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MULTIPURPOSE TREE GERMPLASM

A PLANNING WORKSHOP TO DISCUSS INTERNATIONAL COOPERATION

Washington, D.C., USA
May 31 to June 3, 1983

Organized by: International Council for Research in Agroforestry (ICRAF), Nairobi/Kenya
National Academy of Sciences (NAS), Washington DC/USA;
Commonwealth Forestry Institute (CFI), Oxford/England;
International Board for Plant Genetic Resources (IBPGR), Rome/Italy

Sponsored by: ICRAF, Nairobi/Kenya; German Agency for Technical Cooperation (GTZ), Eschborn/Fed. Rep. of Germany;
NAS, Washington DC., USA

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BACKGROUND DOCUMENT:

Global Needs and Problems of Collection, Storage and Distribution of Multipurpose Tree Germplasm; Dr. J. Burley, March 1983 A

SUPPORTING DOCUMENTS:

Multipurpose Palm Germplasm; Dr. D.V. Johnson B

Tree Seed Supply - A Critical Factor for the Success of Agroforestry Projects; Dr. J.W. Turnbull C

Plant Health Legislation and Forest Trees; Dr. M.N. Ivory D

Non-Governmental Organizations and Agroforestry-Tree Seed Supply in Kenya, A Case Review; Louise E. Buck E

PROGRAMME

Multipurpose Tree Germplasm
A Workshop to Discuss International Cooperation

Monday May 30		Arrival at Washington D.C.,
Tuesday May 31	0800-0900	Meeting of Working Group Chairmen and Rapporteurs in Room 451, NAS - Joseph Henry Building.
	0900-0930	Registration
	0930-0945	Welcome to National Academy of Sciences (Mr. J. Hurley, Director of the Board on Science and Technology for International Development - NAS). Introduction and organization of Workshop by ICRAF (Mr. P. von Carlowitz)
	0945-1100	Summary of background and resource documents (Dr. J. Burley)
	1100-1115	Coffee

Subject 1. <u>The Present Germplasm Situation</u>

Discuss the establishment and maintenance of an inventory of activities in the exploration, evaluation and distribution of multipurpose tree germplasm. Identify problems of taxonomy, seed handling, germplasm preservation, international movements and supplies, and documentation.

1115-1245	Working Group meetings (3 groups simultaneously)
1245-1415	Lunch
1415-1545	Continuation of Working Group meetings
1545-1600	Tea
1600-1730	Continuation of Working Group meetings
(1730-1800	Meeting of Working Group chairmen and rapporteurs)
Wednesday June 1 0900-1100	Free to visit embassies, offices, <u>etc.</u>
1100-1230	Continuation of Working Group meetings
1230-1400	Lunch
1400-1530	Plenary session. Presentation by Working Group chairmen of discussions and draft recommendations on Subject 1.
1530-1545	Tea
1545-1715	Continuation of plenary session on Subject 1.

Subject 2. Strategies To Combat The Problems

Describe the current strategies of exploration, evaluation, conservation and improvement of multipurpose tree germplasm. Identify national and international needs, resources and institutional problems. Seek mechanisms to overcome the constraints. Recommend future activities.

	0900-1030	Working Group meetings
	1030-1045	Coffee
	1045-1230	Continuation of Working Group meetings
	1230-1415	Lunch
	1415-1545	Continuation of Working Group meetings
	1545-1600	Tea
	1600-1730	Continuation of Working Group meetings
	1730-1800	Meeting of Working Group chairmen and rapporteurs)
	1900	Reception
Friday June 3	0900-1100	Plenary session. Presentation by Working Group chairmen of discussions and draft recommendations of Subject 2.
	1100-1115	Coffee
	1115-1245	The views of the donor community
	1245-1415	Lunch
	1415-1545	Final plenary session. Summary of problems and recommended activities .
	1545-1600	Closing comments (P. von Carlowitz)

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May 31 to June 3, 1983
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List of Participants

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MULTIPURPOSE TREE GERMPLASM

A planning workshop to discuss international cooperation

(ICRAF/IBPGR/CFI/NAS)

Washington, DC, USA
(June, 1983)

BACKGROUND DOCUMENT

by

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Commonwealth Forestry Insitute
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Global needs and problems of collection, storage and distribution of multipurpose tree germplasm

Dated 1 March, 1983

(Note: This draft is for discussion and up-dating at the Workshop)

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EXECUTIVE SUMMARY

With increasing human and cattle populations and growing cultural demands there is increasing pressure on all natural resources including forests and land. Rates of regression of tropical forests and rates of desertification are discussed (page 1 and Appendix 1). Of particular importance are fuelwood deficits (page 1 and Appendix 2). Equivalent plantation areas needed by the year 2000 are estimated at 100 million hectares whereas the current annual rate is 1 million hectares (Appendix 3).

The scope of trees and shrubs both in meeting man's needs for products and in sustaining soil productivity is becoming increasingly recognised. The products include many non-traditional forest products and services particularly in the rural sector rather than in industrial forestry (page 1 and Appendix 4), resulting in new directions for forestry research (Appendix 5) and new or difficult sites for afforestation (Appendix 6).

The concept of multipurpose trees includes shrubs, palms and vines and these have application for social forestry objectives and agroforestry land management systems (pages 2-4 and Appendix 7). Many hundreds of species have been considered to have multiple uses (pages 5-6, Table 1 and Appendix 8) but vary extremely in the amount and types of information available about their natural distribution and variation, methods of exploring, collecting and evaluating their germplasm, and needs for and methods of genetic conservation and breeding (pages 6-7 and Table 2). The major sources of such information are described (pages 7-8 and Annexes 9-11).

For exploration, evaluation and conservation of wide-ranging species centrally coordinated programmes have many advantages and the major existing international programmes are reviewed (pages 9-11). The special place of IUFRO and the need for its expansion to facilitate greater support for developing countries, particularly in relation to rural development, energy forestry and conservation, are described (page 12 and Appendices 14 and 15).

Although it is not possible to generalise about the need for germplasm acquisition, evaluation and storage with so many species having potential importance, some of the basic common characteristics of multipurpose trees are described (pages 13-22). These include issues in taxonomy, natural variation, genetics and breeding systems (Appendix 16) but particularly problems of exploration, sampling of natural origins and derived provenances. The design, assessment and management of evaluation experiments pose particular problems (pages 18-19). Care should be taken that enthusiasm for widespread planting does not cause problems of species becoming weeds.

Many of the species and provenances of potential interest may be subject to genetic erosion or loss and both strategies and techniques for genetic conservation are required (pages 20-21).

Despite published suggestions of many suitable species there are few indications of actual seed demands but agencies that encourage planting of such species should also consider the problems of seed supply and source reliability (pages 20, 23-24); a survey conducted for this document indicated that for 26 out of 110 species seed supplies are insufficient to meet demand (Appendix 18).

Legal instruments and agreements exist nationally and internationally for seed source certification and plant health quarantine. These should be reviewed in the light of potential international trade in multipurpose tree germplasm, and both seed donors and seed recipients should be encouraged to follow approved systems and develop appropriate exchange and control techniques (pages 24-26 and Appendix 17).

Tissue culture has potential for genetic conservation and germplasm exchange while all forms of vegetative propagation have application in tree breeding and in afforestation (pages 26-27). The potential and problems of breeding multipurpose trees are reviewed and considerable enhancement of national capabilities is required; strategies should be developed for resource sharing through internationally coordinated breeding pools and data banks (page 27).

It is the object of this Workshop to suggest strategies for meeting global needs and combatting problems in the use of multipurpose tree germplasm,. This document concludes with a number of suggested elements, topics or activities that should be considered in developing such global strategies (pages 28-30).

Some 150 references are cited in support of statements made in this document. Various supporting documents (Annexes) deal with the special case of palms, the question of seed supplies, health legislation, and the impact of non-governmental organizations on germplasm resources.

