Eucalyptus pests and diseases

Report of a meeting
9-12 October 1995
Bangkok, Thailand

M. Diekmann and J.B. Ball, editors
Eucalyptus pests and diseases

Report of a meeting
9-12 October 1995
Bangkok, Thailand

M. Diekmann and J.B. Ball, editors
The International Plant Genetic Resources Institute (IPGRI) is an autonomous international scientific organization operating under the aegis of the Consultative Group on International Agricultural Research (CGIAR). The international status of IPGRI is conferred under an Establishment Agreement which, by December 1995, had been signed by the Governments of Australia, Belgium, Benin, Bolivia, Burkina Faso, Cameroon, China, Chile, Congo, Costa Rica, Côte d'Ivoire, Cyprus, Czech Republic, Denmark, Ecuador, Egypt, Greece, Guinea, Hungary, India, Iran, Israel, Italy, Jordan, Kenya, Mauritania, Morocco, Pakistan, Panama, Peru, Poland, Portugal, Romania, Russia, Senegal, Slovak Republic, Sudan, Switzerland, Syria, Tunisia, Turkey, Ukraine and Uganda. IPGRI's mandate is to advance the conservation and use of plant genetic resources for the benefit of present and future generations. IPGRI works in partnership with other organizations, undertaking research, training and the provision of scientific and technical advice and information, and has a particularly strong programme link with the Food and Agriculture Organization of the United Nations. Financial support for the agreed research agenda of IPGRI is provided by the Governments of Australia, Austria, Belgium, Canada, China, Denmark, France, Germany, India, Italy, Japan, the Republic of Korea, Mexico, the Netherlands, Norway, Spain, Sweden, Switzerland, the UK and the USA, and by the Asian Development Bank, IDRC, UNDP and the World Bank.

The geographical designations employed and the presentation of material in this publication do not imply the expression of any opinion whatsoever on the part of IPGRI, FAO, ACIAR, AFTSC or the CGIAR concerning the legal status of any country, territory, city or area or its authorities, or concerning the delimitation of its frontiers or boundaries. Similarly, the views expressed are those of the authors and do not necessarily reflect the views of these participating organizations.

Citation:

Cover photograph: Eucalyptus globulus south of Concepción, Chile (W.M. Ciesla photo)

ISBN 92-9043-290-X

IPGRI
Via delle Sette Chiese 142
00145 Rome
Italy

©International Plant Genetic Resources Institute, 1996
Acknowledgements

We express our thanks to the Australian Centre for International Agricultural Research (ACIAR) for funding the expert consultation meeting. A special thanks is due to the host institution, the ASEAN Forest Tree Seed Centre (AFTSC), located in Saraburi, Thailand. The Director, Dr Somyos Kijjar, ensured that the meeting was productive and that the participants obtained a good view of AFTSC’s many activities. FAO’s contribution towards the printing cost of this report is gratefully acknowledged. Mr. Jim Ball, Senior Forestry Officer at FAO, acted as Secretary for the meeting. Thanks are due to our editor, Linda Sears, and the staff of the IPGRI publications group for their invaluable help in the production of this report.

Report on the IPGRI/FAO Expert Meeting on Guidelines for the Safe Movement of Eucalyptus Germplasm

Background to the IPGRI/FAO Guidelines series

Collecting, conservation and utilization of plant genetic resources and their global distribution are essential components of international crop and tree improvement programmes. Inevitably, the movement of germplasm involves a risk of accidentally introducing plant pests along with the host plant. In particular, pathogens that are often symptomless, such as those infected with viruses, pose a special risk. In order to manage this risk, effective testing (indexing) procedures are required to ensure that distributed material is free of pests that are of quarantine concern.

The ever-increasing volume of germplasm exchanged internationally for research purposes, coupled with recent advances in biotechnology, has created a pressing need for specific overviews of the existing knowledge in all disciplines relating to the phytosanitary safety of germplasm transfer. This has prompted FAO and IPGRI to launch a collaborative programme for the safe and expeditious movement of germplasm, reflecting the complementarity of their mandates with regard to the safe movement of germplasm. FAO, as the depository of the International Plant Protection Convention of 1951, has a long-standing mandate to assist its Member governments to strengthen their plant quarantine services, while IPGRI’s mandate - inter alia - is to further the collecting, conservation and use of the genetic diversity of useful plants for the benefit of people throughout the world.

The purpose of the joint FAO/IPGRI programme is to generate a series of technical guidelines that provide relevant information on disease indexing and other procedures that will help to ensure phytosanitary safety when germplasm is moved internationally. The scope of the recommendations in these guidelines is confined to small, specialized consignments used in technical crop and tree-improvement programmes, e.g. for research and basic plant breeding programmes. When collecting germplasm, local plant quarantine procedures, for example pest risk assessment, should be considered.

These technical guidelines are produced by meetings of panels of experts on the species concerned, who have been selected in consultation with the relevant specialized institutions and research centres. The experts contribute to the elaboration of the guidelines in their private capacities and do not represent the organizations for whom they work. The guidelines are intended as the best possible advice to institutions involved in germplasm exchange for research, conservation and basic plant breeding. FAO, IPGRI and the contributing experts cannot be held responsible for any failures resulting from the application of the present guidelines. By their nature, they reflect the consensus of the specialists who attended the meeting, based on the best scientific knowledge available at the time of the meeting.

The guidelines are written in a short, concise style, in order to keep the volume of the document to a minimum and to facilitate updating. The guidelines are divided into two parts. The first part makes general recommendations on how best to move germplasm. The second part covers the important pests and diseases of quarantine concern. The information given on a particular pest or disease may not be exhaustive but concentrates on those aspects that are most relevant to
quarantine. The following introductory statement was prepared by Dr Ken Old from CSIRO, Australia.

There are several features of eucalypts that make this tree genus of particular concern and especially appropriate for inclusion in guidelines for safe movement of germplasm. These may be summarized as follows:

- *Eucalyptus* is the tree genus most widely grown as exotic plantations worldwide.
- Most species originate in Australia, the “isolated continent”.
- Eucalypts grown in plantations are fast growing, easily cultivated and suitable for industrial plantations or social forestry.
- Large amounts of seed are being collected every year in native stands and are being disseminated worldwide.
- Australia is a country of immense diversity where eucalypts dominate the tree cover of the better rainfall areas (500+ mm).
- Worldwide deployment of eucalypts across the tropics, subtropics and, increasingly, temperate areas has created a mosaic of exotic plantations by which pathogens and pests can move internationally.
- Introduction of exotic pathogens or pests into Australia in future could severely damage whole ecosystems. The catastrophic damage caused by the pathogen *Phytophthora cinnamomi* in native vegetation in the southwest of Western Australia illustrates this danger.
- There are several examples of major plantation diseases which can severely limit the productivity of eucalypts grown as exotics.
- Pathogens which do not currently occur in Australia and appear to have adapted to eucalypts from other myrtaceous hosts are of particular concern.

