL AS A PLANTATION SPECIES

Information will be available on the potential of *P. jaliscana* as a plantation species after provenance/progeny trials are assessed in several years' time. Observations on its development in natural stands may offer some important insights about how it might perform as a plantation species. Because it must compete against aggressive broadleaf species and fast growing weedy vegetation in humid valleys to survive and grow in its natural areas of occurrence, we believe that it will exhibit very fast initial growth in plantations. Furthermore, since the species seems to develop quickly on disturbed mineral soils, it should be well suited to respond to good site preparation and plantation silviculture. Populations of *P. jaliscana*, especially those that occur on the drier slopes in association with *P. oocarpa*, may exhibit some drought hardiness. At this time it appears that the main limitation of *P. jaliscana* as a plantation species will be its sensitivity to frost. Based on our present understanding, *P. jaliscana* should be tested in mezic environments between 700 and 2000 m altitude on well drained soils that are currently being planted with *Eucalyptus grandis* W. Hill ex Maiden, *P.maximinoi*, *P. oocarpa*, *P. patula* , *P. taeda* L., and *P. tecunumanii*, and where frosts are not common.

ACKNOWLEDGEMENTS

The funding for the *P. jaliscana* project comes from CAMCORE members in 16 countries and a private Foundation in the United States dedicated to the conservation of forest species. We would like to thank Basilio Bermejo, CGF, for his assistance in organizing the explorations, and Raymundo Ramírez, UG, for his help in broadleaf plant identification. We would also like to thank Joy Goforth and William Woodbridge, CAMCORE, for analysis of the wood cores and development of the species distribution map, respectively.

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SEED COLLECTION AND PROVENANCE TRIALS OF *VITELLARIA PARADOXA* IN THE SAHEL

Vitellaria paradoxa (Sapotaceae), commonly known as karité (French) or shea butter tree (English), is a highly valued fruit tree indigenous to semi-arid and sub-humid lands of Africa. In addition to producing edible sweet fruits, the tree also produces nuts which contain an extremely high-quality fat which is used locally and in an international multi-million dollar business which provides several African countries with significant export revenues.

Despite its great importance in local economies and in international trade, *V. paradoxa* remains a wild resource which has never benefited from any major domestication effort. Apart from a local collection carried out by the Cocoa Research Institute in Ghana in 1985 and 1986, the genetic resources of *V. paradoxa* remain largely unexplored.

To fill this gap, the Sahelian Programme of the International Centre for Research in Agroforestry (ICRAF) organized a regional seed collection of *V. paradoxa* in the Sahel in 1997. The initiative was developed in partnership with the International Program for Arid Land Crops (IPALAC), with financial support from the Government of Finland. Field collections were carried out in July-August 1997 in Burkina Faso, Mali, and Senegal by collaborating national institutions : Centre National de Semences Forestières (CNSF-Burkina), Institut d'Economie Rural (IER -Mali) and Institut Sénégalais de Recherches Agricoles (ISRA-Sénégal).

A total of 1800 open-pollinated trees from 6 provenances were collected (3 provenances in Burkina Faso, 2 in Mali and 1 in Senegal). Selection of individual mother trees was based on local knowledge. Collection was made from trees which were known by resident farmers to have desirable characteristics such as large fruits, sweet pulp, high fat content, heavy fruit load, early or late fruiting, fruiting year round, etc. The collected seeds were sown in nurseries in Mali, Burkina Faso and Israel for outplanting in provenance trials during 1998.

For further information on the seed collection and provenance trials of *Vitellaria paradoxa* please contact:

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GENETIC IMPROVEMENT OF TEAK (*TECTONA GRANDIS*) IN THAILAND[1]

by

Apichart Kaosa-ard[2], Verapong Suangtho[3] and Erik D. Kjær[4]

INTRODUCTION

Teak is one of the most important species for forest plantations in the tropics. The natural distribution of the species covers parts of India, Myanmar, Thailand, Laos and Indonesia. In Thailand it occurs naturally in the northern parts of the country (Kaosa-ard, 1981). Large areas of plantation have been established since 1943 by the Royal Forest Department (RFD); and since 1968, by the state-owned Forest Industries Organisation (FIO) (Kaosa-ard, 1996). In recent years, large teak plantings have also been established on private land (RFD 1995; RFD 1996).

Teak is interesting from a tree improvement point of view. It is used on a large scale, the timber has high value, and teak is easily established in plantation regimes, which allows the use of improved genetic material. However, there are also obstacles. The seed yield per tree is low (causing problems in progeny testing and especially in seed production in seed orchards), and only few seedlings are produced per 100 sown seeds in nurseries, aggravating the problems of low seed production. Also, controlled pollination is difficult in teak (Kaosa-ard, 1996).

The long rotations of teak makes teak plantations a long-term investment. Teak also has a long vegetative period before flowering. Ten to fifteen years may therefore pass from the initiation of an improvement programme until improved seed is available, and another 40-50 years will pass before the timber from the first rotation of improved planting stock is harvested. The internal rate of return from tree improvement is high as the timber is valuable (Kjær and Foster, 1995), but the long rotation causes problems for the teak breeder: superior plus trees are selected at a mature stage, but their breeding value must be assessed from progeny tests, and these must be followed for many years, even decades. Continuity in terms of funding and staff is especially important in breeding programmes for teak, because the time span for breeding is long.

REQUIREMENTS OF SEED IN THAILAND

The first teak plantations in Thailand were established in 1906. Today, teak is planted on a large scale and a large amount of seed is therefore required. The annual plantation area established by the RFD and the FIO during 1982-1986 was on average 16,000 ha. This area has been decreasing since, and today approximately 8,500 ha/year are established.

Teak plantings in the private sector have expanded considerably during the past few years due to government incentives and as a result of increasing recognition of high economic returns from investment in teak plantations. The total area established by the private sector in Thailand in 1995 was above 45,000 ha (RFD, 1995). The majority of teak planting in the past few years has been by private growers. However, lack of available land may become a limitation in the future.

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In present nursery practice in Thailand, only 5 seedlings of appropriate size are obtained from 100 seeds sown. This is mainly due to the low germination and sporadic germination behaviour of teak seed. Wellendorf and Kaosa-ard (1988) found that one ton of seed only produced 92,000 seedlings using the present techniques. Typical planting practice requires 1,100 seedlings per ha, and one hectare of teak plantation thus requires about 12 kg of seed. The total use of teak seedlings in Thailand is at least 22 million seedlings per year (Kjær and Suangtho, 1997). This requires almost 240 tons of seed per year.

The productivity of seed in clonal seed orchards (CSOs) is low and very variable in Thailand. On a good site, production can be 70-100 kg per ha (Meekaew, 1992; Kittibanpacha, 1996), but an average of 50 kg per ha (from age 15 onwards) is more common (Wellendorf and Kaosa-ard, 1988). Due to the limited productivity of the CSOs, a large part of the seed used at present is collected from easily accessible non-selected seed sources, e.g. road sides and urban areas.

Low number of seedlings produced per kg of seed is a general feature for teak (see e.g. Srimathi and Emmanuel, 1986, experience of India), but fortunately much can be gained from using improved nursery techniques. Studies on pre-treatment have shown that treating the seed at 80°C for 48 hours can increase both germination percent and germination speed substantially (Suangtho, 1980). Storing the seed for 72 hours in heat traps, or simply sowing the seed four weeks prior to the beginning of the wet season, have also given good results. Other parts of nursery production may also be optimised, and improved nursery practices should therefore be part of a sound seed procurement strategy. A 50% increase in the number of seedlings produced per kg of seed will reduce seed requirement by one third.

GENETIC VARIATION AND POSSIBLE GAIN

The objective of tree improvement is to obtain gains in selected characters. The large differences in growth conditions within the natural range of teak indicate the existence of genetic differences between origins. Provenance differences have been investigated in an international network of provenance trials (Keiding et al. 1986, Kjær et al. 1995), which together with the studies reported by Bingchao et al. (1986) provide information on provenance variation. These trials confirm the existence of genetic variation between provenances, which were tested in locations within and outside the natural distribution range of teak. For Thailand, the international trials indicate that local seed sources should be used. A provenance trial comparing 30 Thai provenances was established in the early phase of the teak tree improvement programme in Thailand, and data based on assessment after 15 years is now available (Kaosa-ard, in prep.)

Little is known of the variation within provenances, as most clonal and progeny trials are still young. The available data does, however, confirm that genetic variation is present within provenances in both growth and stem form (Wellendorf and Kaosa-ard 1988, Wellendorf, unpublished). Wellendorf and Kaosa-ard (1988) estimated that the possible gain from using the best seed sources (seed production areas, SPA) could be 5-12% in volume production. The additional gain from using seed from clonal seed orchards rather than from SPAs was not included in this estimate. However, for stem form such gain will probably be significant. Genetic thinning in the seed orchards was estimated by Kjær and Suangtho (1997) - using data from Kittibanpacha (1995) - to yield an additional 5-10% gain in volume production.

Based on the above, Kjær and Suangtho (1997) estimated that seedlings from classified seed stands will yield at least 8% higher value production than seedlings from unclassified seed sources. This increased value production originates from both improved volume production and from better stem form. CSOs are expected to be at least 4% better than classified seed sources because they consist of selected clones from the best seed sources (effect of plus-tree selection). This means a total of an estimated 12% (8% + 4%) higher value production from CSO-progeny compared to seedlings from unclassified seed sources. An additional 5% can be gained from collecting seed exclusively from the best clones in the CSOs, and multiplying these seedlings by vegetative propagation, yielding an estimated total gain of 17% (in value production) compared to planting stock from unclassified seed sources.

Kjær and Foster (1996) calculated the economic value of using improved planting stock. They estimated the gain during a 50 year rotation to be approximately 3,600 US$ per ha for each percent of improved planting stock better than the unimproved. A gain of 17% from using highly improved material, as mentioned above, thus corresponded to an estimated increased value of 17% x 3,600 US$ = 61,200 US$ per ha established plantation over a 50 year rotation.

The present value of the future gains will depend on the rate of interest, as discussed in more detail in Kjær and Foster (1996). The authors suggest that a present value of 340 US$ per ha - for each percentage of improved planting stock better than the unimproved - was considered a realistic estimate. The present value of using 17% better planting stock will then be 17% x 340 US$/ha = 5,780 US$/ha.

TEAK IMPROVEMENT ACTIVITIES IN THAILAND

Tree improvement activities were initiated in Thailand in the early 1960s (Boonkird 1964; Keiding 1966), and intensified through establishment of the Teak Improvement Centre (TIC) at Ngao, Lampang province, in 1965. During the last 30 years, the TIC has been involved in establishment of provenance trials, selection of plus trees for tree breeding, development of vegetative propagation techniques (grafting, budding, the use of cuttings and tissue-culture), establishment of seed production areas, clonal banks and CSOs, clonal trials and supportive research, mainly on reproductive biology (TIC, 1994).