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ACRONYMS AND ABBREVIATIONS

ADB	Asian Development Bank, Manila, Philippines
AFOCEL	Association Forêt Cellulose, Nangis, France
CAB	Commonwealth Agricultural Bureaux, Farnham Royal, England
CATIE	Centro Agronomico Tropical de Investigacion y Enseñanza, Turrialba, Costa Rica
CFI	Commonwealth Forestry Institute, Oxford, England
CGIAR	Consultative Group for International Agricultural Research, c/o World Bank, Wahington, USA, and FAO, Rome, Italy
CSIRO	Commonwealth Scientific and Industrial Research Organization, Canberra, Australia
CTFT	Centre Technique Forestier Tropical, Nogent-sur-Marne, France
DIALOG	Lockheed DIALOG computer retrieval system, California, USA
DIMDI	Deutsches Institut fur Medizinische Dokumentation und Information, Köln, Germany
DNA	Deoxyribonucleic acid
ESA-IRS	European Space Agency - Information Retrieval Service, Italy
FAO	Food and Agriculture Organization of the United Nations, Rome Italy
FGNFTs	Fast-growing, nitrogen-fixing trees
IARI	International Agricultural Research Institutes
IBPGR	International Board for Plant Genetic Resources, c/o FAO, Rome, Italy
IBRD	International Bank for Reconstruction and Development, Washington, DC, USA. (Now World Bank)
ICRAF	International Council for Research in Agroforestry, Nairobi, Kenya
IDRC	International Development Research Council, Ottawa, Canada
IPPC	International Plant Protection Convention
ISHS	International Society for Horticultural Science
ISTA	International Seed Testing Association, Ås, Norway
IUCN	International Union for the Conservation of Nature and Natural Resources, Morges, Switzerland
IUFRO	International Union of Forestry Research Organizations, Vienna, Austria
MAB	Man and the Biosphere Programme, UNESCO, Paris, France
MPTs	Multipurpose trees
NAS	National Academy of Sciences, Washington, DC, USA
NFTA	Nitrogen Fixing Tree Association, Hawaii, USA
NFTs	Nitrogen-fixing trees
NGO	Non-governmental organization
NiFTAL	Nitrogen-fixing Plants for Tropical Agricultural Lands, Hawaii, USA
NRC	National Research Council, Washington, DC, USA
OECD	Organization for Economic Cooperation and Development, Paris, France
SEPASAT	Survey of Economic Plants for Arid and Semi-Arid Tropics, Kew, England
UN	United Nations, New York, USA
UNEP	United Nations Environment Programme, Nairobi, Kenya
UNESCO	United Nations Educational, Scientific and Cultural Organization, Paris, France
US, USA	United States of America
USAID	United States Agency for International Development, Washington, DC, USA
USDA	United States Department of Agriculture, Washington, DC, USA
USFS	United States Forest Service, Washington, DC, USA
WB	World Bank, Washington, DC, USA

THE SCOPE OF MULTIPURPOSE TREES

BACKGROUND

Largely as a consequence of growing human and animal populations there has been, world-wide, an increase in deforestation and, especially in the tropics, general land degradation. Not only marginal lands but, in many cases, existing cultivated areas are rapidly declining in productivity. The rates and locations of these losses were described by Sommer (1976) and Wood et al. (1982) and the specific case of desertification was summarised by Grainger (1982). The rates of regression of tropical moist forests, rates of desertification and the tropical lands with potential for reforestation are summarised in Appendix 1.

The consequent acute food and fuelwood supply problems are well known. These necessitate intensive counter-measures among which tree planting programmes are in the forefront, both for environmental protection or enhancement on the one hand, and for renewable energy supplies on the other. There is a growing awareness that woody perennials can and must play a prominent role not only in maintaining the sustainability of many tropical land use systems but in meeting farm fuelwood needs. Tropical areas with current and predicted fuelwood deficits are shown in Appendix 2; the equivalent plantation areas required to meet the predicted deficits total over 100 million hectares by the year 2000 (Wood et al., 1982). Since the current annual rate of afforestation is only 1 million hectares, including planting for industrial forestry schemes (see Appendix 3), a massive increase in planting activity is required before the turn of the century, much of it with species or in areas that are not traditionally planted, for energy supplies alone.

Trees and shrubs are, moreover, now being extensively planted outside traditional forest areas to provide not only timber and fuelwood but a wide range of other products and services. The high importance of these additional roles of forests and trees has recently been recognised in the forestry sector policies of FAO, World Bank, Asian Development Bank and other international and bilateral assistance agencies (see e.g. World Bank, 1978). They are summarised in Appendix 4. Emphasis in national development and in assistance programmes has changed from industrial plantation forestry towards forestry for local community development (see e.g. FAO, 1978) and this has been paralleled by a need for increased research. The priorities for such research and some mechanisms for strengthening national research capacity were described by World Bank and FAO (1981) in a paper that was approved by the world forum of forest researchers, the 17th Congress of the International Union of Forestry Research Organizations (IUFRO). These research topics are summarised in Appendix 5. The top two priority groups of subjects are "forestry in relation to agriculture and rural development" and "forestry in relation to energy production and use". In both groups the choice of tree species and provenance, seed supplies and vegetative propagation, and tree breeding are major priorities. Even in the lowest (fourth) priority groups ("industrial forestry") these topics are of the greatest importance while in the third group ("management and conservation of existing resources") conservation of genetic resources is recommended for urgent research.

Different countries and areas within countries have different priorities but a subjective assessment of afforestation types was made by Wood et al.(1982) - see Appendix 6. In view of the overall changes of emphasis in global forestry needs and activities, and the particular need to supply many of man's requirements from small units of land, a large number of little known species are promising candidates (the so-called multipurpose trees or shrubs), and interest in these has increased markedly in a comparatively short time. However, the demand for suitable trees and shrubs (as well as vines and palms) which have the potential for various uses cannot, at present, be met adequately by controlled supplies of appropriate germplasm.

This discrepancy between demand and supply of germplasm has developed into a situation that is rapidly getting out of hand. Not only are national and international tree planting programmes experiencing acute difficulties in drawing on properly authenticated seed sources but very large quantities of seeds of unknown and unevaluated provenance are being exchanged world-wide regardless of the problems this will eventually entail. Even where seed collection is being validly documented the appropriate procedures for sampling are often being overlooked. The questions of legal instruments and source identification have not yet been fully addressed for multi-purpose species.

Another concern is the depletion of genetic resources of potentially important species, either as a result of indiscriminate devegetation or through lack of funds to maintain germplasm collections. The need to conserve multipurpose tree germplasm in appropriate ways is becoming increasingly apparent.

Several leading institutions and organisations have realised that these problems will only escalate if immediate steps are not taken to resolve the growing chaos. The Workshop is intended to take the first steps towards identifying the problems, and to discuss and set in motion appropriate strategies for their possible solution. This document, supported by five consultants' reports on special topics, provides the framework for these activities. It is expected that the Workshop will amplify the document in relation to information on species, countries and sites, documentation and research centres, international and national support strategies, and legal or quarantine aspects of germplasm exchange.

SOME DEFINITIONS AND DISCUSSIONS OF TERMS

Several terms have become common jargon in recent years and, like many jargon terms, they can mean different things to different people or in various uses. Also many acronyms are used in this modern age of initials. The terms used most frequently for this document and Workshop are defined below.

Multipurpose trees

Trees are generally understood to be free-standing (self-supporting) woody perennials with a more or less distinct and elevated head, a single main stem and a mature height generally exceeding a few metres; woody normally refers to xylem material produced annually by a persistent cambium of the dicotyledonous or gymnospermous type but for this Workshop we include monocotyledons (such as palms - see the paper by Johnson, 1983, annexed to

this document - and bamboos). The Palmae include 200 genera and 1500 species, all tropical or subtropical evergreens. The individual tree habit is a crown of pinnate or palmate leaves at the end of an unbranched stem. There are climbing palms or rattans (IDRC, 1979; Dransfield, 1981) and other plants whose common name is palm but which are not botanically in the Palmae (e.g. the sago palm, Cycas circinalis, in the gymnosperm family Cycadaceae). Other plants that may be confused with palms by the layman and which may have several uses include:- some climbing bamboos; the "sword trees" in the Liliales and Agavales; the dragon trees, Dracaena and Cordyline; Yucca, Nolina, Dasylirion and Furcraea; the Australian "grass trees" in the genus Xanthorrhoea. Also the Workshop may consider woody plants with multiple stems often less than 2m tall (shrubs) that are becoming increasingly important as fodder. Together these species are referred to as MPTs.

In addition a morphological group of plants, the climbers, include woody species in several taxa and with multiple uses. Climbing plants use other structures to achieve and maintain a place in the canopy or open light. They do not form much structurally supportive tissue but attach themselves to other surfaces or plants by a variety of specialized organs which allow a fourfold classification:-

(i) Penetrating climbers with roots produced from the stem which draw nutrients from the host surface.

(ii) Falling climbers, with epidermal hooks or barbs, which grow upwards until they fall over under their own weight on other vegetation.

(iii) Twining climbers, which curve around a support; these include climbing bamboos and palms.

(iv) Grasping climbers, similar to twining climbers but with specialised tendrils with or without sticky pads.

Vines are woody tendril climbers including the grape vine but are not widely important for multiple purposes in the tropics. Lianes are a group of tropical and sub-tropical woody climbers, some yielding rubber, alkaloids and drugs; they include some twining and grasping climbers.

Any definition of multipurpose cannot be applied entirely to a completely circumscribed set of species. Virtually every species of tree or shrub can be used for more than one purpose. Even species grown typically for industrial sawnwood or pulpwood may produce more than one output, e.g. in Europe conifers may yield saw timber, Christmas trees and decorative foliage while acting as shelterbelts, although such a mixture of products is rare and one product (in this case saw timber) is dominant over the others in terms of volume, value and intent. However, the term "multipurpose" appears to be used most commonly when a species is deliberately grown at one site and time to produce more than one product or benefit; these include the so-called "minor forest products" such as fuelwood, extractives, medicines, toothpicks, human food and animal fodder (including flowers for bees and leaves for silkworms), and service attributes such as shade, shelter, soil conservation and improvement of soil fertility.

The term should also be used to cover species that may be grown for different purposes on different sites. Thus an accepted timber tree such as Grevillea robusta should be considered multipurpose if it is grown in different places for shade, mulch, honey, etc.