The Expert Meeting on *Eucalyptus* Germplasm

IPGRI originally focused its activities mainly on agricultural species but recently broadened its mandate to include forest genetic resources. It was thus decided to expand the Guidelines series to important forest genera or species. Since 10 million hectares of eucalypts were planted in the tropics and subtropics in forest plantations in the period 1981-90, or nearly one-quarter of the gross area, this genus was selected as the first to be included in the Guidelines series.

Eighteen experts (see List of Participants) attended the meeting, which was funded by ACIAR. It was organized by the ASEAN Forest Tree Seed Centre and was held at the Maruay Garden Hotel, Bangkok from 9 to 12 October 1995. An excursion was made to the ASEAN/CIDA Forest Tree Seed Centre on 11 October. The Agenda of the meeting is given in this report. Papers presented at the meeting follow the Agenda.

Preparation of the Guidelines

The draft of the general recommendations for the safe movement of *Eucalyptus* germplasm was introduced by W. Ciesla. After discussion and review they were prepared in two parts. The first part consisted of the general and technical provisions of the Guidelines themselves. The second part reviewed all the main pests of eucalypts likely to be moved internationally with eucalypt germplasm and to be a threat to the receiving country. The Guidelines will be presented separately from this report (Ciesla, W.M., M. Dickmann and C.A.J. Putter (eds.). 1996. Technical Guidelines for the Safe Movement of Germplasm. No. 17. *Eucalyptus* spp. IPGRI/FAO, Rome).

Conclusions and recommendations

Updating of the *Eucalyptus* guidelines

1. It was noted that 14 Guidelines for the safe movement of germplasm have been published since 1988. It was further noted that Guidelines can be updated if necessary; for example those for *Pinus* sp. were prepared in 1988 and have been updated twice, in 1991 and 1995. For *Eucalyptus* germplasm there was a serious lack of information available both to put the movement of material into context and on technical matters (described below).

2. It was recommended to FAO (PO) that information be gathered on the quantities, sources and destinations, and the purpose and value of the different types of material (seed, *in vitro* material, cuttings, pollen) being moved, as background to the future updating of the Guidelines for eucalypts.

3. It was noted that while the movement of vegetative material may be relatively small at present, it may increase in the future, partly owing to the increasing use of hybrids and select material. Although the use of rooted cuttings was not recommended in the Guidelines, nevertheless there may be occasions when this means of transferring germplasm will be required. Information was needed on the species that cannot be raised in tissue culture, the extent to which rooted cuttings were used, and trends for the future.

4. Symbionts. It was believed that the transfer of associated symbionts such as *Mycorrhizae* was relatively small. The Expert Meeting did not include the transfer of *Eucalyptus* symbionts in the Guidelines both because the Guidelines were concerned with *Eucalyptus* as such and because the transfer of symbionts was believed to be in pure cultures. Research should be carried out to check this for the eucalypts and other genera, and whether specific guidelines will be required for their movement.

5. It was noted that the *Eucalyptus* Guidelines would include a questionnaire for users to submit their suggestions for future modification and improvement. It was recommended to IPGRI and FAO (AGP) that the Eucalyptus Guidelines should be reviewed periodically, and at least no later than 5 years after they are published, in order to check the need to update them.

Guidelines for the transfer of germplasm of other tree species

1. Full background data should be collected before holding expert meetings for the preparation of future Guidelines for the international transfer of germplasm of other forest tree species.

2. The meeting recommended that Guidelines should be prepared for the following forest tree genera/species:
   - *Pinus* spp. (it was noted that an Expert Meeting to prepare Guidelines for the safe movement of *Pinus* germplasm was planned for October 1996 in Opoce, Czech Republic)
   - *Acacia* spp.
   - Selected groups of multipurpose tree species
   - *Casuarina* spp.
• Salicaceae
• Cupressus spp.

3. The meeting recommended that this list be supplemented with genera identified by the Forest Pathology and Entomology Network, by ICRAF, by institutions involved in the movement of tree germplasm for tree improvement, and by other suitable organizations.

4. It was further recommended to the organizers of future meetings that entomologists and pathologists should discuss the Guidelines and the pests and diseases of the target genera/species jointly.

Pest risk analysis
The importance of Pest Risk Analysis (PRA) as a basis for the introduction of all types of germplasm was noted, but there is a complete absence of experience with PRA for tree species. It was recommended that FAO (AGP and FO) carry out PRA for the introduction of different types of Eucalyptus germplasm into selected actual or hypothetical countries as case studies.

Furthermore, there is a need to familiarize the scientific community outside the field of plant quarantine with procedures for pest risk analysis.

Research requirements for the safe movement of Eucalyptus germplasm
1. Entomology and pathology of natural populations of the Myrtaceae: Studies are required of the entomology and pathology of natural populations of the Myrtaceae in general, and of the genus Eucalyptus in particular.
2. Taxonomic studies: in view of the imperfect knowledge of the taxonomy of many diseases, taxonomic studies are required of a wide range of isolates.
3. Pollen: research is needed into the safe movement of Eucalyptus pollen, in particular the risk of moving arthropods and fungi, and methods for their control. The effectiveness of CO₂ as a treatment against insect eggs needs to be determined, in particular in comparison with freeze-drying.
4. Little Leaf Disease: further work is needed on the means of transmission of Little Leaf Disease (Phytoplasma, or MLO), in particular if it can be transmitted by seed.
5. Cylindrocladium leaf spot and blight: there are a number of species of Cylindrocladium with complex biology affecting many Eucalyptus species more or less seriously, throughout a wide geographical range. As a basis for the development of effective quarantine measures, it is necessary to intensify studies into taxonomy, breeding and control.
6. Puccinia psidii rust: it is unclear if the pathogen reported from Taiwan is the same as the one from Brazil.
7. Cryphonectria spp. and Coniophyllum spp.: strategic research is required into the origins, taxonomy, distribution, impact and control (including the identification of less susceptible provenances and clones of these stem cankers).
8. Mycosphaerella spp.: there appeared to be no direct evidence that this has been seedborne in the transfer of germplasm, except that it was noted to be widespread in exotic plantations. The distribution was not yet fully known and the status of the genus on the eucalypts was not yet clearly defined.
9. Cryptosporiopsis eucalypti: This was recently identified as causing a significant disease, but the distribution is not known.
10. Serratia eucalypti: work is needed on the relationship of the fungus found on eucalypts in Australia with members of the genus on Cupressaceae in the Mediterranean and South Africa, as well as its method of transmission.

Fumigation of Eucalyptus seed by CO₂
It was noted that the storage of eucalypt seed in CO₂-filled, airtight containers (e.g., laminated polythene bags) prior to despatch may prevent decrease in seed viability and act as a suitable quarantine environment prior to use (Mitsuda et al. 1973; Shrestha et al. 1985; Vercoe, unpublished). The attention of national seed centres despatching Eucalyptus seed is drawn to this.