Selection of plus trees and establishment of clonal seed orchards

The teak improvement strategy for Thailand is described in detail by Wellendorf and Kaosa-ard (1988), and Kaosa-ard (1996). Two rounds of plus-tree selection have been carried out. 100 clones were selected during the first years of tree improvement. Approximately 60 of these clones have been propagated by budding on a large scale, and a total of 1,830 ha CSOs have been established. The majority (90%) of CSOs were established by RFD at five regional CSO-centres, the rest mainly by FIO. An additional 300 clones have been selected in a second round of selection and included in the long-term breeding population. Clone banks have been established at TIC as well as at the five regional CSO-centres. The first of three new breeding seed orchards (BSOs), each containing 100 clones, has been established. All four BSOs will be replicated at four locations.

As mentioned above, seed supply from the CSOs has been much lower than initially expected. The seed set per flower in teak is generally very low in the South and South East Asian regions resulting in low overall seed production. Recent studies on the reproductive biology of teak have increased the understanding of the reproductive process (Kertadikara and Prat 1995, Kjær and Suangtho 1995, Nagarajan et al. 1996, Palupi and Owens 1996, Tangmitcharoen and Owens 1996). According to these studies, teak flowers are frequently self-pollinated by insects in the crown of the individual tree, because apparently no selection works against self pollination at this stage of the reproductive cycle. However, the selfed embryos tend to abort soon after fertilisation, and the final result is low rate of selfed seed and progeny - but unfortunately also low seed set in general.

Figure 1. Selected plus tree. Photo: DFSC

Locating the large areas (total 2,000 ha) needed for the establishment of CSOs, and maintaining them in good condition, has proven difficult in Thailand. As a result, not all the CSOs have been established on good sites, and the seed production in the CSOs has on average been even lower than expected. However, the majority of the seed orchards are in good physiological condition and should therefore become more productive as soon as extra funds have been allocated to the management of CSOs in recent years. Kjær and Suangtho (1997) have calculated that the orchards should be able to produce at least 56 tons of improved seed per year, which is equal to 7,700,000 seedlings per year (if 138 seedlings/kg is assumed). It is estimated that 7,000 ha of teak plantation can potentially be established every year based on improved stock from the CSOs in the future.

Clonal trials, in which the majority of the 60 clones included in the 'old' breeding population, are tested, have been established at two locations. One seedling progeny trial has been established, but it is not in good condition. New progeny trials will be established and this work has high priority as there is still no information on the concordance between results from progeny trials and those from clonal trials.

Seed production areas

Identification of approximately 1,200 ha of teak forests for the establishment of seed production areas (SPAs) has been an important part of the efforts to procure a sufficient amount of seed of high genetic quality. However, the area of SPAs has decreased over the last decades due to logging. Plantations established since 1943, mostly in the north, are therefore to be surveyed over a five year period to identify areas which are suitable for seed collection. Seed production in lightly thinned stands will however be lower than in the traditional SPAs - maybe only 10 kg per ha on average (Kaosa-ard 1979). Kjær and Suangtho (1997) assume that at least 1,500 ha of good seed production areas can be identified in plantations and used in order to reduce the use of unclassified seed sources.

Development of vegetative propagation techniques

In Thailand, development of vegetative propagation has been given high priority in the past decade with great success. Tissue-culture techniques have been developed on a commercial scale (Kaosa-ard et al., 1987; Kaosa-ard, 1990; Kaosa-ard, 1993), and teak planting stock based on this technique is being produced on a commercial basis. The price for this planting stock is approximately two to three times higher than the price for traditional seedlings or stumps. Different clones require slightly different culture media, and it is therefore difficult to handle a large number of clones in commercial tissue-culture programmes. Tissue culture is for these reasons only used at a small scale at present. However, the combination of tissue culture and subsequent production of cuttings using tissue-culture plantlets has proven to be both technically and economically feasible for the large scale production of clonal planting material.

Vegetative propagation by means of cuttings from juvenile seedlings and tissue-culture plantlets has also been developed on a commercial scale. Under favourable rooting conditions, over 90 percent rooting of stem (nodal) cuttings can be obtained. Serial cuttings (cuttings from plants derived from cuttings) can also be made successfully. In this case, the 45-day-old plants derived from cuttings are used for further propagation. As a result, within one growing season 30-40 plants can be reproduced from one seedling through three cycles of serial cuttings. Through this propagation technique, it is estimated that one kg of improved seed, e.g. seed from CSOs and SPAs, can potentially produce 5,000-6,000 plants (Sirikul pers. com.). The cost compared to conventionally produced seedlings is approximately 50% higher. This extra cost is outweighed by the increased production, provided that the cuttings are produced from improved genetic material. However, cutting production is only being used on a small scale due to the extra production costs. More details on technical aspects of vegetative propagation of teak are given by Goh and Monteuuis (1997) and Monteuuis et al. (1995).

Increased future use of cuttings is planned in Thailand for two reasons. Firstly, to fill the present gap between available improved material and annual demand for planting stock, a gap that otherwise can only be filled by using seed from unclassified sources. Secondly, additional gains can be obtained compared to CSOs by using seed from the best families in the seed orchard, e.g. seed collected from the best 15 clones in the CSO, bulked and used for further production of cuttings. The use of open pollinated seeds will ensure a fairly high level of genetic diversity in the material (Kjær and Graudal, in prep.). The best families will be selected based on results from clonal trials. In the initial phase, the production of 2,000,000 cuttings per year is envisaged (propagation of seedlings from approximately 360 kg of seed per year). If the programme is successful in the first years, the production can gradually be increased. The final goal is the production of 10,000,000 cuttings per year. A broadening of the genetic base of the material used for propagation must then be considered. The cutting option is especially attractive in Thailand because the results from clonal trials allow matching of clone to site.

Only cuttings produced from juvenile seedlings and tissue-culture plantlets give high rooting percentage. It is not considered economically feasible to produce cuttings from older trees, although Monteuuis et al. (1995) obtained surprisingly good results from 15-year-old trees.

It must be stressed that the use of cuttings is only of interest if genetically superior material has been identified, i.e. vegetative propagation must be closely linked with tree improvement activities. The genetic quality of cuttings is no better than that of the seedlings, or tissue-culture plantlets, from which they are propagated.

CONSERVATION OF GENETIC RESOURCES *IN SITU* AND *EX SITU*

The area of natural teak forests in Thailand has decreased rapidly during the past three decades and there is an urgent need for conservation measures (Graudal et al. 1998). The breeding population has a valuable *ex situ* conservation function, but additional *in situ* conservation is also required. A programme for evolutionary *in situ* and *ex situ* gene resource conservation has been formulated (Graudal et al. 1998).

As a basis for genetic conservation measures, the natural distribution area of teak in Thailand has been divided into five genecological zones based on climatic variation, topography, soil conditions and results from provenance trials. The climate, in terms of the rainfall/temperature ratio, in general varies from high values in the north to lower values in the south (Kaosa-ard, 1983). However, the natural teak forests are separated by mountain ridges going north to south, and this may have constituted partial barriers against gene flow between populations. Multivariate analysis of provenance trials supports a pattern of differentiation between east and west (Kjær et al., 1996), and genecological zones have therefore been suggested to be separated by both north-south and east-west boundaries. A total of 15 populations have been identified for genetic resource conservation. Four of these are outside protected areas and will be conserved *ex situ*, according to the above plan.

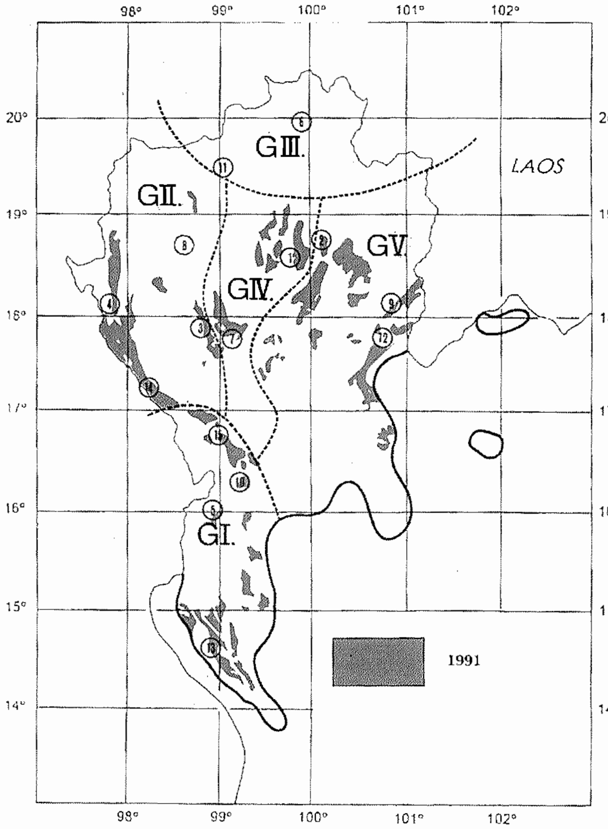

Figure 2. Map showing distribution (1991) of Teak in Thailand and the suggested genecological zones GI - GV.

CONSIDERATIONS FOR THE FUTURE

Tree improvement of teak in Thailand was initiated three decades ago. Several problems have been solved since then. Relative performance of Thai and foreign seed sources has been compared in provenance trials. Budding and grafting have been developed for clonal propagation of mature trees. Techniques for seed pre-treatment have been tested and an effective regime (80°C-treatment) has been developed. Reproductive biology has been intensively studied, and important knowledge gained. Plus trees have been selected and almost 2,000 ha CSOs have been established, constituting one of the largest CSO programmes for a single forest tree species in the world. Vegetative propagation techniques through cuttings and tissue culture for large-scale plant production have been developed.

The establishment of the Teak Improvement Centre (TIC) in Ngao, Lampang province played an important role in the progress of teak breeding. Scientists and technical staff were gathered together in this institution and worked together on the teak project. Fruitful co-operation between TIC and the Chiang Mai University has been important in the development of tissue culture for commercial-scale plant production. Co-operation with scientists from RFD has been valuable.

Transfer of tree improvement technology from Denmark to Thailand was important in the initial phase of the TIC, and is now followed up by Danish support to large scale practical application in the FORGENMAP project (see below). In the coming years, transfer of technology could take place from Thailand to countries that are initiating tree improvement programmes in teak.

Continuity and recognition, at technical as well as policy level, of the importance of this work have been key-factors contributing to success. Resources in terms of manpower and funds have been allocated to the project throughout its duration, and this has been an important prerequisite for the results achieved at TIC.

However, problems arose in the practical application of research results, and to date only few teak plantations have been established using genetically improved material. The institutional set-up, with all activities housed in the Silvicultural Research Division of the RFD, was effective in the initial phases of the programme, as breeding activities require highly skilled staff. However, close co-operation with the Afforestation Divisions of the RFD is important in the implementation stages of the programme and will help ensure getting improved seeds into commercial nursery production. Improved genetic material should be multiplied and introduced into the plantation programmes as soon as possible.