Within the category of multipurpose trees there is a subset of fast-growing nitrogen-fixing trees (FGNFTs or NFTs). These have the ability to fix atmospheric nitrogen in a form that is usable to the individual plant itself, to the soil (through leaching from roots, leaf fall and deliberate mulching) and to domestic animals (through fodder). They include many species in the Leguminosae family, Alnus and Casuarina species. These are considered multipurpose trees because the nitrogen fixation is a service benefit, the foliage is a "minor product" and the wood is used variously for timber, poles, fuel, live fencing, etc.

Germplasm

According to the Dictionary of Genetics (King, 1972) germplasm is the hereditary material transmitted to offspring through the germ cells. Essentially it is the fundamental genetic information carried in the DNA of chromosomes and the definition implies that it concerns only sexually propagated material (i.e. tree seed). However, material that is currently propagated vegetatively contains the same genetic type of information and this germplasm could be used sexually in a future phase of a breeding programme. This Workshop should therefore consider the germplasm of species that are currently propagated by clonal means or in which germplasm could be either evaluated or conserved and distributed vegetatively (e.g. by tissue culture).

Genetic resources

Two other terms frequently used almost synonymously in this connection are genetic (or gene) resources and gene pools. King (1972) defined gene pool as the total genetic information possessed by the reproductive members of a population of sexually reproducing organisms; "pool" could be replaced by "resources" and "population" could be expanded to "species", but for the purpose of this Workshop the organisms should include not only currently sexually reproducing individuals but all individuals that may contribute genetic material to a planting programme through vegetative propagation or, in the future, through genetic engineering.

Social forestry

Jargon words are fashionable words and we must be careful that they do not become confused as fashions in subjects and species change (a very rapid process at present). MPTs and FGNFTs have great potential for meeting mankind's needs in the new subject areas of rural development forestry outlined earlier but it is necessary to see them as only part of one or more land use systems designed to meet one or more objectives.

The terminology for systems and objectives has become confused to the extent that agroforestry (a group of systems) is commonly equated with social forestry (a group of objectives). These were discussed more fully by Burley and Wood (1983) and the definitions of terms associated with social forestry are given in Appendix 7.

The important point to re-emphasise is that MPTs are not a system of land use nor are they the magic solution to all problems. They may be

important components of systems and solutions but their optimum use requires painstaking, site-specific, species-specific research into the exploration, evaluation, conservation and distribution of their genetic resources.

THE PROBLEM OF NUMBERS OF SPECIES

The many roles of trees and forests (Appendix 4), the range of countries and their priorities for lands to be reforested (Appendix 6), and the number of objectives and systems for managing trees and forests (Appendix 7) automatically imply that a large number of species are of interest. No single species can grow on all sites, tolerate all types of management, nor yield all types of products and services. Nearly every local or regional flora and the extensive ethnobotanical and ethnomedical literature cites the diverse uses of trees and shrubs. Several major compilations of the performance of exotic forest trees incude species that have multiple uses (e.g. Streets, 1962, for all countries of the Commonwealth; Kriek, 1970, for Uganda).

A large number of organizations and individuals maintain or have published systematic lists of plants, mainly trees, for a wide variety of site conditions and uses in the tropics and sub-tropics. It is anticipated that sources of additional lists will be identified during the Workshop but those cited in Table 1 and detailed in Appendix 8 indicate the types of published coverage available. They range from selection of trees for multiple purposes and various sites in one country (e.g. Appendix 8a, Bauer, 1982, Honduras; Camacho, 1981, Costa Rica; Nepal, FAO/IBRD, 1978), one region (e.g. Appendix 8b, Koivisto, 1979, Asia-Pacific), one vegetation type (e.g. Appendix 8c, Laurie, 1974, African savannahs), one altitudinal site type (e.g. Appendix 8d, Fenton et al., 1977, lowland tropical hardwoods), one soil/climatic type/phytogeographical zone (e.g. Appendix 8e, Adams et al., 1978, Saharo-Sindian, Sudano-Deccanean and saline soils; Appendix 8f, FAO/IBPGR, 1980, species for comparative trials in arid and semi-arid lands in Latin America, Africa, India and Southwest Asia; Appendix 8g, Delwaulle, 1979, and von Maydell, 1981, for the Sahel; Appendix 8h, Goor and Barney, 1976, for arid zones), and one land use system (e.g. Appendix 8i, Brewbaker et al., 1981; Vergara, 1982; tropical legumes in agroforestry).

In addition global publications classifying species by various climatic types were provided for firewood crops (Appendix 8j, Burley, 1980; NAS, 1980), multiple purposes (Appendix 8k, Webb et al., 1979) and energy biomass (Lavoie, 1981).

Many countries have lists of multipurpose species that are not published but that are available through personal communication (e.g. Malawi, Edwards, pers. comm. and Kenya, Owino, 1983, and Barrow, pers. comm.; Appendix 8l), while in 1982 the NAS distributed widely a mimeographed list of species suitable for the Sahel and analogous drylands elsewhere (Appendix 8m). The special case of bamboos was considered at an IDRC/IUFRO meeting (Lessard and Chouinard, 1980, Appendix 8n) the bamboos of Nepal were described by Stapleton (1982) and their multiple uses in India by Varmosh and Pant (1981). Palms, a group not widely familiar to foresters, are considered by Johnson (1983) in a supporting paper, for this Workshop. The subject of climbing palms (rattans) was considered by IDRC (1979). Many of the 34 introduced woody species recommended

specifically for browse in north Africa (Le Houérou, 1980) may also have potential for other uses (see Appendix 8o) and some of the many indigenous species in 21 families in the Sahel (Le Houérou, 1979) may be plantable. The special case of trees for food and fodder production was considered by Okafor (1980) for Nigeria and Kessler (1981) for Nepal - see Appendix 8r - and globally by Skerman (1977). The chemical composition and nutrient values for tree fodders were discussed by Douglas (1972).

Not all of these species are necessarily suitable for multiple purposes as defined above and not all of them have necessarily been proven to be suitable for planting in the locations suggested in Appendix 8r, nor indeed suitable for artificial regeneration in any form. Nevertheless the lists indicate the extremely large number of species for which genetic resources may be required. The most staggering number within a single taxonomic group occurs in the Leguminosae for which the US Department of Agriculture maintains a computerised data base on 1000 species[1] (Halliday and Nakao, 1982, Appendix 8p); of these some 36 were selected as economically important nitrogen-fixing trees, including seven non-leguminous species and a list of some 50 were chosen as a second priority (Brewbaker and Styles, 1982) - see Appendix 8q. A similar data base for 3000 plants (not only woods) is currently being computerised at the Royal Botanic Gardens, Kew, as part of the SEPASAT project (Survey of Economic Plants for Arid and Semi-Arid Tropics) - SEPASAT (1982).

INFORMATION COLLECTION, STORAGE AND EXCHANGE

Types of information required

The lists of species given in Appendix 8 illustrate the general problem of using multipurpose trees, namely the great number of species that have potential application for planting in one or more environments, by one or more systems and for several purposes. The lists do not exhaust the possibilities since they are compiled mainly from the personal knowledge, experience or judgement of one or several specialists on the basis of less than global reviews. Nevertheless the great number of species in Appendix 8 (nearly 2000) together with the national or topical lists held by many national Forestry Departments and international support agencies and institutions imply that sufficient species exist for choosing some for almost any plantation objective and location.

The specific problems relate to methods of deciding appropriate species to test, determining appropriate methods of exploration and evaluation, and locating suitable sources of germplasm when the optimum species and population are known. The first two of these are described in the CFI Manual on Species and Provenance Research (Burley and Wood, 1976), which was prepared primarily for industrial plantation species; the special problems of multipurpose trees are considered in the ICRAF/CFI/NAS Manual for the Evaluation of Multipurpose Trees currently in preparation. Many of the constraints are described in subsequent sections of this document.

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(1) Personal communication, Dr J. A. Duke, Economic Botany Laboratory, USDA, Beltsville, Maryland, USA.

CAB's ABSTRACTS database is available online through various hosts including Lockheed DIALOG (California, USA), ESA-IRS (European Space Agency - Information Retrieval Service, Italy) and DIMDI (Deutsches Institut für Medizinische Dokumentation und Information, Germany). Individuals or organizations requiring information on a specific topic can request CAB searches on payment of costs or, preferably, can perform their own searches if they have an appropriate telephone line and terminal equipment.

The CAB ABSTRACTS computerized database covers global literature for the last ten years and is searched automatically by user's choice of key search words.

ICRAF is currently preparing an "interactive, user-friendly request service" for agroforestry information (INFO/DOC. ICRAF) which will also be supported by manual searches, staff interviews and correspondence with other organizations (ICRAF, 1983; see Appendix 10b).

The specialist institutions discussed below, particularly including CATIE, CFI, CSIRO, CTFT, FAO and NFTA can supply published and unpublished information and advice on the choice, management and properties of species that are the subjects of their international cooperative programmes.

Lists of major periodicals, bibliographies and general references to nitrogen fixing trees were prepared at the NFTA Bellagio meeting (Duke and Brewbaker, 1982) and are reproduced in Appendix 11a. Additional references to extend the lists to multipurpose trees are included in Appendix 11b.