References
List of Participants

Mr Jim Ball
Senior Forestry Officer (Plantations)
FAO
Via delle Terme de Caracalla
00100 Rome, Italy
Fax: 0039-6-5225-3152
Tel: 0039-6-5225-4047
Email: JAMES.BALL@FAO.ORG

Dr Eric Boa
International Mycological Institute
Bakeham Lane
Egham, Surrey
TW20 9TY, United Kingdom
Fax: 0044-1784-470909
Tel: 0044-1784-470111
Email: E.SOA@CAI.ORG

Dr Ebby Chagala
Kenya Forestry Research Institute
PO Box 20412
Nairobi, Kenya
Fax: 00254-154-32844
Tel: 00254-154-32892/3

Mr William M. Ciesla
Forest Health Specialist
2248 Shawnee Court
Pittsboro, USA
Fax: 001-970-482-4931
Tel: 001-970-482-5932
Email: WTCIESLA@AOL.COM

Dr Marlene Diekmann
Senior Scientist, Germplasm Health
IPGRI
Via delle Sette Chiese 142
00145 Rome, Italy
Fax: 0039-6-575-0309
Tel: 0039-6-5189-2223
Email: M.DIEKMANN@CGNET.COM

Mr Francisco Alves Ferreira
Forest Pathologist
Departamento de Fitopatologia
Universidade Federal de Viçosa
3671-000 Viçosa
Minas Gerais, Brazil
Fax: 0055-31-8992240
Email: DFPX1202@BRUFI.BITNET

Mr Heriel P. Msanga
Head of Seed Research and Development
National Tree Seed Programme
PO Box 4012
Morogoro, Tanzania
Fax: 00255-56-3275
Tel: 00255-56-3192

Dr Kenneth M. Old
Assistant Chief of Division, CSIRO
Division of Forestry
PO Box 4008, Queen Victoria Terrace
Canberra ACT 2601, Australia
Fax: 0061-6-281-8227
Tel: 0061-6-281-8329
Email: KEN.OLD@CISRFOR.CSIRO.AU

Dr Abdou-Salam Ouédraogo
IPGRI
Via delle Sette Chiese 142
00145 Rome, Italy
Fax: 0039-6-575-0309
Tel: 0039-6-5189-2213
Email: A.OUEDRAOGO@CGNET.COM

Mrs Krishna Pongpanich
Forest Research Office
Royal Forest Department
Chatuchak
Bangkok 10900, Thailand
Fax: 0066-2-579-4336
Tel: 0066-2-561-4292-3 ext 443
Email: VIITOOL@MOZART.INET.CO.TH

Mr Prapan Pukittayakamee
ASEAN Forest Tree Seed Centre
Muak Lek
Saraburi 18180, Thailand
Fax: 0066-36-341-859
Tel: 0066-36-341-305
Email: AFTSC@CGNET.COM

Dr C.A.J. Putter
FAO
Via delle Terme di Caracalla
00100 Rome, Italy
Fax: 0039-6-5225-6347
Tel: 0039-6-5225-4022
Email: TONY.PUTTER@FAO.ORG

Prof. A.N. Rao
c/o IPGRI
Tangiin
PO Box 101
Singapore 9124, Singapore
Fax: 0065-7389636
Tel: 0065-7389611
Email: IPGRI-APO@CGNET.COM

Dr Jyoti K. Sharma
Division of Forest Pathology
Kerala Forest Research Institute
Poochi 680603, Trissur District
Kerala State, India
Fax: 0091-487-782249
Tel: 0091-487-782265/782061
Telex: 88-7275 KFRIIN

Mr Tim Vercoe
Officer in Charge
Australian Tree Seed Centre
CSIRO Division of Forestry
PO Box 4008
Canberra, ACT 2600, Australia
Fax: 0061-6-281-8266
Tel: 0061-6-281-8218
Email: TIM VERCOE@CISRFOR.CSIRO.AU
Agenda

Monday, 9 October 1995

8.30  Welcome and Introduction
9.00  Social and economic importance of eucalypts in world forestry
9.45  IPGR’s forest genetic resources programme and the importance of germplasm movement
10.00  Technical Guidelines for the Safe Movement of Germplasm: scope and purpose
10.30  The concept of pest risk analysis
11.00  Movement of Eucalyptus germplasm from the Australian Tree Seed Centre
11.30  Other movement of germplasm
12.00  ‘General Recommendations’ for the safe movement of germplasm
12.30  Lunch break
14.00  Diseases caused by viruses and phytoplasma
14.30  Insects occurring in South America and Asia
15.30  Insects occurring in Africa

Tuesday, 10 October 1995

8.30  Cylindrocladium diseases
9.30  Damping-off diseases/seedling blights (different fungi to be considered)
10.30  Pink disease (Corticium spp.)
11.30  Mycosphaerella, Coniella and Cryptosporiopsis diseases
13.00  Lunch break

Tuesday, 10 October 1995 (cont.)

14.00  Stem cankers (Cryphonectria cubensis, Cryphonectria gyroa, Eutrochus gyroa, Botryosphaeria spp., Seiridium eucalypti)
16.00  Puccinia psidii

Wednesday, 11 October 1995

Excursion to Asian Forest Tree Seed Centre

Thursday, 12 October 1995

8.30  Cercospora spp.
9.30  Coniothyrium spp.
10.30  Phytophthora cinnamomi
11.30  Phaeosporia eucalypti
13.00  Lunch break
14.00  Burkholderia solanacearum (formerly Pseudomonas)
15.00  Pests not listed above, or pests reported on other species which might represent a danger to Eucalyptus spp.
Background Papers

IPGRI’s programme on forest genetic resources and the importance of tree germplasm movement

A.S. Oudraogo
IPGRI, Rome, Italy

Introduction

The forests of the world, particularly tropical forests, are threatened by deforestation. Major threats are due to the expansion of socioeconomic activities including agriculture and infrastructure development. Tropical forests are not the only threatened ecosystems; environmental pollution represents a threat for the health of many tree species in the temperate forests of Europe and North America. According to FAO’s forest assessment study, deforestation and forest degradation have reached an alarming rate, increasing from 11.3 million hectares during 1970-80 to 15.4 million hectares during 1980-90. There is no doubt that the continuous disturbance of the forest ecosystems is leading to great loss of biodiversity in tropical forests. While the decline in tropical forests and associated loss of biodiversity have received the most attention, the loss of whole populations and provenances and related genetic diversity of economically important forestry and agroforestry species is of major concern (Thomson 1992).

In most developing tropical regions, local populations and communities depend on the forests for their survival and provision of their basic needs for food, wood, fuelwood, charcoal and other forest products. Most countries in arid and semi-arid areas are facing the difficult situation of energy and fuelwood and actions have been launched to mitigate the deficit of forest products. Thus a serious effort at a regional and global level is needed to support the improvement and utilization of useful, socioeconomically important tree species in reforestation programmes. This implies that significant efforts be deployed to expand the knowledge on the location, distribution and structure of genetic diversity in both industrial and non-industrial species. This research includes the collecting of germplasm for evaluation and utilization.