Experiences from Thailand show that it is very important to consider the organisational set-up carefully from the very start of the programme. Seed procurement activities must be linked to both the unit or organisation in charge of CSOs and the organisation or unit in charge of nursery production. Information must flow freely among all concerned. Seed procurement, seedling production and tree planting are integrally linked. Funds required for seed procurement are often modest compared to the total budget for plantation establishment. Costs for CSO maintenance and seed collection constitute only 1-2% of the total plantation cost, but these activities are essential for success. It is therefore very important that sufficient funds are allocated for seed procurement. Allocation of adequate resources presupposes that information is available on seed demand in terms of quality (genetic and physiological) and quantity (amounts and timing).

A project, FORGENMAP[5], has recently been initiated in Thailand to facilitate links between genetic resource conservation, seed procurement and planting programmes. Regional seed centres have been set up in order to bridge the gap between research activities and plantation establishment. The Northern Tree Seed Centre in Lampang has teak as a priority species and will work closely together with both TIC and the afforestation units of RFD and FIO, and with the private sector. Special efforts are made to ensure that small scale private planters also have access to improved seed.

The experience from Thailand points to progeny testing as a weak point in the improvement activities. Additional field trials may be required, and the establishment of these simultaneously with the CSOs will often cause a bottleneck of limited human and financial resources. Breeding seed orchards (BSO) combine seed orchards and genetic tests (Barnes, 1995), but this concept is difficult to apply for teak because of the low seed yield per plus tree (Wellendorf and Kaosa-ard, 1988).

[5] Forest Genetic Resources Conservation and Management Project (FORGENMAP) is a project within the Royal Forest Department. FORGENMAP focuses on development of integrated strategies for seed procurement, tree improvement and genetic resource conservation for a number of forest tree species in Thailand. It is supported by the Danish Co-operation for Environment and Development (DANCED)

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ACTIVITIES OF THE INTERNATIONAL NEEM NETWORK

Neem, *Azadiracta indica* A. Juss, is a widely used, evergreen multipurpose tree native to the Indian subcontinent and Southeast Asia. The International Neem Network was established in 1994 with the long term objective to improve the genetic quality and adaptability of neem used in plantations and the sound utilization of this important species world-wide, with special focus on meeting the needs of rural people. The network, in which national institutes in 22 countries collaborate at the present time, is still expanding; China joined in 1997 and Guinea has recently applied to become a member. The network has undertaken activities in relation to provenance exploration, seed collection and exchange and has established coordinated provenance trials on a range of sites. In addition, the network has decided to undertake research in seed physiology and technology, genetic diversity and reproductive biology as well as studies on variation in chemical compounds. FAO has been entrusted the global coordination of network activities. For further description of the International Neem Network, its objectives, organization, networking principles and activities in the early stages of the network please refer to articles in *Forest Genetic Resources* No. 22 (1994), 24 (1996) and 25 (1997).

Establishment of International Provenance trials:

A total of 25 seed sources from 11 countries, sampling the entire eco-geographical variation in the range of distribution of the species, have been identified, described and seed collected. 25 seedlots were exchanged among countries and in 1995-1997 a total of 36 trials were established in 17 countries.

Table 1. Provenance trials established within the International Neem Network

Country	Number of trials established	Country	Number of trials established
Bangladesh	2	Pakistan	1
Burkina Faso	1	Philippines	2
Chad	1*	Senegal	3
India	6	Sri Lanka	1
Lao	1	Sudan	1*
Mali	2	Tanzania	4
Myanmar	3	Thailand	2
Nepal	2	Vietnam	2
Nicaragua	1		

* Due to low survival rate the trials in Chad , Nicaragua and Sudan have been closed.

Assessment and analysis of the trials has begun following guidelines agreed upon by the network collaborators. This activity will have key priority in coming years and a joint, overall analysis (over trials) is being considered.

The International Neem Network has recently issued two booklets related to its activities:

- International Neem Network (1997): Assessment of International Provenance Trials (Guidelines on assessment of trials established within the framework of the Neem Network)
- International Neem Network (1998): Description of Neem seed sources (Detailed information on seed sources included in the provenance trials established within the framework of the Neem Network)

For further information on the International Neem Network please contact:

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IUFRO CONSULTATION ON FOREST GENETICS AND TREE IMPROVEMENT

Beijing, China, 22 - 28 August 1998

The "IUFRO All-Division 2 Consultation on Forest Genetics and Tree Improvement - Contribution of genetics to the sustained management of global forest resources", organized by the Chinese Academy of Forestry, was held in Beijing, China, 22 - 28 August. The scientific programme was set up by Dr Csaba Matyas, Coordinator of IUFRO Research Group 2.02.00, on behalf of Division 2. The objectives of the IUFRO consultation were to present and discuss accomplishments, current trends and expected future developments, to review the role of forest genetics and breeding in contemporary forestry and to set priorities for future research and development.

The consultation was attended by approximately 100 persons from 30 countries, of which 63 foreign scientists. Most foreign participants came from Europe and North America, while Central America, the Near East, Southeast Asia and the Pacific were also represented.

This IUFRO consultation, organized in collaboration with FAO, was essentially based on invited papers, and its main aim was to bring together world specialists in forest tree genetics and breeding. The previous IUFRO/FAO Conference on Forest Genetics and Tree Improvement was held in Canberra, Australia in 1977. Major changes in policies, programmes, priorities and technical possibilities have occurred in the meantime, which were highlighted during the meeting.

The Consultation consisted of eight technical plenary sessions which covered the whole field of forest genetics and the variety of interests and concerns among the community of scientists, lecturers, researchers and managers present. Discussions based on Sessions are summarized in the following.

Opening session:

The consultation was opened by Prof. Hong Jusheng, vice chair of the consultation. Opening addresses were delivered by Mr Wang Zhibao (State Forestry Administration), Dr J. Burley (IUFRO) and Prof. Jiang Zehui (Chinese Academy of Forestry). H. Kriebel, former coordinator of IUFRO Division 2, was awarded Honorary Membership, the highest acknowledgement IUFRO provides.

C. Matyas outlined lessons learned from the first hundred years of forest genetics and tree breeding. He pointed out the rapid expansion undergone in genetics, which now offers unprecedented opportunities. He also questioned whether these advances fully benefited silviculture and development, in the light of fading public support for tree breeding programmes. At global level, he stressed that serious challenges were facing forestry, including the catastrophic depletion of forest resources, the serious shortage of firewood in the semiarid tropics, and the unknown effects of overall climate change. He concluded that the immediate aim of the consultation should be to encourage applied research and the rapid transfer of applicable knowledge to regions where it is most needed.

Session 1 : Situation and challenges for forest genetics and breeding

In many developed countries, several environmental groups have, for the last ten years, promoted a close-to-nature forest management excluding plantations and exotics, and emphasis has switched from wood production to basic research (E. Teissier du Cros, IUFRO). Speakers emphasised that, in the scientific field, new technical opportunities were offered, mainly derived from application of molecular technologies to forestry research. Comparisons between forestry and crop domestication were made. In this regard it was emphasised that in long-rotation species, such as forest trees, "model plants" should be used when possible, to solve important basic questions (M. Campbell, UK). However, most techniques are still at the experimental stage and the choice of appropriate molecular markers has become an important issue in population biology and forest tree breeding. All techniques involve trade-offs in the amount and quality of information that can be obtained. Some authors (A.Szmidt, Sweden; R. Sederoff, USA) stressed that although practical applications to forestry appeared limited in the near future, basic research on new technologies such as marker assisted selection, gene isolation and cloning and genetic transformation, should be developed on model species for future use and application in forestry. J. Hong (China) presented an introduction to advances in forest tree breeding and improvement in China, making suggestions for future developments.

Session 2 : Studies of adaptive potential of populations

The importance of climatic conditions in evolutionary processes of boreal tree species was underlined (T. Skropa, Norway). In Norway, phenological traits assessed in provenances of *Picea abies* (and other conifers) have shown variation between progenies when these have been established in differing environmental conditions. To explain this phenomenon, the possibility of existence of regulatory mechanisms, and the implications for provenance testing and seed orchards, were discussed.

The discrepancy in results between studies on genetic variation and variation patterns in forest tree populations from common-garden experiments and studies using molecular markers was addressed through modelling by A. Kremer, France. Simulations showed that high differentiation of adaptive traits could theoretically be present with only slight differences at allelic level of QTLs, thus limiting the use of such markers in provenance diversity studies. It was pointed out (R. Finkeldey, Switzerland) that genetic markers were more useful in tracing the history of populations than in measuring their adaptive potential. G. Müller-Starck (Germany) demonstrated on *Fagus sylvatica* that selection was operating at several enzyme gene loci, either directly or stochastic associations. Case studies were presented by G. Vendramin (Italy) on the adaptability of relic populations of *Pinus leucodermis* in Italy and Greece; they illustrated the difficulties in translating the information obtained from molecular tools into decisions for conservation. On the other hand, basic information gained on the reproductive biology of *Thuja plicata* – a species with a wide natural range and low levels of genetic diversity - gave way to new proposals for exploiting the high phenotypic plasticity of this species (Y. El Kassaby).

Session 3 : Genetic resources and the changing environment

Basic research based on field studies (D. Karnosky, USA) and on molecular level studies (G.Müller-Starck, Germany) to assess and monitor environmental changes on forest trees and ecosystems, were discussed. V. Koski (Finland) pointed out that little attention had been paid to the potential effects of climatic changes on the reproductive processes of boreal trees. The speaker pointed out the under-utilized role of mature provenance trials for the study of genetic adaptation to variations in the climate.

Session 4 : Managing genetic resources under traditional silviculture

Studies undertaken on the development of tools to monitor changes in genetic diversity as a result of silvicultural practices were reported by T. Boyle (CIFOR). These useful theoretical considerations (genetics are largely ignored in biodiversity studies and assessments) were complemented by case studies (V. Ratnam, Indonesia; Y. El Kassaby, Canada) showing, in a few species, variable levels of decrease in genetic diversity under different intensities of felling and regeneration regimes; these might guide the development of improved silvicultural practices for the species in question, if findings were to be confirmed over time.

Session 5 : Maximizing production in a sustained way

S. Midgley (Australia) noted changes in policies guiding access to genetic resources in Australia, and stressed that similar changes in control may soon become evident also in other countries. Participants stressed the vital need to maintain easy access to research quantities of germplasm. G.Namkoong (Canada) reviewed risks associated with large-scale deployment of improved materials with reduced genetic basis in the field. Sound improvement programmes using unrelated clones have the potential to keep hazards at a manageable level. New technologies also could offer opportunities for the development of active risk abatement measures.

A successful case study of applied traditional multigeneration tree improvement programmes was presented (B. Li, USA) for loblolly pine. Many details were given on expected and observed gains for several characteristics. The programme had been successful not only for increasing timber yield of the plantations, but also contributed to the conservation and sustained use of adjacent woodlands.

Session 6 : Conservation of forest genetic resources

The session provided case studies on the utilization of molecular markers for assessing the patterns and amount of genetic diversity in natural stands of *Eucalyptus sieberi* (J. Glaubitz, Australia) and *Pinus lambertiana* (G. Vendramin). In the former, molecular techniques proved useful in identifying an ancient, distinct population now lost through gene flow and recombination. A review of information needs for guiding and prioritizing conservation was presented (G. Namkoong). It was recalled that data collection is expensive and that it was important to focus on collection of data for well-defined purposes. It was concluded that decision-making tools and methodologies were needed to guide geneticists and managers to optimize resource allocation.