However, extreme care in phrasing searches is required and a large literature exists; Appendix 10a summarises the numbers of references located through DIALOG in preparing this document.

An attack on these problems requires provision and compilation of information on the natural distribution, variation, taxonomy and breeding system of each species together with information on the variation in growth, yield and properties of each species wherever it has been introduced; interpretation of the latter group in turn requires information on the natural and artificial (management) environment at each planting location. In addition rationalisation of efforts in conservation and exchange of germplasm requires knowledge of the practical needs for seed or propagules of the commonly used species.

Table 2 summarices the subjects on which information is required on each species and the types of institution likely to deal actively with the subjects or to be aware of information on them.

Sources of information

Nearly every national forestry department and research institute and many forestry educational establishments would maintain that they conduct some research or management of some of the species considered here as multi-purpose trees. The list of nearly 1000 research institutions in all member countries of FAO (FAO, 1982) is being supplemented by a questionnaire on topics of research related closely to the priorities identified by the World Bank and FAO (1981) and reproduced in Appendix 5[1]. The Bean Bag, a newsletter to promote communication among researchers concerned with the systematics of the Leguminosae, published a list of 399 members many of whom deal with woody legumes (Gunn, 1982).

Of more specific reference to multipurpose trees is the list of institutions studying nitrogen fixing trees prepared at the NFTA Bellagio meeting (van den Beldt and Huxley, 1982); this lists some 200 institutions in 67 countries. Major collections of nitrogen fixing tree species are held in arboreta in 13 countries and herbaria in 18 countries (Sastrapradjaradja and Brenan, 1982). Knowledge of wood anatomy and properties of multi-purpose trees may be obtained from the 125 xylaria listed in Stern (1978). All of the institutions listed in the three sources discussed in this paragraph plus the horticultural institutes in 54 countries listed by International Society of Horticultural Science (1972) (and preferably all those identified by FAO) should be approached to enquire about their specific activities and information on multipurpose trees; however, the enquiry and the maintenance of the resultant data base would require prodigious efforts. Few of the sources of information referred to above have considered actual germplasm needs (see Greathouse, 1982).

Direct approach to individual institutions would of course yield information on species and techniques but some of the relevant information is published in recognized journals and some in less familiar series ("grey literature"). Most of the literature is abstracted by such services as the Commonwealth Agricultural Bureaux in the United Kingdom (see Appendix 9) and the less conventional literature is incorporated in FAO's AGRIS Index.

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(1) Personal communication, H. A. Hilmi, Institutions, Education and Research Branch, Forestry Department, FAO, Rome, Italy.

tropical and 6 Mediterranean or sub-tropical species, viz. Araucaria angustifolia, A. cunninghamii, A. hunsteinii, Cedrela odorata, Eucalyptus camaldulensis, E. microtheca, Gmelina arborea, Pinus caribaea, P. kesiya, P. merkusii, P. patula, P. oocarpa, P. pseudostrobus, Tectona grandis, Pinus halepensis, P. brutia, P. eldarica, Abies cephalonica, Pinus radiata, P. muricata.

Progress is being made on the exploration, collection and distribution of a number of other species and genera, e.g. Aucoumea spp., Terminalia spp., Acacia aneura, A. auriculiformis, A. mangium, Cordia alliodora, Eucalyptus deglupta, E. urophylla, E. globulus, E. delegatensis and Cedrela spp., (supplementary collections); plans have also been made for the collection/evaluation of some additional species such as Pinus strobus var. chiapensis, P. canariensis, Prosopis spp. and Leucaena leucocephala. Through the activities of IUFRO, good progress has been made in the collection, distribution and evaluation of temperate species, expecially North American conifers and Populus spp. Detailed biological studies are being conducted on a number of potentially important tropical species, e.g. Agathis spp. and Triplochiton spp.

EXISTING INTERNATIONAL COOPERATIVE PROGRAMMES

Although some of these species clearly have potential as multipurpose trees, there appear to be currently only four major international collaborative programmes with MPTs (although many institutions have bilateral and bi-multilateral arrangements for the exchange of germplasm, e.g. CSIRO, Australia, for the provision of seed of Australian species, and Texas A and I University [1] for seed of American Prosopis species.

FAO

The FAO/IBPGR project on genetic resources of arboreal fuelwood species for the improvement of rural living (FAO, 1980,1981c) deals primarily with fuelwood, but many of the species will have other uses including fodder, fruits, poles, nitrogen fixation and soil stabilization. The collections planned and completed are shown in Table 3; the natural ranges of the species are detailed in Appendix 8f.

Although centrally coordinated by FAO, with recommended standardised procedures, collection of the seed and herbarium material is arranged by each host country, seed is stored at the Danish Tree Seed Centre, and taxonomic research is contracted to specialist institutions.

NFTA

The Nitrogen Fixing Tree Association, Hawaii, (which was mainly responsible for the Bellagio meeting referred to frequently above) is a non-profit, publicly supported corporation with nearly 1000 members each of whom pay a small annual subscription. Its purpose is to encourage international research and development, communication, and utilization of nitrogen fixing trees to provide improved fuel, fertilizer, forage, food, fibre, forests and other benefits. Inter alia it publishes research reports (e.g. Leucaena Research Reports, Nitrogen Fixing Tree Research

(1) Personal communication, Dr P. Felker, Cesar Kleberg Wildlife Research Institute, Texas A and I University, Campus Box 218, Kingsville, Texas, USA.

SYSTEMATIC MULTIPURPOSE TREE RESEARCH PROGRAMMES

DESIRABILITY OF CENTRAL COORDINATION

The optimum choice and use of species and population for a given site and objective requires research and development through a range of stages discussed above and implied in Table 2 (and detailed in Burley and Wood, 1976). Not all individual countries or institutions have the capacity to carry out all the stages, particularly those involving exploration, collection and taxonomy of germplasm in foreign countries. It would indeed be inefficient and wasteful of resources if all countries wishing to grow a particular species (the recipient countries) mounted their own collecting expeditions and it could place an unacceptable burden on the host (germplasm donor) country's organization and forests. "Collection by correspondence" is a poor way to assemble well documented collections but, if it is necessary, considerable lead time is required - see the Annex by Turnbull to this Workshop.

Clearly one collection by experienced staff on behalf of all potential planting countries would reduce these problems. Further a centrally coordinated programme could (i) collect samples and data or undertake research on topics of common interest (e.g. environmental data in the site of origin; laboratory or environmental herbarium studies for taxonomic and genetic purposes),(ii) distribute seed of different origins with experimental designs that permit comparison of performance or properties over all recipient countries, (iii) recommend uniform assessment methods for comparative trials, (iv) assist with national analyses if required and perform combined analysis over all sites to estimate species/provenance stability or genotype-environment interaction, (v) compile manuals and monographs on individual taxa based on global results of such collaborative trials, and (vi) give advice on the place of such introduced trial material in breeding programmes.

The value of such central support by specialist institutions was proposed by Burley and Kemp (1972, 1973) and Kemp et al. (1972). It has been recognised by FAO's Panel of Experts on Forest Gene Resources, which has recommended FAO to support various national institutions in their efforts to explore and conserve species of international interest. (See FAO, 1977, for the report of the fourth Panel meeting; the recommendations are shown here in Appendix 12.) Some of these institutions only collect and distribute seed while others provide taxonomic services and offer design, assessment, analysis and interpretation of comparative evaluation experiments.

Among the former is CSIRO and among the latter is CFI which originally concentrated on industrial plantation species but which is now beginning to include multipurpose trees for a range of tropical and sub-tropical site types. Lists of species and sources collected by these and other institutions have been given in issues 1 - 11 of FAO's Forest Genetic Resources information (FAO, 1973-82); a summary of progress in the global programme for improved use of forest genetic resources (FAO, 1974) was given by Palmberg (1981):-

> "Based on the priority lists drawn up by the FAO Panel, exploration and collection followed by the establishment of centrally coordinated international provenance trials have to date been accomplished for 14

Reports), sponsors workshop and seminars, and assembles, increases and disseminates germplasm. Under the stimulus of Professor J. L. Brewbaker, an agricultural geneticist, NFTA has made great progress in the selective breeding and testing of Leucaena but attention is also paid to other woody legumes through comparative trials of the species listed in Appendix 8i.

NFTA is closely associated with NiFTAL (Nitrogen Fixation by Tropical Agricultural Legumes), a team of University of Hawaii scientists contracted by USAID with the goal of increasing agricultural productivity throughout the tropics by promoting more effective use of the symbiosis between legumes and rhizobia in production systems; NiFTAL conducts an international network of legume inoculation trials and maintains a large library with a copying service.

NFTA is also associated with the Economic Botany Laboratory of the USDA which, inter alia, maintains computer-based data banks and bibliographies on the ecological amplitude, uses and literature of legumes (see e.g. Appendix 8p and Oakes, 1982). The future of this laboratory is currently under discussion; although it was established in support of US agriculuture, it has great value to other countries and its data bases should be maintained and extended.