Efforts in this direction are significantly increasing in the forest genetic resources community. Several research and development groups have developed comprehensive programmes for the evaluation, production, distribution and conservation of germplasm of useful forestry and agroforestry species.

Major action groups with significant activities on tree germplasm movement

The action of the major groups dealing with germplasm movement of forest tree germplasm is not extensive.

The most active international groups include ACIAR’s forestry programme, CSIRO, ATSC, the Forest Service of Queensland, CIRAD-Forêt, Danida Forest Seed Centre, ITC-EGFI and OFI. At regional level, several National Tree Seed Centres in sub-Saharan Africa such as Burkina Faso, Senegal, Kenya, Zimbabwe and Tanzania have a significant impact on the dissemination and use of germplasm in their respective countries and in the region.

In Southeast Asia, the ASEAN Forest Tree Seed Centre is playing a key role in promoting research on indigenous and exotic species. In Central America, institutions such as CATIE have accumulated valuable experience on germplasm collecting and evaluation in several countries, such as El Salvador, Guatemala, Honduras, Nicaragua and Panama with the active contribution of DANIDA-PSC and OFI. Coniferous species, such as Pinus spp., have benefited by vigorous support from CAMCORE. In South America, EMBRAPA-Brazil is active in the exploration, introduction and evaluation of exotic species, in particular Australian Eucalyptus spp. In addition, several forest genetic resources networks in West Africa (GIFSS), Southern Africa (SADC) and Southeast Asia (FORSIPA, FORTIP and others) are active in conducting or coordinating a wide range of collections of major useful multipurpose tree species such as Acacia indica and probably in future Swietenia macrophylla.

In addition, increasing interest is being shown in the improvement and utilization of leguminous trees, in particular Acacia spp. in many regions.

Considering the activities of the various groups and the activities carried out in different countries, it is likely that the volume of movement of forest tree germplasm will remain high or increase in the future. There is growing interest in testing lesser-known species as well as new provenances to broaden the genetic base of introduced germplasm. There is also an urgent need to assess bulk seed quantities and superior provenances. This includes species such as Eucalyptus spp., Pinus spp., Tectona grandis, Acacia indica, Gmelina arborea, Swietenia macrophylla, Piscarea rhombifolia, as well as several multipurpose tree species, fruit trees, bamboo and rattan. The movement of such germplasm may involve the risk of accidentally introducing pests and diseases to new areas as well. Thus, it is necessary to increase awareness for the development of effective disease therapy and testing procedures for tropical tree species and for the development of technical guidelines for safe movement of tree germplasm.

IPGRI’s forest genetic resources programme and safe movement of tree germplasm

Through wide consultation over the last 3 years, IPGRI in close collaboration with FAO, CIFOR and ICRAF has developed the basis for a comprehensive and coordinated programme on forest genetic resources (Thomson 1992; Cossellet 1993; Tomsett 1995; Vercoe 1993). In July 1995, IPGRI organized a Forest Genetic Resources Network in Rome, jointly with CIFOR, ICRAF and FAO (IBPGR 1995). Over the last 2 years significant development has taken place in the work carried out by IPGRI on forest genetic resources. This work is being coordinated through a system-wide programme on genetic resources (SGRP). IPGRI is playing a leading role in the SGRP to coordinate and enhance collaborative work among the centres and to promote effective relationships with other relevant programmes at national, regional and international levels.

The major thrusts of IPGRI’s work on forest genetic resources are:

- an information system on forest genetic resources
- methods for locating genetic diversity and assessment of genetic erosion
- methods for effective in situ conservation and sustainable management and use of forest genetic resources
• methods for improving the handling and storing of tree seeds with recalcitrant and intermediate characteristics, including alternative methods for preservation, such as in vitro and cryopreservation
• guidelines for safe movement of tree germplasm
• human resources development through training, education and public awareness.

A comprehensive programme has been developed based on the following considerations:
• the need to provide readily accessible information on forest genetic resources
• the need to promote conservation and use of timber and non-wood forest species
• the focus on in situ conservation with ex situ as a complementary conservation strategy
• the importance of socioeconomic and cultural factors of conservation of forest genetic resources leading to the need to develop and promote community-based management strategies
• the development of the work through a network approach
• the development of the European Forest Genetic Resources Programme (EUFORGEN).

Some key aspects of the work on safe movement tree germplasm include:
• determine the risk of transfer of potentially damaging pests and diseases through movement of germplasm with special priority given to industrial tree plantation species and multipurpose species
• collect information on seedborne pathogens of woody legumes
• conduct an expert consultation with the involvement of expert entomologists and pathologists to identify risks and to develop guidelines to prevent the spread of destructive pests and diseases on woody germplasm
• promote awareness of safe movement of germplasm among researchers by developing safer means of germplasm transfer (seed, pollen, in vitro culture) and technical guidelines for the safe movement of priority genera/species
• conduct research to develop detection methods for important pathogens, e.g. development of probes for detection of viruses
• coordinate networks by developing linkages among existing national institutes and scientists, thus making the best use of the limited expertise in relation to the scale of work and potential problems.

Approach and partnership

Since its foundation, IPGRI has worked to develop methods for conserving plant genetic resources and to promote the use of those genetic resources. The Institute has worked largely through partnership and close collaboration with national programmes throughout the developing world and its current strategy – Diversity for Development – emphasizes the central role played by individual countries in the regional and global effort.

Attention is given to management and use of tree species of high socioeconomic and commercial value. Several partnerships can be built with relevant institutions to promote the safe movement of tree germplasm. The various institutions which have effectively contributed to the workshop are clear evidence of this partnership. Other joint collaborative efforts will be needed in the future to promote and support the development of guidelines for the safe movement of other useful species or groups of species, such as Pinus spp., Acacia spp., and others.

References
Tomsett, P. 1993. Consultant's report on biodiversity and taxonomy; germplasm collection; ex situ storage and in vitro culture, seed and pollen storage; germplasm health and disease indexing; and reproductive biology. IBPGR/CIIFOR, 82 pp.
International social and economic importance of Australian eucalypts

T.K. Vercoe
Australian Tree Seed Centre, CSIRO Division of Forestry, Canberra, Australia

Summary
Eucalypt seeds were some of the earliest emigrants from Australia following European settlement. Many different species were grown initially in botanical gardens and private collections throughout Europe, and from there, started a journey into most countries in the world. More than 100 countries have now planted eucalypts, and many now have substantial plantation areas. They are used for everything from commercial timber and pulp to soil stabilization and honey production. International trade and movement of eucalypt seed is extensive and represents a significant opportunity for movement of pests and pathogens. This paper reviews the planting of the eucalypts on a regional basis and establishes the international importance of the group.