Session 7: Towards a coherent framework for the conservation, management, sustainable utilization and enhancement of forest genetic resources

The session described FAO's efforts to facilitate the elaboration of integrated strategies on forest genetic resources at regional level. The importance of optimizing the allocation of limited resources, focusing on priority species and activities, was stressed.

Action taken by FAO to assist countries in the Sahelian sub-region of Africa was presented and discussed (P. Sigaud, FAO). Scientists from Mediterranean countries, the Near East and China expressed interest in the initiative and called for similar efforts in their respective regions. A number of countries have already developed comprehensive national forest genetic resources strategies. Dynamic regional collaboration schemes on forest genetic resources have also been developed. S. de Vries (Netherlands) presented a case study on *Populus nigra* network in the framework of the IPGRI coordinated EUFORGEN network. IUFRO (F. Yeh, Canada) also presented the recently established Task Force on Management and Conservation of Forest Gene Resources linking IUFRO, FAO, IPGRI and CIFOR in activities aiming at preparing State of Knowledge reviews and identifying research gaps to be tackled in the future. The discussion that followed emphasized the importance of associating all partners concerned in priority setting, and the urgent need to raise awareness, at all levels, of the contribution that wise use of forest genetic resources can make to overall development.

Session 8 : Research policies in forest genetics and breeding.

A case study from USA (S. Schlarbaum) noted that many publicly funded tree improvement programmes in the country have shifted their emphasis to basic research on biological diversity, ecosystem dynamics, and the development of new (bio)technologies. Under pressure from environmental groups, harvesting restrictions have been commonly introduced. Demand for wood fibre is however increasing. Efforts of the North Carolina State University (USA) were reported as an exception to the trend towards basic research and away from aims to increase yields of wood.

The implications of changes in policy and the development of new technological tools for early selection were reviewed (R. Burdon, New Zealand). The author noted that it was too early to assess long-term implications, however concern was expressed that short-term interests of the private sector might negatively influence the continuity of tree improvement and conservation efforts which are, by definition, long-term.

Research institutions and management organizations both of the public and the private sector have efficiently joined efforts in common programmes and priorities for tree improvement research on *Pinus pinaster* in south-western France (Y. Lesgourgues). However, private sector driven initiatives have not been supported by public agencies in many countries in Latin America, resulting in slow progress (R. Salazar, CATIE). Cooperative efforts at regional and international level could help countries to define long-term research strategies and develop economic and technical support.

The consultation was followed by two optional field excursions organized by the Chinese Academy of Forestry, in Heilongjiang (boreal forests of north east China) or Sichuan (subtropical continental mountain forests).

Tentative conclusions/findings:

Tree selection and improvement programmes of varying types and intensity have been implemented in more than 100 countries, and are vital to some of them. Participants noted the deficit in information accessible to the general public and policy and decision-makers. In particular, the increasing contribution of tree plantations to fulfilling the basic needs of developing and developed societies and alleviating the pressure on natural forests should be more widely recognized. Higher yields could be obtained by increasing the productivity of the forest rather than increasing areas.

The consultation recognized the complementarity of traditional tree breeding and improvement programmes, and the development of new tools for basic research and investigation at genomic level. In each particular situation, the choice of appropriate tools should be adapted to the strategies developed.

Participants recognized the departure from studies on Mendelian inheritance, which had sometimes led to oversimplified strategies. Close interactions should be developed between studies on genetic markers, quantitative traits and tree physiology for both conservation and tree improvement purposes. Studies on biological diversity would benefit from a better integration of genetic issues in overall assessments. At the same time, it was recognized that conservation and management of forest genetic resources should be developed under the overall framework of silvicultural and forest management plans.

The consultation supported FAO's initiative to facilitate the preparation of regional action plans for the conservation, management, sustainable utilization and enhancement of forest genetic resources. Such plans could strengthen national programmes and promote the elaboration of integrated conservation and development strategies, and contribute to raising awareness of issues relating to genetic resources.

Proceedings of the consultation will be published and will include all invited papers and conclusions and recommendations addressed to institutions and organizations responsible for decision making in management of forest genetic resources, with special reference to forest tree breeding.

The efforts of IUFRO and the Chinese Academy of Forestry, which had ensured a high quality of the consultation, were acknowledged.

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RECENT PUBLICATIONS FROM THE DANIDA FOREST SEED CENTRE

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Technical Note No. 47. Calibration of seed moisture meters, by Finn Stubsgaard.

Technical Note No. 48. Planning National Programmes for Conservation of Forest Genetic Resources, by Lars Graudal, Erik Kjaer, Agnete Thomsen and Allan Breum Larsen.

Technical Note No. 49. Marketing at a Tree Seed Programme, by Karsten Raae and Svend J.C. Christensen.

Technical Note No. 50. Thirty Years of Experience with Tree Improvement of Teak in Thailand, by Apichart Kaosa-ard, Verapong Suangtho and Erik D. Kjær.

Proceedings of the seminar on Forests and Trees in Environment and Development Co-operation, Denmark 1998: *The Importance of Managing Forest Genetic Resources Material for Sustainable Forest Management.*

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SEED CONSERVATION OF DRYLAND PALMS OF AFRICA AND MADAGASCAR: NEEDS AND PROSPECTS[1]

by

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SUMMARY

Twenty six species of palm are found in the drier regions of Africa and Madagascar. About half of these species are considered to be highly utilised and are, in some areas, overexploited for leaves and trunks. As a consequence, the conservation status of 11 species (42%) is rated from rare to endangered. Eight of these species are confined to three genera, *Borassus*, *Dypsis* and *Ravenea*. Species regeneration is primarily from seed and such material will necessarily underpin species recovery programmes. However, knowledge on all aspects of palm seed technology is inadequate. For example, 10 species are thought not to possess recalcitrant (desiccation intolerant) seeds; the seed storage status of the other species is unclear. Also, there is no detailed germination data for 58% of the species. Recent encouraging results on dryland palm seed storage are discussed in the context of the prospects for long-term seed conservation in support of the sustainable utilisation of palm species.

THE PALMS OF AFRICA AND MADAGASCAR

The Palmae is, according to some sources, the world's third most useful plant family after grasses and legumes (Johnson *et al.*, 1996). Of the *c.* 200 genera (Uhl and Dransfield, 1987) and *c.* 2500 species found in the Palmae, *c.* 28 genera (Table 1) and *c.* 224 species are found in Africa and Madagascar (Dransfield and Beentje, 1995; Tuley, 1995)[2]. In this respect, Africa possesses the smallest palm diversity of any tropical area in the world (Johnson *et al.*, 1996). However, Madagascar, which is the fourth largest island in the world (Dransfield and Beentje, 1995), has about three times as many palm species than Africa and also exhibits a very high rate (*c.* 97%) of species endemism (Dransfield and Beentje, 1995).

[1] Received July 1998. Original in English.

[2] The uncertainty about the specific number of taxa in this region is a reflection of the complex taxonomy of certain genera, especially *Hyphaene*.

Table 1. Palm genera of Africa (Tuley, 1995) and Madagascar (Dransfield and Beentje, 1995)

Area	Genera
Africa*	*Areca, Calamus, Chamaerops, Eremospatha, Jubaeopsis, Laccosperma, Livistona, Medemia, Nypa, Oncocalamus, Podococcus, Sclerosperma*
Madagascar **	*Beccariophoenix, Bismarckia, Lemurophoenix, Marojejya, Masoala, Orania, Ravenea, Satranala, Voanioala*
Africa and Madagascar	*Borassus, Cocos, Dypsis, Elaeis, Hyphaene, Phoenix, Raphia*

* Africa (Tuley, 1995) includes mainland Continental Africa, excluding off-shore islands with the exception of Zanzibar, Pemba, Malabo (Fernando Po), Sao Tome and Principe.

** Madagascar (Dransfield and Beentje, 1995) includes mainland Madagascar but also includes the Comoro Islands and Pemba Island.

DRYLAND PALMS OF THE REGION: USES AND CONSERVATION STATUS

Centres of Plant Diversity (CPD) sites in both Madagascar and areas of Africa (in particular Namibia, Angola, Somalia and South Africa) contain significant areas of dryland (Prendergast, Davis and Way, 1997). Overall, fifty seven percent of the land in this region is classified as being semi-arid or drier (Fig. 1). In these areas are found a total of 26 palms, i.e. 11% of the total palm flora for the region as a whole.

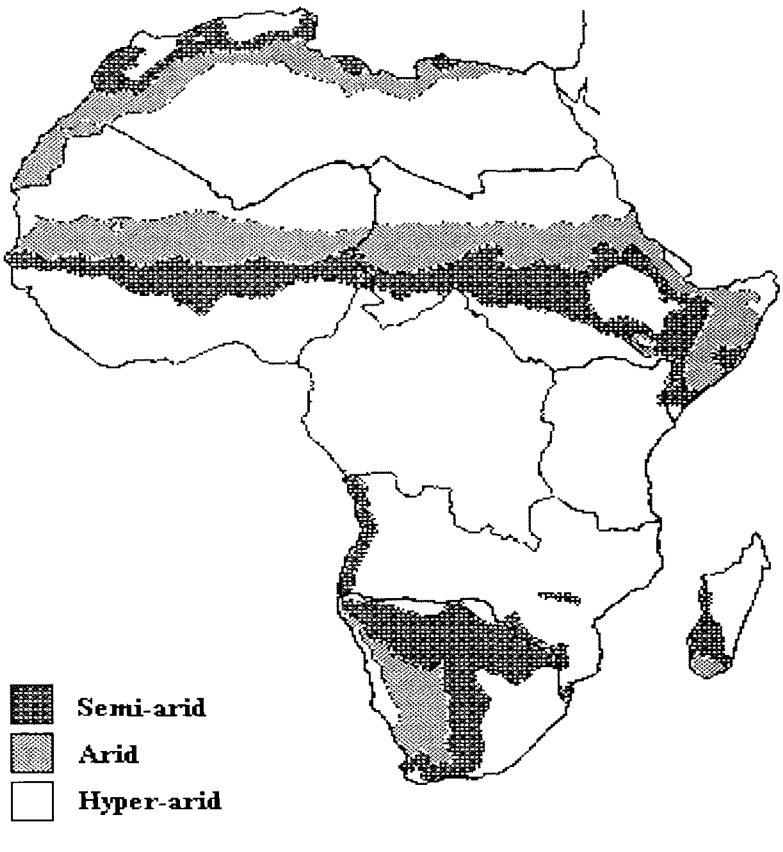

FIGURE 1. The distribution of African and Madagascan aridity zones (Middleton and Thomas, 1992). Outlines of the geographical regions used by Hollis and Brummitt (1992) are also shown.