CFI

The Commonwealth Forestry Institute, Oxford, has 20 years of experience in the exploration, conservation and evaluation of industrial plantation species, particularly tropical pines (CFI, 1980). Recently it has added a project for arid zone species mainly from Central America, including Acacia caven, A. deamii, A. pennatula, Atelia herbert-smithii, Caesalpinia velutina, Calliandra calothyrsus, Crescentia alata, Diphysa robinioides, Gliricidia sepium, Guazuma ulmifolia, Leucaena leucocephala, Leucaena shannoni, Senna atomaria (syn. Cassia emarginata), Parkinsonia aculeata, Pithecellobium dulce, Prosopis juliflora, Schinus molle and Swietenia humilis. These are being treated in the same way as the industrial species with collection of detailed site data at each seed source, central taxonomic evaluation, provision of seed lots with designs and recommended assessments, the offer of assistance with analysis and interpretation, and the maintenance of a computerised bank for data and bibliography.

NAS

The National Academy of Sciences supports research and development of multipurpose trees in two ways:-

(i) Firstly, through its Research Grants programme, NAS is assisting some 11 "grantee" institutions in trials of leguminous woody species and assessment of their nitrogen fixation capacity. The institutions and project titles are shown in Appendix 13.

(ii) Secondly, NAS has sponsored trials of many species (Appendix 8m) in several countries of the Sahel region. One of the problems is the lack of guaranteed life of the field trials; another is the lack of planned centralised evaluation.

IUFRO

The International Union of Forestry Research Organizations is the world's forum for researchers in forestry and forestry products. Its members are research institutions (approximately 400 in 93 countries) which pay a small annual fee for each working scientist. Each institution receives copies of IUFRO News for each of the staff for which subscriptions are paid (approximately 8000).

IUFRO activities are grouped into six Divisions (each led by a Co-ordinator and one or two Deputy Co-ordinators), within each of which there is a hierarchy of Subject Groups (Leader and Deputy Leaders) and Working Parties (Chairman and Co-chairmen). These Working Parties may have from 10-300 members all concerned with a common problem or programme. Inter-divisional Project Groups (Leader and Deputy Leaders) as well as inter-divisional meetings provide interactions between major disciplines.

The business and organization of IUFRO is conducted at the quinquennial Congress and managed between Congresses by an Executive Board (some 25 Divisional Co-ordinators, Deputy Co-ordinators and Regional Representatives) governed by an International Council (made up of a representative from each country that has more than one member institution, and meeting during the Congress).

Until 1972 there were no research groups dealing specifically with tropical problems and prior to that date there had been only one to two meetings outside Europe and North America. Since then, however, there has been an increased awareness of the need to incorporate members from developing countries in the operations of IUFRO and of the desirability of arranging meetings in the developing countries themselves. This culminated in the passing of a special resolution at the last IUFRO Congress following discussion of the review of research needs presented by World Bank and FAO (1981).

A complete breakdown of IUFRO's structure and officials was given in IUFRO News No. 36 (IUFRO, 1982). The research units most relevant to multipurpose trees are listed in Appendix 14.

IUFRO does not have funds (other than the small annual membership fee which covers the cost of printing and mailing the regular News); its relevance to forestry research and development problems depends on the enthusiasm and activities of its individual scientists and the financial support they receive from their home institutions. Nevertheless IUFRO has been highly effective in solving problems through coordinated research, publishing manuals and monographs on selected topics or species, organzing training courses, and keeping scientist aware of global problems and progress through meetings and the publication of their proceedings.

An attempt is currently being made by World Bank and UNDP to fund a special technical coordinator within IUFRO to increase IUFRO's programme activities in support of forestry research in developing countries. The announcement of this position is shown in Appendix 15. The position will be for two years in the first instance as an exploratory period and thereafter, if it proves successful, additional funding and donors will be sought together with means of generating funds internally within IUFRO itself.

GERMPLASM ACQUISITION, EVALUATION AND STORAGE

SPECIAL CHARACTERISTICS OF MULTIPURPOSE TREE GERMPLASM

The various sources of information listed in Table 1 referred to 2000 species (shown in Appendix 8) in nearly 100 genera and many families. It is thus impossible to generalise to the same extent as is possible, with increasing degrees of relevance or precision, for various subsets of industrial plantation species (e.g. conifers/pines/tropical pines or eucalypts/tropical eucalypts/arid zone eucalypts). Multipurpose trees may be found for a wide range of uses on a global range of sites. (Although the bulk of this document is concerned with tropical and subtropical species mainly for developing countries, it should not be forgotten that some species have multiple uses in temperate regions and that their development may be subject to the same constraints.)

Clearly the first characteristic of MPTs as a group is their inter-specific variability not only in terms of taxonomy but in terms of the information known about them. Some are extremely thoroughly researched from their distribution, taxonomic, genetic, breeding and managerial aspects (e.g. Leucaena leucocephala; see NAS, 1977; Brewbaker 1982, 1983). Others are virtually unknown from any of these viewpoints (including many species in Appendix 8 which may have been listed by an individual worker on the basis of casual observation of use in natural habitats or of performance in a small introduction plot).

In developing strategies for the improved use of multipurpose trees (see last chapter of this document) it will be difficult to identify research topics that are common to all species or even to a large number of species and it will be equally difficult to rank species in order of priority for attention in different countries or on varied site types. Excellent starting points for the latter are of course the "A" and "B" lists of the Bellagio meeting (see Appendix 8q) and the FAO/IBPGR set (Appendix 8f).

ISSUES IN TAXONOMY AND GENETICS

For many species the taxonomy and nomenclature are not in doubt. For others, particularly the larger groups (e.g. eucalypts and legumes), close phenotypic similarities among species, variation between trees and between populations within species, hybridization between species, lack of knowledge of the plasticity of some characters, and uncertain records of origin of plantations make identification, classification and nomenclature difficult.

The following extract from FAO (1979) summarises the current taxonomic situation for eucalypts:-

> "For many decades there was discussion about the ability of eucalypts to hybridize and whether certain names referred to stable species or to hybrids. Some taxa were regarded as hybrids by field collectors, yet named as stable species by responsible botanists; at other times botanists were reluctant to recognize populations which appeared distinct in the field. Some of the difficulty was caused by clinal variation, where a species population gradually varied from one district to another or from one altitude to another. In any one place the population seemed to be stable. This caused some confusion in nomenclature. Moreover, there was uncertainty whether some eucalypt

taxa should be given specific or subspecific rank.

Great help in resolving the relationships of taxa and the question of actual or potential hybrids has been given by several scientists who have experimentally manipulated crossings between eucalypt species and have demonstrated, by sorting out progeny, that certain suspect species were, in fact, of hybrid origin. This work has shown which eucalypts are likely to hybridize and those between which hybridization is apparently impossible. The work has demonstrated that the potential for hybridization in the genus is enormous. The reason that hybridization is not more prevalent in Australia is that species between which hybridization is likely to take place are separated by considerable distances in a large continent or by different flowering times. Particularly since the Second World War, many countries of the middle and lower latitudes of the world have planted a variety of Australian eucalypts from widely separated localities of natural occurrence within close range of each other. It has become apparent that significant crossing of species is taking place.

Based on extensive research work on ability to manipulate hybridization, and a vast amount of field work throughout the Australian continent and adjacent islands, Pryor and Johnson (1971) published a classification of eucalypts in which the genus Eucalyptus of L'Héritier and the closely related genus Angophora of Cau are combined. The classification divides the genus Eucalyptus into seven subgenera with sections, subseries, superspecies, species and subspecies."

The subgenera and sections in the Pryor and Johnson Classification and the number of taxa in each section are as follows:-

Subgenus	Code letter	Section	Section code letters	Number of taxa
Blakella	B	Lemuria	BA	10
Corymbia	C	Rufaria	CA	30
		Ochraria	CC	9
Eudesmia	E	Quadraria	EA	12
		Apicaria	EF	5
Gaubaea	G	Curtisaria	GA	2
Idiogenes	I	Gympiaria	IA	1
Monocalyptus	M	Renantheria	MA	106
Symphyomyrtus	S	Equatoria	SB	3
		Tingleria	SD	1
		Transversaria	SE	17
		Bisectaria	SI	104
		Dumaria	SL	36
		Exsertaria	SN	36
		Maidenaria	SP	68
		Umbrawarria	SQ	1
		Howittaria	SS	1
		Adnataria	SU	79
		Sebaria	SW	1

An analogous summary for the legumes may be taken from Allen and Allen (1981):-

> "The enormous plant family Leguminosae, with a worldwide distribution, has a currently estimated 16,000 to 19,000 species in about 750 genera. In economic importance it is second only to the grasses, Gramineae; in size, only to the Orchidaceae and the Compositae. Taxonomists conventionally have divided the family into three clearly distinct subfamilies, Mimosoideae, Caesalpinioideae, and Papilionoideae; division has been based mainly on floral differences, a concept adhered to in the generic synopses in the present volume. Although some recent taxonomic restructuring has accorded full family status to each of the three subdivisions, as Mimosaceae, Caesalpiniaceae, and Fabaceae in Order Leguminales, this is a matter of choice, for, whatever their rank, the distinctions between the three basic groups are clear and universally accepted. The current trend for the elevation of subtribes to full tribal status has served to improve the demarcation of previously ill-defined or controversial genera."