Introduction
In 1783, Tobias Furneaux (attached to the British Royal Navy) collected seed of Eucalyptus obliqua which was subsequently grown in Kew Gardens in London. This initial export commenced two centuries of eucalypt seed movement across most countries and all the inhabited continents of the world. Movement was initially only outwards from Australia for primary introductions to other countries. Over time, a range of secondary introductions were carried out into countries which had limited, or no, direct contact with Australia. In many cases, species have become naturalized and the original introductions forgotten. Material exported from early collections in Australia caused mainly scientific interest but by the mid-1900s elements of Australia’s unique flora were established on all the inhabited continents (Zacharin 1978).

Seed, and in some cases live plants, were moved along trade routes and the timing of many introductions can be traced to the early colonial administrations. There may be some exceptions, particularly from tropical parts of Australia, where it is believed that some earlier trade between aboriginal people from northern Australia and Indonesians may have resulted in the movement of plant material (Levitt 1981).

Australian forests are among the most diverse in the world, consistent with the continent’s global position as a centre of immense diversity with high levels of species endemicism. Within the 40 million hectares under forest cover there are over 3500 tree species, with nearly 800 eucalypt species. Over 90% of these species are unique to Australia. Of the total species, some 200 (most of which are eucalypts) are of current commercial significance in Australia or overseas.

Early success and rapid growth of eucalypts hastened their movement and use in tropical and subtropical parts of the world. Biological characteristics, derived from evolution under relatively harsh conditions and poor soils, have conferred a number of advantages when grown as exotics in other countries. Growth rates of 2 to 3 times native material are not uncommon. Eldridge et al. (1993) report routine annual growth rates of around 10-15 m³/ha for unsel ected Australian genetic material.

In spite of the intense interest in eucalypts, only a relatively small number of species have been thoroughly trialed and subsequently used. In many places, the small genetic base of introduced eucalypt species is now having an impact through inbreeding depression of growth and yield. This has been a particular problem with, but not restricted to, secondary introductions. Many countries are seeking to broaden the genetic base of breeding programmes or to re-commence the introduction process with widely based seed collections. A number of the species in use have been introduced because they performed well as introductions in other places but they are not always the best material for the secondary location. Trial programmes are identifying better-adapted species which are often not widely known in Australia. Narrow genetic base populations will also have an important impact on breeding programmes for insect and pathogen resistance. Substantial provenance differences in tolerance of Eucalyptus camaldulensis to leaf fungal pathogens in Vietnam have been recorded.

Absence of natural pests and diseases is one of the advantages that eucalypts are able to exploit outside Australia although they are susceptible to a range of new pests and diseases under certain conditions. It is important that these conditions and pathogens become known and appropriate control measures put in place to minimize damage to the extensive international eucalypt plantings as well as protecting the natural forests.

Survey of the plantation base of Australian trees

The Australian Tree Seed Centre has been a focus for the collection and distribution of seed and information on Australian trees and shrubs for more than three decades. The Centre supplies seed and information to more than 2000 clients each year in about 100 countries. It is essential for the planning and continuing success of the Centre that it keep ahead of new developments in domestic and overseas use of Australian trees while continuing to support existing use. This network of contacts provides an excellent base for gathering data on the use of Australian trees in these countries.

As a basis for the figures given in later sections, 143 contacts were made with researchers in 106 countries requesting information on the extent of Australian species in their country. The results for eucalypts have been compared with Government estimates and with an FAO report (Pandey 1995) to derive the figures given in the subsequent sections.

Use of eucalypts on the continents

The following sections of this paper summarize plantation areas of eucalypts on a regional basis. Some of these figures are probably minimal estimates due to the extensive use of eucalypts as farm and community forestry trees in less-developed areas. These plantings are not usually counted in the total plantation area but can amount to substantial numbers of trees. For example, in China, in addition to an estimated 670 000 ha of plantation eucalypt, there is an area equivalent to 1.2 million ha in community plantings of eucalypts around farms, roads and waterways (S.J. Midgley, pers. comm.).

The accuracy of the figures in the following tables is dependent on many factors and thus the data should be used with caution. A survey respondent estimated the
actual successful plantation area established in one country to be about 55% of that quoted by the Government agencies.

The productivity of these forests is highly variable; Eldridge et al. (1993) give details for a number of widely grown eucalypt species. The economic impact of severe pest and disease outbreaks could be estimated from these figures but, to date, calculations have not been made.

The final column of the following tables is based on Australian Tree Seed Centre records and shows the number of Australian species supplied to each country in the last 10 years for trial. While not all of these species would have received adequate testing or even survived planting, it demonstrates the exposure of forest researchers in these countries to the Australian flora.

### Asia

A number of southeast Asian countries have species in common with Australia and utilization of Australian seed sources has drawn attention to SE Asian provenances, a number of which have shown similar or better performance. Table 1 shows the approximate forest areas of Australian species compared with the total areas of plantation on a country by country basis. Estimates of the rate of expansion of these planted areas are also given.

### Table 1. Australian species in Asia.

<table>
<thead>
<tr>
<th>Country</th>
<th>Plantation area (ha)</th>
<th>No. of Austr. spp. tested since 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>India</td>
<td>18,500,000</td>
<td>45,000</td>
</tr>
<tr>
<td>Indonesia</td>
<td>8,750,000</td>
<td>500,000</td>
</tr>
<tr>
<td>Laos</td>
<td>800,000</td>
<td>500,000</td>
</tr>
<tr>
<td>Malaysia</td>
<td>300,000</td>
<td>200,000</td>
</tr>
<tr>
<td>Myanmar</td>
<td>334,000</td>
<td>25,000</td>
</tr>
<tr>
<td>Nepal</td>
<td>80,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Pakistan</td>
<td>569,000</td>
<td>28,500</td>
</tr>
<tr>
<td>Philippines</td>
<td>500,000</td>
<td>10,000</td>
</tr>
<tr>
<td>FR China</td>
<td>38,300,000</td>
<td>1,320,000</td>
</tr>
<tr>
<td>Sri Lanka</td>
<td>198,000</td>
<td>4,000</td>
</tr>
<tr>
<td>Taiwan</td>
<td>680,000</td>
<td>5,600</td>
</tr>
<tr>
<td>Thailand</td>
<td>755,000</td>
<td>62,000</td>
</tr>
<tr>
<td>Vietnam</td>
<td>2,100,000</td>
<td>125,000</td>
</tr>
<tr>
<td>Total</td>
<td>71,466,600</td>
<td>1,749,600</td>
</tr>
</tbody>
</table>

### Africa

Africa has a large area of land which is environmentally very similar to Australia, probably more than any of the other continents. Native forest is still providing many of the wood needs of African rural populations resulting in critical wood shortages in a number of countries. Australian species are increasingly being used in community and agroforestry plantings to supply wood and non-wood products including fodder and human food. Some countries have carried out very detailed studies of the suitability of the Australian flora (e.g. Poynton 1979). Table 2 gives figures on total forest plantation areas and areas of Australian species for countries on the African continent.