Whilst being floristically relatively poor, the dryland region contains 11 of 28 palm genera from the region. Moreover, these palms are of high human utility with 17 out of a total of 26 species with known uses - records of use for some species, such as *Hyphaene*, *Medemia* and *Phoenix*, go back to the time of the early Egyptians (El Hadidi, 1985; Tuley, 1995). Most species have multiple uses, from beverage/food products to construction materials and weaving. Vegetable ivory, primarily from *Hyphaene*, was once popular for button making but has been replaced by more modern materials. However, there is evidence that it has potential as a substitute for animal ivory for carving (Doren, 1997). A more detailed account of the economic botany of all these genera can be found in various references (Moore, 1977; Johnson, 1985; Uhl and Dransfield, 1987; Ballick *et al.*, 1990; Dransfield and Beentje, 1995; Tuley, 1995).

It has recently been suggested, based on changes in the IUCN Red Lists, that half the palm species world-wide could be condemned to extinction within the next 50 - 100 years (Smith *et al.*, 1993; May, Lawton and Stork , 1995). In the drylands intensive utilization by humans of palms and lack of management to ensure sustainability is generally acknowledged to be contributing to this potential loss of biodiversity (Dransfield and Beentje, 1995; Hilton-Taylor, 1996; Johnson *et al.*, 1996). For the drylands of Madagascar and Africa, 42% of the palm species (i.e. 11 species) are rated as rare to endangered (Table 2). However, the other apparently less threatened species also require attention. For example, although most of the palms in the genera *Borassus*, *Hyphaene*, and *Phoenix* are considered not to be at threat, many local populations have been reported to be decreasing as a result of their over-exploitation for leaves and trunks (Johnson *et al.*, 1996). Unfortunately, additional problems of warfare and the difficulties of access undoubtedly increase the threat to isolated palm species. Such problems may have contributed to the alarming decrease in *Livistona carinensis* plants in Somalia from 50 to only 11 individuals in ten years (Thulin, 1995).

PROSPECTS FOR SEED STORAGE

Palm species regeneration is primarily from seed and such material will necessarily underpin the conservation effort and species recovery programmes. However, knowledge on all aspects of palm seed technology (storage and germination) is inadequate for species from both the wet and dry zones (Johnson, 1991; Dickie, Ballick and Linington, 1992; Johnson *et al.*, 1996; Davies and Pritchard, 1998; Pritchard, Beeby and Davies, 1998).

Information on the seed storage potential of palms is very limited. In an early review, De Leon (1961) primarily classified palm genera as being either long-lived (remain viable for two to three months); intermediate-lived (four to six weeks) or short-lived (two to three weeks); only two monotypic dryland species from Africa and Madagascar were individually cited, *Bismarckia nobilis* (short-lived) and *Chamaerops humilis* (long-lived). Similarly, in a more recent compilation (Hong, Linington and Ellis, 1996) a majority of seed storage records relate to the genus level (Table 2). In the latter case, though, information was available for 11 named species, with 8 species probably possessing seeds which can survive relatively extreme drying (< 20%, fresh weight basis), i.e. they are not recalcitrant. Our more recent studies have clarified further the situation for three species, *Hyphaene petersiana*, *H. thebaica* and *Medemia argun* (Davies and Pritchard, 1998). The longevity of the seeds (within the fruits) in warm dry storage was considerable, with *H. petersiana* seed exhibiting 40% germination after 5 years' storage (Davies and Pritchard, 1998). In addition, *H. thebaica* seed tolerated desiccation to c. 6% moisture content and short-term freezing at -20°C, i.e. conventional seed bank conditions. Fruits and seeds of the latter species which weigh c. 110 and 33 g (fresh weight) respectively are, to our knowledge, the largest plant propagules known to exhibit an orthodox-type of storage response.

Table 2. Conservation status and seed storage behaviour of the dryland palms of Africa and Madagascar

Species[3]	Conservation Status		Seed Storage Behaviour	
	Category	Reference	(De Leon, 1961)	(Hong *et al.*, 1996)
Borassus sambiranensis Jumelle & Perrier	E	1, 3, 4	Long-lived (g)	Uncertain# (g)
Livistona carinensis (Chiov.) J. Dransfield & N. W. Uhl	E	3, 4	-	Uncertain
Medemia argun Wuert ex H. Wendl.	E	3, 4	-	Uncertain
Ravenea xerophila Jumelle	E	1, 3, 4	-	-
Borassus madagascariensis Bojer	V	1, 4	Long-lived (g)	Uncertain (g)
Dypsis decaryi H. Beentje & J. Dransfield	V	1, 4	-	-
Dypsis onilahensis (Jumelle & Perrier) H. Beentje & J. Dransfield	V	1, 4	-	-
Jubaeopsis caffra Becc.	V	2, 4	-	Uncertain
Ravenea glauca Jumelle & Perrier	V	1, 4	-	-
Ravenea sambiranensis Jumelle & Perrier	V	1, 4	-	-
Dypsis madagascariensis (Becc.) H. Beentje & J. Dransfield	R	1, 4	-	-
Medemia abiadensis[4] H. Wendl.	I	4	-	-
Bismarckia nobilis Hildebr. & H. Wendl.	Nt	1	Short-lived	Recalcitrant?/ Uncertain
Borassus aethiopum Mart.	Nt	2	Long-lived (g)	Uncertain
Chamaerops humilis Linn.	Nt	3	Long-lived	Uncertain
Hyphaene coriacea Gaertn.	Nt	1, 2	Long-lived (g)	Uncertain (g)
Phoenix reclinata Jacq.	Nt	1	-	Orthodox?
Raphia farinifera (Gaertn.) Hylande	Nt	1, 3	Short-lived (g)	Recalcitrant? (g)
Phoenix dactylifera Linn.	Cultivated only	3	-	Orthodox
Hyphaene compressa H. Wendl.	-	-	Long-lived (g)	Uncertain (g)
Hyphaene guineensis Schum. & Thonn.	-	-	Long-lived (g)	Uncertain (g)
Hyphaene petersiana Klotzsch ex Mart.	-	-	Long-lived (g)	Uncertain (g)
Hyphaene reptans Becc.	-	-	Long-lived (g)	Uncertain (g)
Hyphaene thebaica Mart.	-	-	Long-lived (g)	Uncertain (g)
Phoenix caespitosa Chiov.	-	-	Long-lived (g)	-
Raphia sudanica A. Chevalier	-	-	Short-lived (g)	Recalcitrant? (g)

E = endangered; V = vulnerable; R = rare; I = indeterminate; Nt = not threatened;
'-' = relevant information could not be found; 1 = Dransfield and Beentje (1995);
2 = Hilton-Taylor (1996); 3 = Johnson *et al.* (1996); 4 = Walter and Gillett (1997).
(g) = storage behaviour cited for genus only; # uncertain = may not show recalcitrant seed storage behaviour, i.e. is capable of surviving drying to < 20% moisture content.

[3] plant name authorities from Index Kewensis (Royal Botanic Gardens Kew, UK)
[4] the general consensus is that the genus *Medemia* is monotypic and that *M. abiadensis* may be a form of *M. argun* (Uhl and Dransfield, 1987; Tuley, 1995);

Some inter-species variation in drying (from 54 - 73% down to 21 - 30% relative humidity) and freezing tolerance has been noted in dryland palms (Davies and Pritchard, 1998) and further studies are therefore needed on optimising the methods of collecting, processing (drying and germinating) and storing such material. However, the evidence suggests there is an opportunity to underpin the conservation effort on the dryland palms of Africa and Madagascar with medium- to long-term seed storage.

SEED GERMINATION

Collecting, storing and distributing seed material is an efficient means of supporting the conservation of plant germplasm. However, the material is only of use if reliable germination methods are available and this is generally not the case for palms. For example, little is known about the growth requirements (including germination) of the estimated 83% of palm species which are only found in the wild (Johnson, 1991). Some palm seeds germinate within a few weeks (Ishihata, 1973; Ellis, Hong and Roberts, 1985), including some rattans (Pritchard and Davies, 1998). For others, germination can be irregular, protracted and occur to a low extent (Koebernik, 1971; Grout, Shelton and Pritchard, 1983; Ellis *et al.*, 1985; Broschat, 1994; Pritchard and Davies, 1998). A means of overcoming slow germination has been suggested for 29 palm species using embryo isolation and culture *in vitro* (Pritchard *et al.*, 1998).

In the dryland palm species belonging to the genera *Bismarckia*, *Borassus*, *Hyphaene*, *Jubaeopsis*, and *Livistona*, retarded germination may result from the presence of a hard endocarp which most likely reduces the rate of water uptake (e.g. *Jubaeopsis caffra* [Robertson and Small, 1977]). Soaking seeds in water and the removal of the endocarp ensures a more rapid and uniform germination. Soaking is thought to not only improve water uptake (Robertson and Small, 1977), but also to remove germination inhibitors from the seed (e.g. *Borassus aethiopum* [Morris, 1994]). The latter explanation is consistent with a putative mechanism of action of elevated oxygen tension to stimulate *Jubaeopsis caffra* seed germination whereby an inhibitor is oxidised to its inactive form (Robertson and Small, 1977). Whatever the mechanism, however, soaking dryland palm seeds has been usefully applied to a range of species, including *Hyphaene thebaica* (Karschon, 1952; Davies and Pritchard, 1998), *H. petersiana* (Davies and Pritchard, 1998), *Bismarckia nobilis* (Loomis, 1958; 1961) and *Borassus aethiopum* (Morris, 1994).

Soaking reduces the mean time to emergence to about one month or less in *Hyphaene thebaica* and *H. petersiana* (Davies and Pritchard, 1998). Benefits of soaking have also been observed in *Dypsis decaryi* (Ratsirarson and Silander, 1997) and *Medemia argun* seeds (Davies and Pritchard, 1998) even though neither possesses a hard endocarp. The temperature of soaking appears not to have a dramatic effect on the response (e.g. *H. coriacea* [syn. *H. natalensis*] Tietama, Merkesdal and Schroten, 1992]). However, over-soaking kernels/seeds in water may reduce germination through oxygen deficiency (Robertson and Small, 1977). Generally then, only short-term (7 days) soaking is used (Broschat, 1994), for example in *Bismarckia nobilis* (Loomis, 1958). Longer periods of soaking (about 1 month) can be used as long as the kernels are only partly submerged in water (Davies and Pritchard, 1998). The distribution of many of the dryland palms considered here is limited to high water table environments including water courses/riverbanks (Uhl and Dransfield, 1987). Thus, the soaking response of the seeds appears to be an adaptation to the ecology of the species. Another adaptation may similarly influence the distribution of some species: the presence of a hard endocarp will protect the seed when the fruit is consumed by frugivores and thus facilitate dispersal. Apparently, one of the best sources of viable seed of *Hyphaene petersiana* is fresh elephant dung (Sneed, 1983).

There are few reports on the temperature requirements for dryland palm seed germination. Acceptable temperatures recorded include: 30°C (*Phoenix dactylifera* and *P. reclinata* [Ellis *et al.*, 1985]);

c. 27°C (*Bismarckia nobilis* [Loomis, 1958]; *Hyphaena petersiana*, *H. thebaica* and *Medemia argun* [Davies and Pritchard, 1998]); between 20 and 30°C (*Chamaerops humilis* [Ishihata, 1973]).