Among the most widely useful woody legume genera, Acacia and Prosopis, confusion exists in several tropical species with invalid subspecific and varietal epithets (but see Burkhart, 1976; Duke, 1981; Greaves 1978, 1979; Polhill and Raven, 1981). Sometimes the same species is called by two different names in different countries, e.g. Acacia tortilis in India is A. raddiana in Israel (FAO, 1980; hopefully the FAO/IBPGR project will provide adequate material for clarification of some of these issues).

Even for groups in which classical taxonomy at the specific level is not in doubt, for the vast majority of potentially multipurpose trees information on their intra-specific variability is lacking. Range-wide collection or study of herbarium specimens has not been undertaken and taxonomists have tended to ignore the variation seen in introduced, planted materials. To some extent these may be attributed to lack of trained taxonomists, lack of resources for expeditions and herbarium work, and lack of appreciation by foresters and agriculturists of the implications of intra-specific variation and the need for unequivocal identification (for germplasm collection, evaluation, management and future breeding).

For both the taxonomist and the geneticist an important issue is the natural breeding system of the species. For common industrial species such as pines and eucalypts it has often been assumed that outcrossing is the rule yet recent evidence indicates that selfing may occur at rates up to 10%. In eucalypts outbreeding is favoured by mechanisms operating at two different developmental stages, reducing the degrees of self-pollination and self-fertilization, but selfing does occur (FAO, 1979).

Most tropical trees including legumes appear to be cross-fertilized; among 43 species of nitrogen fixing trees identified as economically important, only Leucaena leucocephala was found to be highly self-fertilized (Brewbaker, 1982; Brewbaker and Styles, 1982); it is polyploid and hybridises with several other species, although this often yields sterile hybrids (NAS, 1977; Brewbaker, 1982). There are indications that at least some species

of Acacia do set considerable quantities of seed by self-pollination, e.g. A. dealbata [1]. For many other families information is lacking on the complete breeding system (see Burley and Styles, 1976) or pollination vectors (see Regal, 1982). Without such knowledge optimal sampling can not be planned for either genetic conservation or evaluation and breeding.

PROBLEMS IN EXPLORATION AND COLLECTION

The practical, administrative and political problems of seed collection were described by Kemp (1976); these apply equally to industrial species and multipurpose trees. Issues that are particularly relevant to the latter, especially tropical hardwoods, include the following:-

Distribution

There is often a serious lack of information on the distribution and extent of geographic distinction between populations within the natural range. This obviously adds to the time and cost of field exploration and necessitates prior searches for maps, prior correspondence with local professional staff, and field discussions with rural populations. For studies of indigenous species a Forest Service should encourage its staff to observe and record the locations of species. The problem of exploration of exotic stands is considered below under "Sampling".

Phenology

Expeditions for collection clearly need prior information on the seasonal periodicity and the annual fluctuations in flowering and seed production and in leaf phenology (for taxonomic collections). Again local staff may help but they may experience the problems of taxonomy and nomenclature discussed above.

Timing of seed collection

It is preferable to collect only in a year of abundant seed production since this offers much greater freedom of action in the choice of stands and trees, as well as the possibility of obtaining more seed for a given cost. Crop assessments made a few months before harvest, by reliable and experienced observers, are useful and can be progressively improved in accuracy if they are later compared with the actual quantities of seed obtained. Visual assessments from the ground can be very imprecise and it is often preferable to climb one tree in a group and make an estimate based on each climbed tree and its immediate neighbours. By this means specimens can also be collected that will help to determine the stage of development of the crop and thus the timing of the collection.

When attempting to collect provenance samples over a wide range the total time allowed by the length of the fruiting season can be a severe constraint. Determination of the most appropriate sequence of collecting sites, to take advantage both of differences in fruiting time and also the available means of transport between sites, can be a complex problem. Adverse climatic conditions may greatly alter the time needed at a given site, by hampering travel, collection and seed extraction. The preparation of alternative plans to cover such contingencies is particularly important

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(1) Personal communication, Miss J. Kenrick, M.Sc. student, School of Botany, University of Melbourne, Australia, including extracts from thesis shown in Appendix 16.

when synchronization of work between separate collection teams is needed. All parties should know in advance what alternative programme will be adopted if the timing of the preferred programme cannot be followed.

Sampling

If the resources and information available are too restricted to permit complete range-wide collection in one year, there are advantages in collecting from widely scattered points across the entire range in the first year, thus gathering much additional information needed for more detailed sampling later. Such a procedure may reveal some populations in danger of extinction or severe genetic impoverishment which can then be given priority for *in situ* conservation or for collection of reproductive material. Repeated sampling of any stand in two or more years is desirable to ensure a greater number of parents contribute to seed production and genetic representation.

Methods for the sampling of stands and trees were described by Kemp (1976). The pattern of stand sampling, whether systematic or random or stratified random, depends on the continuity or discontinuity of the distribution of the species, the evolutionary migration pathway of the species and the location of communication systems (roads, rivers, airstrips, *etc.*) Many tropical species are found only as single trees widely separated from the nearest breeding specimen of the same species, and they may be self-pollinating, in which case there is no "stand" to be considered and the seeds may be kept separately by trees or merged by sites depending on the objectives.

For both evaluation and conservation it is desirable to capture as much as possible of the potentially valuable genetic variation within a population. For most natural origins there is no estimate of population genetic variance and therefore large numbers of parents should be sampled for security. The general IBPGR recommendations for conservation collections (Hawkes, 1980) state that seeds from 50-100 individuals should be bulked to represent a population and, for outcrossing, heterozygous species, this procedure adequately safeguards against loss of alleles (see Burley and Namkoong, 1980). For evaluation, however, it is preferable to keep parental identities separate so that replicated field trials provide information on variance within as well as between populations.

Derived provenances

The evaluation of the genetic variability of a species is normally concerned mainly with collections made in the natural range, taking account of environmental variability and human interference within the range. This interference, whether eugenic or dysgenic, may move the population genotype away from what would be the result of purely natural selection. In some cases, where trees are planted on farms within the natural range, a low level of selection may occur leading towards the development of local land races.

Where the species has been planted outside its natural range as an exotic, local selection by nature and by man in the new site is inevitable, again changing the population genotype. Such populations are derived provenances (as opposed to natural provenances or origins - see Jones and Burley,

1973, shown in Appendix 17), and should be sampled for evaluation, adding to the sampling costs. Determining the location and genetic history of such populations is difficult particularly when seed source records are not kept and when so many haphazard introductions and seed movements are made (see the two Annexes to this document on the activities of non-governmental organizations by Buck and Greathouse).

PROBLEMS IN EVALUATION

Evaluation normally refers to the design, analysis and interpretation of comparative trials of different seed sources (species and provenances) but it also includes the taxonomic and ecological studies of the natural range discussed above. Certainly the locational and ecological features of the natural sources are used to interpret variation observed in field trials under exotic conditions.

Appropriate sequences, designs and analyses for species and provenance trials were described by Burley and Wood (1976) largely for industrial plantation species. Some experimental approaches to studying multipurpose trees are described in the ICRAF/NAS/CFI manual now in preparation. These include appraisal of existing data, evaluation of ecological situations where existing stands of mature species are immediately available, study of single trees introduced into agricultural systems, and formal experiments; these experiments include species elimination trials, field trials of survival and vigour, performance and management trials, and, eventually, experiments with agroforestry system.

Design

For many of the multipurpose trees considered here there are three major design problems. The first is the lack of information on variation between and within populations and, often, sites. Technically this information is necessary to obtain optimum precision and efficiency. In practice robust designs such as randomised complete blocks are used with large plots (many trees per plot).

Secondly a given experiment may include many species or provenances in which more complex designs such as lattices may be desirable to obtain required precision but these are undesirable because of their complexity in layout, management and analysis. A centralised project with experienced staff and adequate statistical and computing support may be able to deal with such designs whereas an individual research worker in a rural situation may not. By coordinating the design and analysis of a large number of experiments a centralised agency may also obtain information on the extent and sources of genotype - environment interaction (see Barnes et al., 1982).

Thirdly, when many germplasm sources are involved, they may be at different stages of information and genetic development or have different breeding systems and hence variance, e.g. one or two bred varieties of Leucaena leucocephala may be compared with bulked, wild type collections of other species not previously tested, or different amounts of seed may limit the degree of replication of some lots. In these cases the augmented designs described by Federer and Raghavarao (1975) and Brewbaker (1978) may be useful.

Assessment

The principal problem in assessing multipurpose trees is implicit in their name. If they are for multiple uses, multiple characters have to be assessed. Many of these are not familiar to foresters (e.g. foliage or fruit yield, nitrogen fixing capacity) nor to agriculturists (e.g. woody biomass, fuelwood or charcoal yield and properties). Methods of sampling, measurement (laboratory or field) and analysis still have to developed for some traits. An extensive list of characters to be assessed is included in the ICRAF/NAS/CFI manual in preparation, including characters of the environment as well as the plant.

Apart from the simple problems of time, cost and skill in assessing multiple characters, a major problem is their compilation into an overall index reflecting the gross economic value of each seed source for each site.