### Table 2. Use of Australian species on the African continent.

<table>
<thead>
<tr>
<th>Country</th>
<th>Expansion rate (ha/yr)</th>
<th>Total</th>
<th>Eucalypt</th>
<th>Acacia</th>
<th>Casuarina</th>
<th>No. of Austr. spp. tested since 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Angola</td>
<td>171,500</td>
<td>135,000</td>
<td>7,000</td>
<td>2,000</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Burkina Faso</td>
<td>28,000</td>
<td>40,000</td>
<td>25,000</td>
<td>3,000</td>
<td>27</td>
<td></td>
</tr>
<tr>
<td>Burundi</td>
<td>132,000</td>
<td>1,500</td>
<td>46,500</td>
<td>500</td>
<td>45</td>
<td></td>
</tr>
<tr>
<td>Cameroon</td>
<td>23,000</td>
<td>13,000</td>
<td>5,000</td>
<td>2,000</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Centr. Africa</td>
<td>9,000</td>
<td>1,000</td>
<td>2,000</td>
<td>2,000</td>
<td>142</td>
<td></td>
</tr>
<tr>
<td>Comoros</td>
<td>1,000</td>
<td>600</td>
<td>500</td>
<td>21</td>
<td>21</td>
<td></td>
</tr>
<tr>
<td>Ethiopia</td>
<td>270,000</td>
<td>550</td>
<td>5,000</td>
<td>142</td>
<td>114</td>
<td></td>
</tr>
<tr>
<td>Gabon</td>
<td>20,000</td>
<td>2,000</td>
<td>400</td>
<td>98</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Ghana</td>
<td>73,000</td>
<td>14,000</td>
<td>41</td>
<td>4</td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Kenya</td>
<td>168,000</td>
<td>17,000</td>
<td>237</td>
<td>40</td>
<td>237</td>
<td></td>
</tr>
<tr>
<td>Madagascar</td>
<td>310,000</td>
<td>130,000</td>
<td>40</td>
<td>66</td>
<td>66</td>
<td></td>
</tr>
<tr>
<td>Malawi</td>
<td>180,000</td>
<td>15,000</td>
<td>82</td>
<td>52</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Mali</td>
<td>20,000</td>
<td>2,000</td>
<td>82</td>
<td>52</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Mauritius</td>
<td>11,900</td>
<td>3,000</td>
<td>300</td>
<td>50</td>
<td>50</td>
<td></td>
</tr>
<tr>
<td>Mozambique</td>
<td>40,000</td>
<td>14,000</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Niger</td>
<td>17,000</td>
<td>2,000</td>
<td>98</td>
<td>98</td>
<td>98</td>
<td></td>
</tr>
<tr>
<td>Nigeria</td>
<td>216,000</td>
<td>11,000</td>
<td>43</td>
<td>43</td>
<td>43</td>
<td></td>
</tr>
<tr>
<td>North Africa</td>
<td>1,400,000</td>
<td>610,000</td>
<td>2,000</td>
<td>100</td>
<td>100</td>
<td></td>
</tr>
<tr>
<td>Rwanda</td>
<td>125,000</td>
<td>60,000</td>
<td>32</td>
<td>32</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Senegal</td>
<td>160,000</td>
<td>18,000</td>
<td>76</td>
<td>76</td>
<td>76</td>
<td></td>
</tr>
<tr>
<td>South Africa</td>
<td>1,500,000</td>
<td>115,000</td>
<td>5,000</td>
<td>140</td>
<td>140</td>
<td></td>
</tr>
<tr>
<td>Sudan</td>
<td>290,000</td>
<td>145,000</td>
<td>118</td>
<td>118</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>Tanzania</td>
<td>220,000</td>
<td>10,000</td>
<td>168</td>
<td>168</td>
<td>168</td>
<td></td>
</tr>
<tr>
<td>Tchad</td>
<td>6,000</td>
<td>100</td>
<td>23</td>
<td>23</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Togo</td>
<td>43,000</td>
<td>100</td>
<td>4</td>
<td>4</td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>Uganda</td>
<td>28,000</td>
<td>10,000</td>
<td>52</td>
<td>52</td>
<td>52</td>
<td></td>
</tr>
<tr>
<td>Zaire</td>
<td>60,000</td>
<td>4,000</td>
<td>47</td>
<td>47</td>
<td>47</td>
<td></td>
</tr>
<tr>
<td>Zambia</td>
<td>68,000</td>
<td>26,000</td>
<td>84</td>
<td>84</td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Zimbabwe</td>
<td>120,000</td>
<td>10,000</td>
<td>195</td>
<td>195</td>
<td>195</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>5,756,400</td>
<td>1,717,500</td>
<td>18,800</td>
<td>18,800</td>
<td>18,800</td>
<td></td>
</tr>
</tbody>
</table>

### South and Central America

Some of the most productive plantations of Australian species occur in South and Central America. The proximity of many of these countries to the large American market for forest products has encouraged rapid development of fast-growing plantations. Australian species have enabled the achievement of high productivity in a relatively short period. Breeding programmes for Australian trees are highly focused and in many cases in advanced stages.

Table 3 gives figures for plantation area in countries of Central and South America. A number of these countries have large industrial plantation estates for which reasonable figures on area and productivity are available.
Table 3. Plantation areas in Central and South America.

<table>
<thead>
<tr>
<th>Country</th>
<th>Total</th>
<th>Expansion rate (ha/yr)</th>
<th>Eucalypt</th>
<th>Acacia</th>
<th>Casuarina</th>
<th>No. of Austr. spp.</th>
<th>tested since 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Argentina</td>
<td>760,000</td>
<td>25,000</td>
<td>256,000</td>
<td>9,000</td>
<td>1,000</td>
<td>150</td>
<td></td>
</tr>
<tr>
<td>Bolivia</td>
<td>40,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>112</td>
<td></td>
</tr>
<tr>
<td>Brazil</td>
<td>7,000,000</td>
<td>200,000</td>
<td>3,617,000</td>
<td>42,000</td>
<td></td>
<td>245</td>
<td></td>
</tr>
<tr>
<td>Chile</td>
<td>1,600,000</td>
<td>85,000</td>
<td>180,000</td>
<td>10,000</td>
<td>10,000</td>
<td>197</td>
<td></td>
</tr>
<tr>
<td>Colombia</td>
<td>180,000</td>
<td>5,000</td>
<td>31,000</td>
<td></td>
<td></td>
<td>84</td>
<td></td>
</tr>
<tr>
<td>Costa Rica</td>
<td>40,000</td>
<td>10,000</td>
<td></td>
<td></td>
<td></td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Cuba</td>
<td>350,000</td>
<td>30,000</td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Ecuador</td>
<td>64,000</td>
<td>2,000</td>
<td>44,000</td>
<td>200</td>
<td>1,000</td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>El Salvador</td>
<td>6,000</td>
<td>2,000</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td></td>
</tr>
<tr>
<td>Guatemala</td>
<td>40,000</td>
<td>1,000</td>
<td>6,000</td>
<td></td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Haiti</td>
<td>12,000</td>
<td>2,000</td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td></td>
</tr>
<tr>
<td>Honduras</td>
<td>4,000</td>
<td>150</td>
<td>500</td>
<td>10</td>
<td></td>
<td>41</td>
<td></td>
</tr>
<tr>
<td>Jamaica</td>
<td>21,000</td>
<td>500</td>
<td>80</td>
<td>10</td>
<td>10</td>
<td>32</td>
<td></td>
</tr>
<tr>
<td>Mexico</td>
<td>192,000</td>
<td>38,000</td>
<td></td>
<td></td>
<td></td>
<td>92</td>
<td></td>
</tr>
<tr>
<td>Nicaragua</td>
<td>20,000</td>
<td>4,000</td>
<td>5,500</td>
<td></td>
<td></td>
<td>12</td>
<td></td>
</tr>
<tr>
<td>Paraguay</td>
<td>13,000</td>
<td>8,000</td>
<td></td>
<td></td>
<td></td>
<td>57</td>
<td></td>
</tr>
<tr>
<td>Peru</td>
<td>263,000</td>
<td>1,000</td>
<td>211,000</td>
<td></td>
<td>7,000</td>
<td>155</td>
<td></td>
</tr>
<tr>
<td>St Vincent</td>
<td>200</td>
<td>20</td>
<td></td>
<td></td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Uruguay</td>
<td>208,000</td>
<td>2,000</td>
<td>160,000</td>
<td></td>
<td></td>
<td>29</td>
<td></td>
</tr>
<tr>
<td>Venezuela</td>
<td>362,000</td>
<td>30,000</td>
<td>70,000</td>
<td></td>
<td></td>
<td>18</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>11,158,200</td>
<td>385,670</td>
<td>4,656,080</td>
<td>61,220</td>
<td>19200</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Pacific