Overall, there is no detailed germination data for more than 50 % of the 26 dryland palms covered here. Moreover, the environmental conditions for germination are often not well established. Clearly, if seeds are to be utilised to support the sustainable use of palm germplasm, effective and efficient germination techniques need to be developed for a broader range of species.

CONCLUSION

Dryland palms of African and Madagascar are highly utilised forest genetic resources which are also of immediate conservation concern. The plight of these species will worsen unless there is concerted action to support their sustainable utilisation and it is recommended that palms are targetted for conservation within developing regional initiatives (see Palmberg-Lerche, 1997). To underpin this effort, it is suggested that *ex situ* technology-based studies on seed storage and germination methods should be performed as a complementary activity to *in situ* conservation.

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MANAGEMENT OF FOREST GENETIC RESOURCES: SOME THOUGHTS ON OPTIONS AND OPPORTUNITIES

by

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The safeguarding of forest genetic resources is today rightly a subject of global concern. While some losses in present-day biological diversity over time are inevitable due to both natural and man-made causes, diversity can be conserved and managed through a wide range of human activity, from the establishment of nature reserves and managed resource areas, to the inclusion of conservation considerations into improvement and breeding strategies of species under intensive, human use.

Active and vigorous measures are needed to reverse present trends leading to loss and depletion of genetic resources. These must be based on improved technical and scientific understanding of species and ecosystem functions, and of the extent, distribution and dynamics of biological diversity and genetic variation.

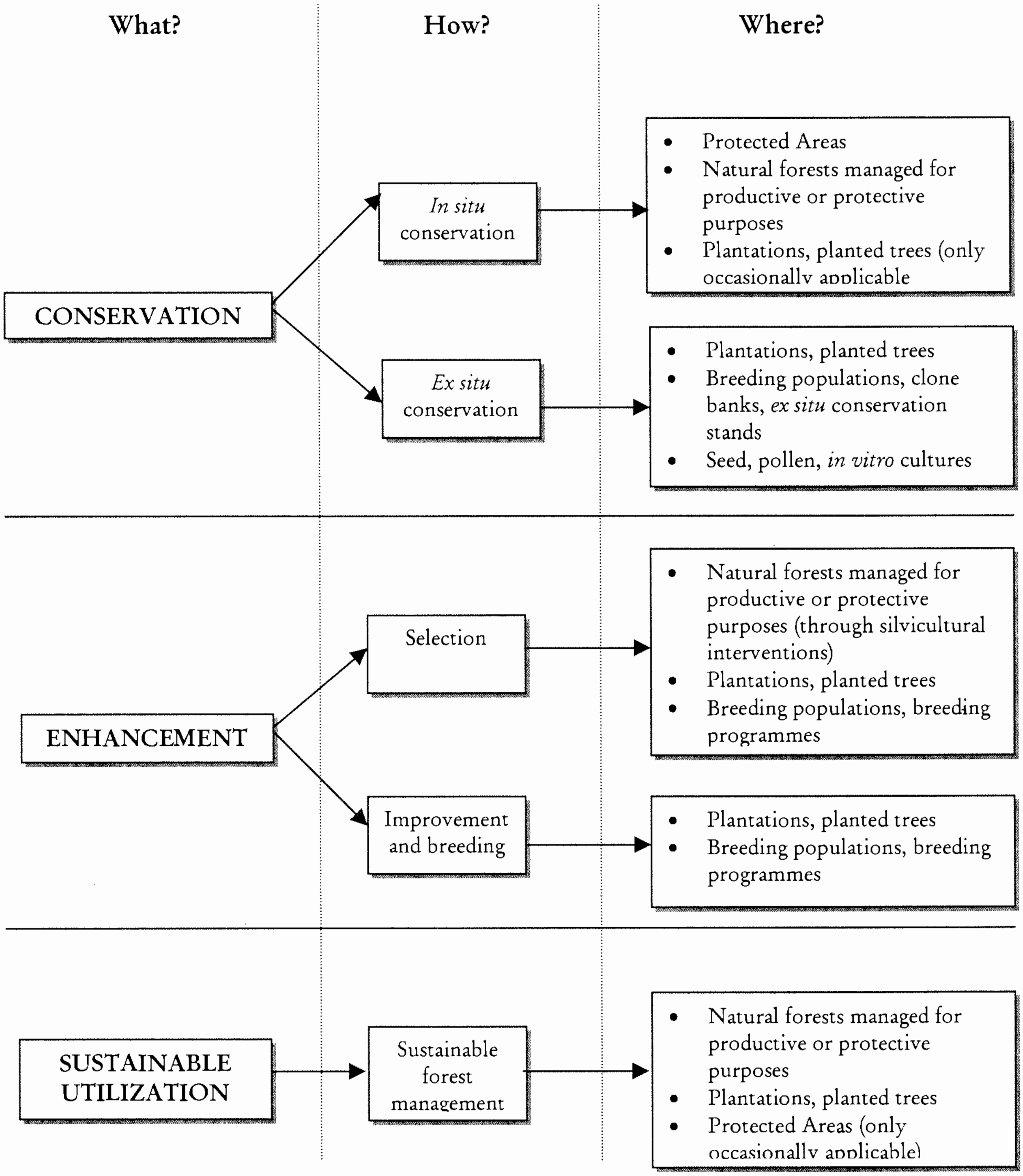
Neither natural ecosystems nor breeding programmes are static. Genetic conservation must not be aimed at freezing a given state of dynamically evolving, living systems. Efforts to conserve, enhance and wisely utilize forest genetic resources for present-day and future use will involve action related to the management of protected areas, the management of productive forests, and the management of breeding populations, supplemented by *ex situ* conservation measures to ensure greater security over time. The key to success will lie in the development of active and dynamic programmes, which harmonize conservation and sustainable utilization of forests and forest genetic resources within a mosaic of land use options, and which include a strong element of active gene management.

An attempt is made below to further clarify the concept and components of management of forest genetic resources, and the role that alternative management strategies applied in forests and woodlands can play in this regard.

Management of genetic resources of forest trees and shrubs: sub-division by category of land use.

Management Category (Type of Area)		Main Activity Supporting the Management of Forest Genetic Resources
PROTECTED AREAS	⇨	Conservation
MANAGED NATURAL FORESTS	⇨ ⇨	Conservation Sustainable utilization
PLANTATIONS, PLANTED TREES	⇨ ⇨	Enhancement Sustainable utilization
TREE IMPROVEMENT, BREEDING (Incl. *ex situ* collections)	⇨ ⇨	Conservation Enhancement

MANAGEMENT OF GENETIC RESOURCES OF FOREST TREES AND SHRUBS CONCEPT AND COMPONENTS



THIRD EUFORGEN NOBLE HARDWOODS NETWORK MEETING[1]

Background

The European Forest Genetic Resources Programme, EUFORGEN, was established in October 1994 as the implementation mechanism of Resolution S2 adopted at the First Ministerial Conference on the Protection of Forests in Europe, held in Strasbourg in 1990. The Resolution addressed the need to increase awareness and action in the conservation of forest genetic resources in Europe. The EUFORGEN Programme, endorsed at the Second Ministerial Conference in Helsinki in 1993, aims at promoting and coordinating the *in situ* and *ex situ* conservation of genetic diversity, development and implementation of country-driven, long-term gene conservation strategies and monitoring of progress. Within its five Networks, EUFORGEN operates through "pilot species" representing different biological characteristics and eco-geographic regions in Europe. Opportunities for further work include incorporating the issue of genetic resources in all aspects of forest management and strengthening links with non-European countries within the framework of the outcome of the Third Ministerial Conference, which was held in Lisbon in June 1998.

The Programme is coordinated by the International Plant Genetic Resources Institute, IPGRI. Most European countries which endorsed Resolution S2 in Strasbourg, are members of one or several of the Networks. EUFORGEN is operated as a multilateral trust fund, with participating countries contributing to the cost of meetings, publications and overall coordination. The Programme is overseen by a Steering Committee of National Coordinators nominated by the participating countries. The Steering Committee meets once in three years to evaluate the progress made and to decide upon future activities. FAO's Forestry Department, which was involved in the conceptualization and planning of follow-up action to Resolution S2 from the outset, is a member of the Management Committee of EUFORGEN and also regularly attends meetings of the Steering Committee. For further information on EUFORGEN please refer to paper in Forest Genetic Resources No. 23, p 51 (1995).

Third Noble Hardwoods Network meeting in Estonia

The EUFORGEN Noble Hardwoods Network includes species of the genera *Acer, Alnus, Castanea, Fraxinus, Juglans, Tilia, Sorbus, Ulmus* and wild fruit trees of the Rosaceae family (*Malus, Prunus, Pyrus* ssp.). Discussions during the third meeting of the Network, held in Sagadi, Estonia, 13-16 June 1998, focused on the further development of strategies and methodologies for the genetic conservation of these species. The strategies, previously developed for maples (*Acer*), elms (*Ulmus*), rowan (*Sorbus*) and the wild fruit trees, are concerned with a number of issues from inventories of occurrence and abundance, genetic variation and variation patterns, breeding and reproductive systems, to regeneration, silviculture and sustainable use of the species covered. It was confirmed that "rareness" of species - a term often associated with Noble Hardwoods - is a relative concept because most if not all species become "rare" at the extremes of their distribution range.

The core of any conservation strategy for Noble Hardwoods (and for most forest tree species), is their silvicultural management and sustainable use, carried out with due attention to genetic principles. An overview paper was presented on this topic by Dr P. Rotach, Network member from Switzerland. Technical guidelines aimed at forest officers responsible for genetic conservation in European countries will be produced by the Network and their outline was agreed upon during the meeting.

[1] Received November 1998. Original in English.

Strategy documents prepared by Network members on ash (*Fraxinus*), chestnut (*Castanea*) and lime (*Tilia*) were adopted and will be published in the Report of the meeting. In the case of *Castanea*, in which local "fruit varieties" (propagated by grafting) were in danger of being lost, these should be incorporated into conservation populations. It was stressed that appropriate institutional and professional links need to be forged between horticulturists and foresters to provide mutual support and constructive collaboration.

The basis for concern related to a global climate change must lie in ensuring availability of genetic variation in tree populations, which will allow them to adapt to changing environments. A discussion paper on this topic, prepared by Prof. G. Eriksson, Chair of the Network, pointed out the inconsistency of modelling and predictions of "migration" of entire tree species northwards (in the Northern Hemisphere) as a consequence of global warming. It was noted that while there could potentially be losses of the presently found genetic variation over time (e.g. in marginal populations), the genetic adaptability of trees, which are among the genetically most variable organisms, provide a rather comforting view of the future in this regard. There was, however, a need to give priority to research on mating patterns and reproductive biology of the Noble Hardwood species, as a basis for the development and implementation of the long-term genetic conservation strategies.