Management

One of the dangers of publishing lists of species such as those shown in Appendix 8 is that many of the countries or organizations interested in testing them may have no experience of actually growing them. Seed treatments, nursery techniques including mycorrhizal or rhizobial inoculation and field management may be either completely unknown or different between the different seed sources in the given experiment.

Although a central coordinator can provide general advice, local techniques should ideally be developed before comparative trials are established. Yet because of current pressing needs and enthusiasm many species trials are proceeding before sufficient silvicultural research is completed with the result that species may fail not because of inherent unsuitability for a given site but because of inappropriate treatment or managerial problems (e.g. some of the sites in the NAS Sahel trials[1]).

THE PROBLEM OF WEEDINESS

Two problems often arise with species that are introduced as a result of current fashion or enthusiasm (the "new" or "marvel" tree that is intended to solve all our problems); one is simply that the species do not live up to expectations through incorrect choice of species and provenance or through poor management.

The second problem is the highly successful adaptation of an exotic species to its new environment to the extent that it flowers profusely and regenerates abundantly, spreading as a weed to areas where it is not required (agricultural fields, pastures, etc.) Well known examples include Opuntia in Australia (for which biological control has been developed); Robinia pseudoacacia, Ailanthus altissima and some eucalypts in the eastern Mediterranean (Greece and Turkey, often spreading vegetatively); Ficus and Melaleuca in Florida, USA; Acacia in South Africa and Queensland; Lantana in Africa, Australia and Hawaii; Prosopis in India, Pakistan and USA; Leucaena leucocephala is being closely watched in the Philippines. The cases for and against biological control of Acacia species in South Africa by seed destroying insects from Australaia were presented by Lückhoff (1977) and Stubbings (1977).

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(1) Personal communication, JA Gritzner, BOSTID, NAS, Washington DC, USA

SEED SOURCE RELIABILITY

The various types of seed sources (natural and derived provenances) were discussed above and in Appendix 17. It is one thing to classify sources; it is quite another to guarantee their authenticity. Further to be meaningful the results of a comparative study must be seen in the light of features of the environment of the germplasm sources included in the trial. It is therefore inadequate to name only species or country of origin in seed supplies.

The control and recording of seed origin are discussed below under "source germplasm certification" (see also Appendix 17) but far more data on seed origin are needed for evaluation experiments than for routine germplasm movement. Such detailed information is usually collected by the coordinators of major international programmes (see e.g. the descriptions of seed sources of P. caribaea and P. oocarpa used in the CFI programme - Greaves, 1978, 1979).

Few tropical countries follow the seed certification system discussed below and virtually no commercial seed supplier worldwide can provide sufficient information on the source environments to facilitate interpretation of trials.

PROBLEMS IN GENETIC CONSERVATION

Needs for conservation

The needs to conserve natural resources, both for current use and for future generations, are now widely appreciated (Stockholm, 1978; NAS, 1978; Anon., 1981) and serious attempts are being made by organizations, national Governments and international agencies to conserve representative samples of natural ecosystems. Some 900 reserves have already been established within the UNESCO MAB (Man and the Biosphere programme) - see UNESCO (1973). Strategies for in situ conservation of forest genetic resources were considered by FAO/UNEP (1981).

At the other end of the spectrum considerable efforts are being made to conserve individual plant and animal species that are in danger of extinction (see Prance and Elias, 1976; Lucas and Synge, 1981; Pryor, 1981; Synge and Townsend, 1981). The International Union for the Conservation of Nature and Natural Resources (IUCN) has a Threatend Plants Committee which maintains the Red Data Book (see IUCN et al., 1978; Synge, 1981).

Neither of these activities, however, fully takes action at the level which is most important for both industrial and multipurpose trees, namely safeguarding the resources of threatened populations within species and the maintenance of derived provenances and local land races. This level of need has long been recognized for agricultural crops and most of the International Agricultural Research Institutes within the CGIAR system maintain global collections of wild and cultivated types as well as weedy relatives of their specific crops. However, it is only recently that deliberate measures have been taken to conserve populations of forest trees, mainly industrial conifers and eucalypts, by ex situ stands (Roche, 1975; Wood and Burley, 1980). IUFRO Working Party S2.02-01 attempts to collate and stimulate such efforts. With the exception of a few multi-purpose species that have been explored intensively (e.g. some eucalypts by CSIRO; the CFI and the FAO/IBPGR arid zone hardwoods; or the CATIE

Central American hardwoods), there have been no systematic attempts to collect material for conservation as opposed to evaluation in small trial plots.

Subjects of conservation

In conserving an ecosystem *in situ* we automatically conserve its species and their genetic resources although the size of area reserved obviously controls the number of individuals of each species. To determine the minimum area of forest to conserve adequate numbers of individuals *in situ* requires knowledge of the reproductive biology, ecology, pattern of distribution and genetic variance of the species.

For both exotic industrial and multipurpose plantations, species and population conservation is more important than ecosystem conservation. If desirable species and populations can be identified from exploration of the natural range, from *ad hoc* introductions, or from comparative trials, we need to decide what genetic properties of the populations should be conserved:- genes, gene frequencies, gene complexes or genotypes (see Burley and Namkoong, 1980).

According to Thompson (1979) the essential requirements for collection and maintenance of plant genetic resources are:-

(a) Representation: genetic diversity (large population)
(b) Prevention: genetic erosion (no selection)
(c) Preservation: genetic integrity (no gene flow)
(d) Retention: gene frequencies (no distortions to breeding pattern)
(e) Conservation: longterm security (low energy input)

Further, Thompson (1979) considered the following conditions should be avoided in collections of plants held as genetic resources:-

(a) Small populations (collected or maintained)
(b) Selection (random or directed)
(c) Hybridization (gene flow)
(d) Unnatural breeding patterns (level of heterozygosity)
(e) High risk survival factors (individual enthusiasms, cultivation in glasshouses, *etc*).

Methods of ex situ conservation

Ex situ conservation can be done by agencies with an interest in the species and in areas where environmental conditions or management techniques are suitable. It can take the form of pollen storage, seed storage, tissue culture (see Wilkins *et al*., 1982), or growing plants in conservation stands which themselves continually evolve (see Roche, 1975). Appropriate techniques for these four methods are not known for many multipurpose trees and for some may require considerable research (*e.g.* species with recalcitrant seed - see King and Roberts, 1979).

SEED STORAGE

Seeds may be stored over long periods for genetic conservation or short periods until distributed for evaluation trials or routine plantings. Ideal conditions for storage, routine germination and germination testing have been determined for many temperate species but few tropical species

(see ISTA, 1976; USDA, 1974). In the absence of researched methods for a given species, those appropriate to the species that is nearest taxonomically and environmentally should be adopted. Meanwhile considerable research is required to ensure the longest life and greatest germination of valuable seedlots and IUFRO Project Group P2.04-00 should be able to stimulate and coordinate such work. A survey of equipment and supplies for seed testing was published by ISTA (1982). In the circlar questionnaire discussed below (under Germplasm demand) there were reported to be seed problems in 50 our of 100 species.

DATA BANKING AND DISSEMINATION

During the course of exploration and evaluation of a species considerable amounts of data accumulate both nationally by each country conducting research on the species and internationally by agencies coordinating larger programmes. Such data are only useful if analysed correctly and the results disseminated. They should also be stored in accessible form for future use. In too many countries forestry research data are collected, filed away and forgotten so that the next generation of researchers attempts to rediscover the wheel; a review of existing information should always precede new research.

As the numbers of species, institutions and experiments increase, this problem of data management escalates. Fortunately we live in a period of rapid development and lowering of prices of computers but it is desirable to ensure that data management systems are compatible among those dealing with multipurpose trees. Portable microcomputers can now be linked by ground or satellite telephone systems and data exchanged easily.

The results of research should be published in recognised journals and compiled eventually in bibliographies and monographs (see Appendix 11b) which are themselves noted by the abstracting and information services described earlier.

GERMPLASM DISTRIBUTION AND USE

DEMAND

The first chapter of this document and Appendix 8 demonstrate that nearly 2000 species have been considered to have potential for several uses or for difficult environments (physical and social). However, few of the many references examined gave any indication of the supply and demand situation.

The commendable enthusiasm of international, governmental and non-governmental organizations to establish trees in degraded sites or in rural situations or for non-industrial purposes can lead to two dangers. Firstly and simply, seed or other propagules may not be available in sufficient quantities to meet planned planting targets. Secondly, the urgency for planting or the lack of seed of some species may lead to the planting of inappropriate species and provenances. Either of these can cause dissatisfaction and disillusionment in government planners and administrators as well as in the rural populations themselves. The Annex to this document prepared by Turnbull uses Australian experience to increase awareness among planners and managers that currently a severe bottleneck exists between the stages of choosing species and actual planting. In a review of 55 USAID tree planting projects, Greathouse (1982) reported that the question of seed supply was specifically mentioned in only three implementation documents. It is necessary for agencies which promote the planting of multipurpose tree species through publications and the sponsorship of meetings or development projects to have an equal commitment to support seed collection activities to satisfy the demand they create.