Most countries in the Pacific have limited land area which can be used for plantation forestry. The economies of scale which come with extensive plantations are generally not met. There is increasing interest in these countries to use the limited available land to produce high-quality timber products. A number of Australian rainforest species are being used for this purpose.

Table 4 gives data on plantations for countries in the Pacific region. These figures are significant given the small areas available for forest plantations in many of these countries.

Table 4. Plantation areas in the Pacific region.

<table>
<thead>
<tr>
<th>Country</th>
<th>Total</th>
<th>Expansion rate (ha/yr)</th>
<th>Eucalypt</th>
<th>Acacia</th>
<th>Casuarina</th>
<th>No. of Austr. spp.</th>
<th>tested since 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cook Islands</td>
<td>630</td>
<td>100</td>
<td>8</td>
<td>150</td>
<td></td>
<td>14</td>
<td></td>
</tr>
<tr>
<td>Guam</td>
<td>220</td>
<td>22</td>
<td></td>
<td></td>
<td></td>
<td>6</td>
<td></td>
</tr>
<tr>
<td>New Caledonia</td>
<td>9,000</td>
<td>200</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td></td>
</tr>
<tr>
<td>New Zealand</td>
<td>1,400,000</td>
<td>60,000</td>
<td>22,000</td>
<td>2,000</td>
<td>1,000</td>
<td>118</td>
<td></td>
</tr>
<tr>
<td>Niue</td>
<td>100</td>
<td>100</td>
<td></td>
<td></td>
<td></td>
<td>11</td>
<td></td>
</tr>
<tr>
<td>Papua New Guinea</td>
<td>42,000</td>
<td>10,000</td>
<td></td>
<td></td>
<td></td>
<td>56</td>
<td></td>
</tr>
<tr>
<td>Solomon Islands</td>
<td>28,000</td>
<td>1,400</td>
<td>1,500</td>
<td>200</td>
<td></td>
<td>30</td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>1,479,950</td>
<td>61,822</td>
<td>33,508</td>
<td>2,350</td>
<td>1,000</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Background Papers

Other areas

The tables given previously account for most areas of the world where Australian trees are significant contributors to timber production. Other regions in which Australian species are used include the Mediterranean region and parts of North America and Europe. Spain and Portugal have about 400,000 ha of eucalypts each and there are expanding areas of eucalypts and casuarinas in the southern and western USA and southern Europe (about 200,000 ha).

Table 5 combines the totals for all regions to give global totals.

Table 5. Global totals of plantation areas.

<table>
<thead>
<tr>
<th>Region</th>
<th>Total</th>
<th>Expansion rate (ha/yr)</th>
<th>Eucalypt</th>
<th>Acacia</th>
<th>Casuarina</th>
<th>No. of Austr. spp.</th>
<th>tested since 1980</th>
</tr>
</thead>
<tbody>
<tr>
<td>Asia</td>
<td>71,466,600</td>
<td>1,749,600</td>
<td>5,982,000</td>
<td>890,925</td>
<td>1,435,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Africa</td>
<td>5,756,400</td>
<td>1,177,500</td>
<td>975,000</td>
<td>18,800</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>S and Central America</td>
<td>11,158,200</td>
<td>385,670</td>
<td>4,656,080</td>
<td>61,220</td>
<td>19,200</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pacific</td>
<td>1,479,950</td>
<td>61,822</td>
<td>33,500</td>
<td>2,350</td>
<td>1,000</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Europe/North America</td>
<td>600,000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total</td>
<td>78,702,950</td>
<td>12,989,080</td>
<td>9,294,495</td>
<td>1,474,000</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Using the figures in the preceding tables and comments made by respondents to the survey, it is estimated that more than 15 million hectares of eucalypts are currently in the ground and that the rate of expansion is of the order of 1.5 million hectares per year. Because of the difficulty in obtaining figures on trees planted in non-industrial configurations, this estimate is considered to be conservative. It is estimated that around 300 tons of seed would be required to support this level of planting. This estimate is based on an average seedling yield of 75 per gram of seed for the species being planted and an initial establishment rate of 150 trees/ha.

Doran and Gardiner (1992) estimated an annual export of 25-30 tonnes of tree seed from Australia (all species) of which eucalypts probably make up 5-10 tonnes. This seed comes predominantly from natural forests as very little seed orchard seed is available from Australia. The shortfall between the amount required and the amount derived from Australian sources represents an estimate of the seed produced by other eucalypt-growing countries for their own use and export.

Material now in plantations around the world is still mostly in a relatively early state of development and domestication, and advances in breeding and understanding of genetic variation are broadening the opportunities for export of germplasm. In spite of the long association of some countries with eucalypts, serious, broadly based breeding programmes are a relatively recent phenomenon. The Australian forest genetic resources currently in use around the world are not a comprehensive sample and most breeding programmes are still dependent on infusion of genes from natural populations or other derived sources.

It is impossible to estimate the monetary value of the global eucalypt estate. The figures for areas are too flexible and the amount going into various end uses is unknown. In addition, the proportions used for domestic consumption and export with corresponding differences in value are unknown. The tables above show the relative importance of eucalypts as a proportion of the total plantation areas in countries across the regions given and from this it can be assumed that the
economic importance is substantial in both direct and indirect terms. Likewise, social values are difficult to quantify but readily evident in countries throughout the tropics and subtropics. Because of their fast growth rates and utility for a range of purposes, eucalypts are often used by small landholders as their primary tree cash crop.