The Network also discussed the information management on Noble Hardwoods genetic resources in Europe. The common descriptors, previously proposed by the Network, should be kept to the very minimum. If countries wish and are able to record additional variables, this would be an advantage but should not necessarily be coordinated at the international level. While the development of national databases was encouraged, the issue of a common, centralised information system on Noble Hardwoods would need to be further discussed. In the meantime, a link page will be set up on the Network's Internet site, which will include a list of the agreed, common descriptors, and electronic links to existing national databases, as requested by the countries concerned.

The Network decided to regularly update the overview of ongoing national and international research projects. The possibilities of securing additional EU funding for some of the Network activities were noted, including shared-cost projects (EU Framework Programme V, INCO-Copernicus etc.). The participants also expressed their wish to strengthen the links between EU funded research projects and scientists in non-EU countries. The need to continue to raise awareness of policy makers, foresters and the general public of the role and potential of the often overlooked species, covered by the Network, was emphasized. A first step had been taken through the recently published Leaflet on Noble Hardwoods, but much still remains to be done in this area.

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THE CONSERVATION AND SUSTAINABLE UTILIZATION OF MAHOGANY GENETIC RESOURCES

BACKGROUND

The most important Meliaceae genera in the neotropics are *Swietenia* and *Cedrela*. For more than a century the mahoganies, as they are commonly known, have been of fundamental importance to national progress in many countries in Latin America, supporting the advancement of rural communities, the development of forest industries and the generation of local and national employment and revenue. Species of these two genera are important in plantation programmes also outside of their natural range, notably in countries in the Asia-Pacific region.

Increasing human populations and new demands have led to changes in land use in countries in which species of these genera occur naturally. Related loss of forests has, in turn, led to the disappearance of some specific sub-populations of mahogany species. Through dysgenic selection (harvesting of the phenotypically most desirable individuals) the genetic constitution of accessible natural populations of intensively used species in forested areas is also likely to have changed over time in a manner which, if allowed to continue, may endanger the sustainability of these populations, and which may pose difficulties to future adaptation of the species to environmental changes and limit the possibilities for genetic improvement to meet evolving human needs.

Based on concern about possible deterioration of the genetic quality of the mahoganies which, unless addressed in a timely manner, may negatively affect countries in which these species occur, the FAO Panel of Experts on Forest Gene Resources has over the past years flagged the need for national and regional action and international support to research and studies on the distribution and variation of mahogany species and corresponding trends, with the aim of furthering the conservation and sustainable utilization of this important resource based on improved knowledge. These calls for action are in line with similar recommendations passed by a number of national and international institutes and fora, notably by the Convention on International Trade in Endangered Species (CITES).

ACTION TAKEN TO DATE AND FUTURE PLANS

Information on activities related to genetic resources of *Swietenia* and *Cedrela* spp. in the neotropics was published in Forest Genetic Resources No. 25 (1997). Copies of the report "Genetic Resources of *Swietenia* and *Cedrela* in the Neotropics: proposals for coordinated action" (FAO 1997), which was briefly described in the above issue of FGR, are available from the Forest Resources Division of FAO, in Spanish and in English (see below for address).

An International Symposium on Genetic Resources, Ecology and Management of Big-Leaf Mahogany (*Swietenia macrophylla*), was organized in October 1996 in Puerto Rico by the International Institute of Tropical Forestry (IITF), in technical collaboration with FAO. The symposium, which was attended by experts from countries in Latin America and the Caribbean and from a range of countries in other regions interested in neotropical mahogany species, identified a number of priority issues in need of attention and passed recommendations for related action (proceedings in press; IITF 1999). The participants also preliminarily discussed a proposal by FAO to support networking activities among institutes working on the conservation and management of genetic resources of neotropical mahogany species. The general aim of the proposed forest genetic resources network was to support the programmes of national institutes already active in this field in countries which expressed a wish to participate, and to help strengthen links and collaboration between them, thus ensuring complementarity of action. Country-driven action within the framework of the network would be carried out in a manner complementary to already on-going or planned work in this and related fields coordinated by other agencies or institutions.

A draft project proposal for networking activities in genetic resources of mahogany species was subsequently elaborated by FAO consultants from the region. The proposal was submitted by FAO in 1997 and 1998 for comments and suggestions to institutes in potentially interested countries in Latin America and the Caribbean and in other tropical regions. The proposal was also made available to the CITES Secretariat, and has been preliminarily discussed with participants in recent CITES-related meetings, with a view to streamlining possible future forest genetic resources activities with trade-related action being proposed within the framework of CITES.

The draft proposal was discussed in a side meeting on genetic resources of mahoganies, organized in connection with the 20th Session of the Latin American and Caribbean Forestry Commission in La Havana, Cuba, in September 1998. The side meeting was attended by some thirty participants representing thirteen countries and three regional or international organizations. While countries of the Amazon Cooperation Treaty cautioned against potential overlap with planned activities within the framework of CITES, others showed enthusiasm for the proposal, which they confirmed should - as originally proposed - focus on activities related to the conservation, enhancement and sustainable utilization of mahogany genetic resources, and include a range of species of Meliaceae occurring in the region. The participants agreed to further discuss the draft proposal in their respective countries and, following such discussions and careful in-country analysis, provide additional comments to FAO for incorporation into the proposal.

Based on feed-back from countries and on availability of funding, consideration will be given to the organization of a regional workshop to finalize the proposals and to initiate corresponding activities.

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IUFRO SEED SYMPOSIUM 1998[1]
"Recalcitrant seed"

by

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The International Symposium on Recalcitrant Seeds was organized on behalf of IUFRO Project Group P2.04.00 by the Forest Research Institute of Malaysia and the Forest Departments of Peninsular Malaysia, Sabah and Sarawak, in Technical Collaboration with the International Plant Genetic Resources Institute (IPGRI), the Food and Agriculture Organization of the UN (FAO) and the Danida Forest Seed Centre (DFSC)

The IUFRO Symposium, which was held 12 - 15 October in Kuala Lumpur, Malaysia, went very smoothly. This was the first time an international meeting on tropical recalcitrant forest tree seeds had been organized in Malaysia. The Symposium was opened by the Minister of Primary Industries of Malaysia, Dato Seri Dr. Lim Keng Yaik. The opening of this Symposium was also used as the platform for the launching of the IUFRO 2000 Congress Logo. The Congress will be hosted by Malaysia in the year 2000.

A total of about 140 participants from some 24 countries attended the Symposium. Eleven Keynote Lectures and thirty-three presentations were made at the meeting, organized under the following six Sessions: (i) Seed Biology; (ii) Seed Storage; (iii) Seed Health and Quality; (iv) Cryopreservation; (v) Seed Monitoring, Collection and Handling; and (vi) Nursery Techniques for Recalcitrant Seeds. To wind off the Symposium, a Panel discussion on "Progress and Future Directions for Recalcitrant Seed Research", was organized. The members of the Panel were: Daniel Baskaran (Chairman), Dr. Christina Walters, Dr. Hugh Pritchard, Dr. Marlene Diekmann, Prof. Norman Pammeter, Dr. Paul Tompsett and Mr. Somyos Kijkar.

Among recommendations on future directions for research in recalcitrant seeds the following can be mentioned:

Seed Biology - Research Needs

1. There is a need for acquisition of high quality seeds. Research emphasis needs to be placed on:
   a. Phenology patterns of seed production.
   b. Methods to 'reinvigorate' seeds in the laboratory by i.e. reducing microbial infestation; developing embryo rescue techniques, and by *in vitro* maturation.

2. Identify seed physiology (firstly, at seedlot level, leading on to species level):
   a. Reliable screening techniques for viability:
      germination of whole seeds;
      culture of axes.

[1] Received November 1998. Original in English

b. Quantitative classification (raising the question, what does recalcitrant mean anyway?):
 define recalcitrance in terms of maturity status, in terms of cell biology, in terms of protein patterns, in terms of moisture level, in terms of water content of axes and in terms of water potentials.

3. Understand physiology
 a. Develop models to understand plant stress:
 what is stress?
 what are protective mechanisms?
 why doesn't our seed lot have this mechanism?
 - immature seeds
 - environmental influences
 - genetic influences

4. Manipulative physiology
 a. Remedy slow germination
 b. Enhance tolerance

Seed Quality and Health - Research Needs

1. Application of new methodologies to seed testing.
2. Survey of seed mycoflora on selected key species.
3. Pest Risk Analysis (PRA), to identify pathogens of Quarantine significance (safe movement) and pathogens giving rise to concern over Quality.
4. Development of treatment protocols to control fungal contamination/infection.

Cryopreservation - Research Needs

1. Why a technique works or does not work?
 -we are still too empirical
 -we need quantification of freezing rates
 -we need quantification of effects of pretreatments.

2. Do different tissues respond differently ?

3. Recovery media - do we need to modify these?

Seed Storage - Research Needs

1. Harvesting at the right time (seed development drives storage behaviour):
 Need for more physiological screening of seed storage response with particular attention to developmental age.

2. Heterogeneity of Response:
 Need to improve the accuracy of the assessment of desiccation sensitivity and be aware of/look for, causes (morphology/anatomy studies and water differentials [we need some isotherms]).

3. Post-storage treatments:
 Need to know more about germination.

4. Dissemination and technical outputs:
   Handbooks, articles, databases placed on the web, training courses, networks etc.

Nursery Techniques - Research Needs

1. Ageing of parent stock from which vegetative materials are obtained needs to be studied. Methods to reinvigorate stock plants are a concern.

2. Management of the donor stock needs to be studied.

3. Number of vegetative clones to ensure adequate genetic diversity is of concern and needs to be studied.

4. There is a need to develop appropriate techniques for exchange of vegetative materials.

Proceedings of the Symposium

The Proceedings of the Symposium are being compiled and will be ready hopefully in the first quarter of 1999.

Other activities in connection with the seed symposium

Two related events were held just prior to the Symposium: a Workshop on Cryopreservation of Tropical Tree Germplasm (7-9 October), and a Satellite Meeting of the IPGRI/Danida Forest Seed Centre (DFSC) Project on Recalcitrant Seeds (10-11 October).

The Workshop on Cryopreservation was organized to provide training for those interested in new techniques in cryopreservation, such as vitrification and encapsulation. Three resource persons well versed in the field conducted the course. They were Drs Hugh Pritchard, Florent Englemann and Akira Sakai. The workshop was attended by some 15 participants. I believe they had a wonderful time.

The Satellite Meeting of the IPGRI/DFSC Recalcitrant Seeds Project was attended by some 26 researchers from 19 participating countries. Participants in the meeting reported on and discussed findings from the first phase of the project, and elaborated plans for a second phase. For further information on this project please refer to article on page 56.

Acknowledgements

The organizing committee wishes to extend its special thanks to all the agencies that have helped in one way or another to make this meeting a success. A special thanks goes out to FAO for its financial support and to IPGRI which provided financial support through the funding of some 18 foreign participants to the symposium.