Conclusion

Australian species are of major importance to world forestry. A significant number of species have been grown around the world in trials as well as in larger scale commercial, community and agroforestry plantings. The risks to this large estate through movement of pests and diseases with germplasm are great and need careful and responsible management. Increasing collaboration between countries and the ease by which seed in particular can be transferred across quarantine boundaries are cause for concern. Eucalypt seed is generally very small and clandestine movement would be very easy should movement protocols become too restrictive or difficult. Measures which allow for free flow of material for breeding and improvement while restricting the flow of pathogenic organisms are urgently required.

References


The role of the Australian Tree Seed Centre in movement of Eucalyptus germplasm

Tim Vercoe and Stephen Midgley
Australian Tree Seed Centre, CSIRO Division of Forestry, Canberra, Australia

Introduction

It is estimated that Australian tree and shrub species now constitute some 30-40% of all trees planted in tropical areas of the world. They are used for everything from commercial timber and pulp through to soil stabilization and honey production. The Australian Tree Seed Centre (ATSC) is entering its fourth decade as a focus for collecting and evaluation of this tree and shrub germplasm. From a request in the early 1960s by FAO to the Australian Government for a Eucalyptus seed and information centre, the ATSC has grown to include a wide range of multipurpose trees of Australian origin and now holds about 30,000 accessions comprising 1000 species from several thousand collection sites. Eucalypts make up about half the species in the collection while multipurpose genera represented include Acacia, Casuarina, Grevillea, Melaleuca, Sennaia and Terminalia. Most accessions come from natural populations but the Centre is establishing and managing an expanding range of seed orchards.

The Centre is self-funded from specialized grants, training activities, sale of seed and information. Staff numbers rise from about 15 to 20 during peak collecting periods.

Past and present activities

Germplasm collecting and documentation

Over the last 5 years, an average of 40 person-months per year have been spent in the collecting and documentation of tree and shrub seed. Collecting has taken place across all Australian states and in the neighbouring countries of Indonesia and Papua New Guinea in collaboration with scientists from these countries. Collecting of wild populations is most common and trees are selected for genetic representation. Minimum standards for numbers and separation of parent trees are strictly enforced. Seed of an increasing number of collections is available by individual mother trees. The collecting plan is dynamic and responsive to the demands of clients and sponsors but major plans are prepared every 2 years. Overseas collecting is conducted in a manner consistent with the proposed FAO Commission on Plant Genetic Resources voluntary code of conduct for germplasm collecting and transfer.

All seedlots, including those purchased from other collectors, meet minimum standards for documentation. Minimum requirements are: seed collected from natural stands (unless specified), location of collecting (including latitude, longitude and altitude), date of collecting, number of trees in collection, minimum spacing of 100 m between trees and a minimum standard for seed cleanliness. For ATSC collections, additional documentation includes: soil data, associate vegetation information, tree descriptions, phenological data, photographs and botanical specimens.
Gerplasm storage

ATSC has an active seed collection with most seedlots being stored for a maximum of 5-10 years. Some seedlots have been stored for up to 20 years and several long-term storage trials are ongoing. Seed is routinely stored in one of three different regimes: 23°C/40% RH, 4°C/95% RH and -18°C. Experiments on long-term storage of eucalypts have been initiated and the Centre will operate a -80°C storage facility for long-term storage of special seedlots by the end of this year. Seed entering storage is reduced to at least 6-8% moisture content before being placed in air-tight containers within cotton bags. Fumigation is carried out with carbon dioxide for 2 weeks prior to seed entering the store. This treatment is directed towards control of insects only and has been successful during the 15 years of operational use. No control of fungal or other non-insect pests is carried out prior to or during storage. Concerns over pathogens present on the seed in the ATSC store led to a study of fungi present on a range of different species (Yuan 1989).

Gerplasm dispatch

Gerplasm handled by the Centre is most commonly in the form of seed. Some clonal material is available (as tissue-cultured plantlets) for several eucalypt species and an increasing demand for pollen samples is expected for some species in the future. The alternative forms of gerplasm are so rarely encountered that no fixed procedures have been developed. Seedlots are processed and packaged to meet the hygiene requirements of recipient countries with special treatments carried out prior to dispatch. The Centre is authorized to issue phytosanitary certificates as required for export of material to other countries. Each year the Centre responds to more than 2000 requests for seed and information and dispatches about 10,000-12,000 seedlots to more than 100 countries. Figure 1 shows the proportion of eucalypt seedlots sent to various regions around the world.

Fig. 1. Summary of seedlots dispatched by regions, 1993 and 1994.

Gerplasm movement

Requests for research seedlots from the Australian Tree Seed Centre have increased during the last two decades although the species requested and the types of collections have changed significantly. Two and three decades ago researchers required semi-bulk seedlots representing particular species. As the differences in performance due to provenance variation became more apparent, the demand shifted to provenance-based seedlots and the species requested broadened to include other genera. There is now an increasing demand for seedlots based on families within provenances. Family-based seedlots can be utilized readily in breeding and seed production programmes although greater resources and expertise are required to manage and make best use of family-based material. With each of these changes, researchers have had access to greater numbers of seed parents from a wider range of sites.

As plant breeders in agriculture have found, conditions change over time and breeding programmes need the flexibility provided by periodic access to fresh genetic material. This material may come from wild populations subject to natural environmental processes and limitations. In forestry, the domestication process is at a much less advanced stage than in agricultural crops, and large gains in productivity can still be made in many cases by using seed from the best wild provenance. As breeding programmes progress and the domestication of forest trees proceeds, the natural populations in Australia will become more valuable as sources of particular genes for adaptation and resistance. It is important that this germplasm be moved in a safe manner which does not include pathogenic organisms.

Australian quarantine rules for the importation of seed into Australia are relatively strict in an attempt to exclude foreign pests and diseases which may adapt to the natural eucalypt forests. With widespread use of eucalypts and with large quantities of seed being produced at low cost, the risk of inadvertently or deliberately importing eucalypt seed has greatly increased. Contamination of the primary sources in Australia would be catastrophic and must be strenuously resisted.

However, in examining control measures and means of achieving safe movement of germplasm, practical considerations need to be taken into account. Seed viability must be maintained and the safety of seed workers ensured. Treatments which involve dangerous chemicals or which impact adversely on seed longevity risk not being implemented by suppliers and/or users.

Conclusions

There are currently no restrictions on research access to Australia's forest genetic resources. It is important that this free access does not also include free access to crippling pests and diseases. The ATSC is involved in large-scale movement of eucalypt seed around the world from natural forests. It is essential that the Centre maintain its responsible attitude to gerplasm movement and maintain contact with the latest work in pest identification and control.

From an operational point of view, it is important that treatments and controls are simple, specific and easily applied. Blanket application of severe treatments with the potential to adversely affect seed viability or longevity may be counterproductive. Research is required to optimize treatments at least for key species.
Reference