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SPRIG: SOUTH PACIFIC REGIONAL INITIATIVE ON FOREST GENETIC RESOURCES[1]

by

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SPRIG is a three-year pilot project which aims to strengthen conservation, management and utilization of forest genetic resources in the South Pacific. SPRIG is being jointly implemented by the Forestry Departments in Vanuatu, Fiji, Tonga, Samoa, Solomon Islands and an Australian Consortium with expertise in tropical forest genetic resources. The Australian consortium consists of the Australian Tree Seed Centre, CSIRO Forestry and Forest Products, the Queensland Forestry Research Institute, and FORTECH, a commercial forestry consulting company, which forms part of the Dames and Moore group. Major funding for SPRIG is provided by AusAID with additional funding and in-kind support provided by the Governments of the five Pacific countries.

The three main activity sectors of SPRIG are:

I. Strategies for conserving the genetic resources of priority indigenous tree species
II. Tree improvement; assist South Pacific countries to collect, distribute, exchange, propagate and evaluate priority tree species germplasm, especially indigenous species
III. Institutional development; improve the capability of South Pacific institutions in the conservation and utilisation of forest genetic resources.

Considerable progress has been made in each area since the project was initiated in December 1996. SPRIG has also played an important role in raising awareness of the values of forest genetic resources, their fundamental importance for sustainable development, and issues related to their use, exchange and enhancement.

CONSERVATION

The principle activities of the conservation component are to conduct *Rapid Rural Appraisals* (RRAs) to ascertain local and traditional knowledge, including conservation practices, of important tree species, and to develop conservation strategies for ten priority tree species.

The main objectives of the RRA's are to obtain information from rural communities on:

a) conservation strategies for endangered priority species (and populations).
b) seed collection in priority species
c) priority forestry and agroforestry species for conservation and development from a community perspective, and
d) data on priority species for inclusion in SPRIG forest genetic resources database.

[1] Received November 1998. Original in English.

The RRAs are conducted in close cooperation with Forestry Department staff in countries. In each country RRAs will be undertaken in 20 carefully selected communities. The location of these communities for survey requires good knowledge of the natural distribution of target species. Clusters of households rather than individual households are preferred for survey and men and women are interviewed separately. Time spent in each community varies from 1-3 days. Information given by villagers is verified, wherever possible, through inspection, especially information given on folk varieties and closely related, but little known, species.

RRAs have been completed in Vanuatu, Samoa and Tonga, partly completed in Fiji and planned to commence in late 1998 in the Solomon Islands. These have yielded much useful information; country reports from Vanuatu and Samoa are available.

The species conservation strategies aim to develop complementary *in situ* and *ex situ* conservation strategies for conserving the genetic resources of ten specified priority indigenous tree species. Key genera and species were identified during the first SPRIG meetings in Nadi in November 1996. This list has subsequently been further refined in consultation with national Forestry Departments. The list of species is given in Table 1 below.

Table 1. Indigenous tree species for conservation strategies

SPECIES	Distribution in SPRIG countries	Distribution elsewhere
Agathis macrophylla	SI,V*,F,	
Agathis silbai	V*	
Cordia subcordata	SI*, V, F, T, S	SE Asia/Indian Ocean
Dacrydium nausoriense	F*	
Endospermum medullosum	SI, V*	PNG, Irian Jaya
Intsia bijuga	SI, V, F, T, S*	SE Asia
Manilkara hoshinoi	S*	Fed.States of Micronesia
Santalum austrocaledonicum	V*	New Caledonia
Santalum yasi	T*,F	
Terminalia richii	S*	Niue

SI = Solomon Islands, V = Vanuatu, F = Fiji, T = Tonga and S = Samoa
* = Country to take lead role in strategy development

Detailed information on each of these species, relevant to the conservation of its genetic resources, has been gathered through the RRA surveys of traditional and local knowledge, during seed collection, and through a search of the available literature. This information will be collated and strategies prepared during the coming year, using guidelines for *in situ* conservation of forest genetic resources being developed by FAO and IPGRI. Preliminary work on the elaboration of conservation strategies for several of the species was undertaken by SPRIG/AusAID-supported counterparts in each participating country as part of an ANU short course on forest conservation and genetics, held in Canberra, Australia in September-October, 1997.

TREE IMPROVEMENT

The objective of the tree improvement component is to assist the five collaborating South Pacific countries to collect, distribute, exchange, propagate and evaluate germplasm of priority tree species, with special emphasis on indigenous species. The main activities are:

1. Development of a regional database on forest genetic resources. Information on more than 350 tree species of socio-economic importance in the South Pacific is being gathered and included in the database. The initial focus has been on about 50 species of high priority.

2. Tree seed collections and procurement of high-priority indigenous and exotic tree species. The main genera and species being targeted for seed collection are *Agathis, Endospermum, Intsia bijuga, Santalum, Swietenia macrophylla, Terminalia* and *Toona ciliata.* Many of these species have seeds which are intermediate or recalcitrant in character, with attendant seed handling and storage difficulties. CSIRO has contacted IPGRI and the DANIDA Forest Seed Centre on behalf of SPRIG partners, requesting to participate in the second phase of the IPGRI/DFSC project on intermediate and recalcitrant forest tree seeds[2]. Research proposed would entail detailed studies on two Pacific tree species per country, which have problems in seed handling and storage.

3. Field trials. Each collaborating country is establishing demonstration plantings of priority indigenous and exotic tree species. The objective is to establish five hectares of trial plantings in each country, each year of the project. The trials are designed to serve both for provenance testing and to contribute to *ex situ* genetic conservation. These plantings have been established using high silvicultural standards, including notably high-quality seedlings and good weed control. They are being well-maintained, protected and monitored by the respective Forestry Departments. Field trials established to date include:
   a) Vanuatu: 5 ha established in February 1998 (mainly *Swietenia* provenance and family trials)
   b) Tonga: 5 ha established in March 1998 (mainly *Toona* provenance and family trials)
   c) Samoa: 5 ha established in April-June 1998 (*Swietenia* provenance trial, *Terminalia ritchi* seed stand, *Eucalypus camaldulensis* seed production stand), and
   d) Fiji: seedlings propagated for *Swietenia* provenance/family trials (awaiting wet season).

4. Development of vegetative propagation techniques. The Queensland Forest Research Institute, in collaboration with partners in Fiji and Vanuatu, is conducting a research program to develop vegetative propagation techniques for tree species from the Pacific. Genera and species investigated to date include *Toona ciliata, Swietenia macrophylla* and *Santalum* spp.

5. INSTITUTIONAL STRENGTHENING

The objective of institutional strengthening activities within SPRIG is to improve the capability of existing institutions in the five participating countries to support action in the conservation, management and improvement of forest genetic resources. Activities include skills upgrading through in-service training, work programs, technical and post-graduate training, participation in workshops, establishment of a regional forest genetic resources expert group, a regional quarterly newsletter (PIF&TSP's "Pacific Islands Forest and Trees") and provision of some equipment.

[2] For further information on this project, please refer to the article on the project on page 59.

Most training is of a "hands-on"-nature, carried out during regular visits to the region by project staff and consultants. Another important training activity is participation of collaborators in formal short courses including seed technology, vegetative propagation, and genetic conservation. SPRIG is also supporting postgraduate training.

Work-related "attachments", of up to one month's duration, in the fields of seed collection and genetic conservation, have been undertaken at the Australian Tree Seed Centre, CSIRO Forestry and Forest Products; and sponsorship of national scientists from collaborating countries to attend international meetings dealing with forest genetic resources.

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RECALCITRANT AND INTERMEDIATE TROPICAL FOREST TREE SEEDS[1]

Early information on the IPGRI[2]/DFSC[3] project on handling and storage of recalcitrant and intermediate tropical forest tree seeds was provided in Forest Genetic Resources No 24 (1996).

This Danida funded project was initiated by IPGRI and DFSC in 1993. The project has helped establish an informal international network for forest tree seed research where seed centres and research institutes and universities in Africa, Asia, Latin America, Europe and North America have worked on the development of improved techniques for seed collection, handling and the determination of seed storage physiology for 20 economically important species. The species that have been investigated in the project are: *Azadirachta indica*, *Azadirachta indica* var. *siamensis*, *Butyrospermum paradoxum*, *Hancornia speciosa*, *Hieronyma alchorneoides*, *Hopea odorata*, *Khaya anthoteca*, *Khaya senegalensis*, *Lannea microcarpa*, *Pometia pinnata*, *Prunus africana*, *Sclerocarya birrea*, *Shorea leprosula*, *Syzygium cuminii*, *Trichilia emetica*, *Virola koschnyi*, *Virola sebifera*, *Vochysia ferruginea*, *Vochysia guatemalensis and Warburgia ugandensis.*

The network, based on strong partnerships and twinning of scientists, has jointly developed a useful research protocol for collecting, handling, testing and screening of desiccation tolerance and optimal storage conditions. A specific protocol for seed development studies was also developed. Regular exchange of information among the members of the network is maintained through a bi-annual newsletter. Research capacity in developing counties is further enhanced through training workshops and well-focused publications. Scientific links are established with the International Neem Network, co-ordinated by FAO, and also with ICRAF[4] Tree Domestication Programme, ISTA[5] and the IUFRO Research Group on Seed physiology and technology.

In connection with the recent IUFRO Seed Symposium on recalcitrant seeds, held in Malaysia, 12-15 October 1998, a Satellite Meeting of the IPGRI/DFSC project was organized. Results and experiences were exchanged including information on the importance of seed moisture content at harvest, fruit and seed sizes, germination speed etc in addition to desiccation and storage test results. Preliminary results have been presented in the project newsletters, and a summary for all the experiments related to species included in the work programme will be published in Newsletter No. 5, which is expected to be distributed in January 1999. A separate scientific publication with all project results, including also the agreed upon handling and storage protocols, will subsequently be jointly published by IPGRI and DFSC.

As work on establishing optimal seed handling procedures for a number of important forest tree species with presently unknown seed physiology has just started, IPGRI, DFSC and partners in the network are planning a second phase of this project. A proposal has been developed and submitted to Danida for funding for another 3 year period. The purpose of this extension is to continue the

[1] Received October 1998. Original in English.
[2] International Plant Genetic Resources Institute, Rome, Italy
[3] Danida Forest Seed Centre, Humlebaek, Denmark
[4] International Centre for Research in Agroforestry, Nairobi, Kenya
[5] International Seed Testing Association

screening work including additional species, to further strengthen the network, to train more scientists in the use of the protocol, and to test the laboratory results under large scale conditions in the seed centres collaborating in the project.

The newsletter can be ordered from DFSC free of charge.

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RECENT LITERATURE OF INTEREST[1]

(i) BOOKS, HANDBOOKS

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[1] Individual papers included in Proceedings or books will not be listed under (iii) or (iv).

Throughout the list, addresses of publishers or authors are given in brackets after the reference, whenever possible. Please write to these addresses directly should you wish to have a copy of the publication/article in question.

E: available in English
F: available in French
S: available in Spanish

(ii) CONFERENCE AND WORKSHOP PROCEEDINGS

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(iii) INFORMATION, REPORTS FROM INSTITUTIONS, ASSOCIATIONS, ETC.

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