Current annual planting rates are approximately 1 million ha of industrial plantations and 0.5 million ha of non-industrial forests (fuelwood, domestic products and protection) according to Lanly (1982). The review by Wood et al. (1982) suggested that the equivalent of 100 million ha would be needed by the year 2000 (i.e. 5 million ha per year) to meet predicted deficits of wood products and to reforest degraded land. China will plant 1 - 2 million ha annually to meet established targets for industrial and domestic wood and Brazil is currently planting approximately 0.2 million ha (see Turnbull, 1982, and Annex to this Workshop).

Most of these plantings will be based on seedlings (excluding some 10,000 ha annually of eucalypt cuttings in Brazil and Congo and equivalent areas of poplars and willows in South America and Europe) and clearly large quantities are involved. Since the number of species is so large and seed size is so variable it is not possible to predict precisely the seed weight for each species. However, conservative estimates of global needs exceed 100 tons of coniferous seed and 25 tons of eucalypt seed for industrial plantations while similar amounts of hardwood and palm seed are likely for non-industrial planting because of the greater seed size of many multipurpose species and because of the lower efficiency of seed use in rural planting as opposed to managed industrial plantation schemes.

Problems in supply of multipurpose species occur when newly recognised species or superior populations are required in substantial quantities and the only source is natural forest in the country of origin, e.g.

Eucalypts dunnii (restricted natural distribution), E. camaldulensis (the remote Petford population) or Acacia mangium (remote natural stands and difficult seed extraction). For these and others of the 1300 potential species of Acacia, Casuarina, Eucalyptus, Grevillea and Melaleuca there will be difficulty in meeting demands in the short term even with the well organised seed collection services in Australia.

In preparing for this Workshop a questionnaire was circulated to 200 heads of tropical forest departments and research institutions, and individuals (tree breeders and silviculturists) to seek information on their national use of multipurpose trees. Forty-two replies were received and 160 species were nominated (see Appendix 18). Of these 50 were mentioned by the Australian respondent as having potential elsewhere as exotics but without estimates of demand. Of the remaining 110 species seed supply was considered adequate for only 71; for 26 the supplies were considered definitely inadequate. These 42 responses are obviously not fully representative of all countries, organizations or species but they begin to give an indication of the problems that lie ahead. (Although the responses to the questionnaire were of variable quality it appears that the following uses of species are claimed:- firewood 110, charcoal 41, fodder 26, fruit 47, shelter 115, soil protection 57 and soil improvement 35.)

SUPPLY

FAO maintains a directory of tree seed suppliers (FAO, 1975). In its 1961 edition the directory consisted of over 400 pages listing a number of suppliers for each species. Since then the volumes of exchange and trade in forest tree seeds have expanded greatly and the 1975 edition is a directory of countries able to supply seed of species and varieties. The addresses of national seed coordinating centres are given rather than those of commercial suppliers. It is primarily for seeds of trees used in forest production, with less emphasis on woody plants suitable for erosion control, ornamentals, game and wildlife management, shelterbelts, fodder, etc.

Lists of suppliers of seed of legumes are maintained by the USDA and NFTA while suppliers of Australian species are listed by Turnbull in the Annex for this Workshop. A novel approach to keeping up-to-date and disseminating information on seed suppliers was adopted by Benge (1982); his report consists of photocopies of letters and/or letterheads together with current catalogues and, as suppliers increase or go out of business or change species, new information can be supplied in loose-leaf form.

While all the agencies and organizations promoting tree planting need to be aware of seed suppliers, National Seed Coordinating Centres need to be aware of the worldwide interest in non-industrial species and the necessity of good certification and health procedures (see below).

LEGAL REQUIREMENTS

Where the movement of exotic species from one country to another is desired, two aspects benefit from legal instruments - certification and plant quarantine. Even for movements within a country records of origin and genetic history are important.

Germplasm certification

Certification literally means the authoritative attestation of facts or statements and it usually implies documentation by formal written certificate. As commonly used in forestry it refers to seed certification (although the OECD, 1974, scheme refers to all reproductive material and hence to all germplasm) and it is an official statement that a seed lot conforms to certain standards which may include specific identity, origin, genetic characters and seed purity. As discussed by Jones and Burley (1973) (and above under the topic of seed source reliability) considerably more information is required for evaluation than is required by the OECD or most national seed certification schemes.

The OECD scheme is open on a voluntary basis to all member countries of OECD or the United Nations and its specialised agencies. However, few countries outside Europe and North America participate and, although many Forest Departments and seed suppliers do provide source information, there is rarely a national legal requirement for them to do so. Governments and Forest Departments in both seed donor and recipient countries must be made aware of the importance of adequate source records.

Plant quarantine

The widespread distribution of germplasm of exotic species entails increasing risks of import of diseases and insects. This is particularly the case for seed but pollen may well contain bacteria, fungal spores and nematodes while tissue culture can carry viruses and virus-like organisms. The problem is not only restricted to the tree species itself but may apply to indigenous crops; for example, Pinus caribaea seed may not be imported to Malaysia from Central America because it grows in association with oaks which are the alternative host to South American leaf blight (Dothidella ulei) which could virtually wipe out the Malaysian rubber industry.

The major risks and the steps required to minimise them were described by Kahn (1977,1978, 1979a, b, 1981, 1982), Waterworth and White (1982) and Ivory (Annex for this Workshop). With the exception of tissue cultures and movements between European Common Market countries, whole living plants may rarely be moved internationally. Import of soil is prohibited except for research purposes in which case the importer is usually required to certify the soil will be heat sterilised after the research.

Regulations may entail any of the following:-

(a) Specific prohibition
(b) Specific prohibition with exceptions for scientific purposes
(c) Quarantine procedures required
(d) Treatment on arrival
(e) Inspection on arrival
(f) Permit required
(g) Phytosanitary certificate and/or certificate or origin required
(h) Various treatments and inspection before dispatch
(i) Restrictions on the size and type of material involved.

An international plant protection convention (IPPC) was established in 1951 and has been ratified by 80 countries. Regional organisations also exist (see Ivory, 1983). Most countries have established national Plant

Protection Authorities as have some States within federal countries (e.g. Australia, USA). The regulations of all these agencies control the import but rarely the export of germplasm; donors, scientists and commercial suppliers should be fully aware of the plant health regulations in the importing country.

PLACE OF VEGETATIVE PROPAGATION

Tissue culture was mentioned above as a valuable means of minimising the risks of germplasm transfer (see particularly Kahn, 1979b). For internally seed-borne pathogens embryo culture combined with microbiological assay and virus indexing offer a useful technique. For virus-infected material heat therapy of shoot tip cultures may be combined with virus indexing.

Tissue culture would also be valuable for genetic conservation as long as the in-culture mutation rate is not high. Such gene pools can be propagated and maintained in several locations for security. Techniques and problems of tissue culture storage for genetic conservation were reviewed by Withers (1980).

Easily perishable plant material and species with difficulties of seed collection, storage or germination could also benefit from tissue culture. However, techniques of organ, embryo, tissue or cell culture have been evaluated for only a few tree species (e.g. oil palm, Unilever Company, England; teak and sandal in India; Douglas fir and some pine species, Weyerhauser Company, USA; Maritime pine, AFOCEL, France; some eucalypt species by several workers in Australia and USA; Prosopis species, Dr P. Felker, Texas A and I University, USA; rubber in China (see Han and Qiquan, 1981) and many North American species but not on the commercial scale (Brown, 1981). Techniques and possibilities for tissue culture in forestry were described in Bonga and Durzan (1982). A review of the global potential for plant cell and tissue culture was conducted by a Working group of the National Research Council (NRC, 1982). It identified eight research areas as prospects for near-term, mid-term, and long-term applications of plant cell and tissue culture techniques:-

Near-term (many new applications possible now or within 5 years)

- Clonal propagation
- Disease elimination
- Germplasm exchange
- Gene transfer by wide hybridization

Mid-term (some applications to plant improvement possible within 5 - 10 years)

- Variant selection (including somaclonal selection)
- Production of haploids

Long-term (plant improvement applications unlikely for at least 10 - 15 years)

- Secondary natural products
- Molecular genetic engineering in plants.

Other forms of vegetative propagation, especially the rooting of cuttings, have places in tree breeding (for the creation of clonal banks and seed orchards) and in commercial afforestation (e.g. eucalypts in Brazil and Congo). The many places of vegetative propagation in forestry were described by Barnes and Burley (1982) and Burdon (1982).

PLACE OF GENETIC IMPROVEMENT

Tree breeding is a well established practice with many industrial species and in many countries (see e.g. Wright, 1976). An indication of the scope may be obtained from:- the Proceedings of three FAO/IUFRO World Consultations of Forest Tree Breeding in 1963, 1969 and 1977 published by FAO; the many papers in 33 volumes of Silvae Genetica; the Proceedings of three meetings of IUFRO Working Party S2.03-01 (Breeding tropical species) in 1972, 1973 and 1977 published by CFI, Oxford; and many other published articles. Recommendations have been made for tropical breeding strategies under varying resource constraints (Namkoong et al., 1979) and Burley (1980) reviewed the problems and possibilities for genetic improvement of species for community forestry and individual smallholder planting. In addition to many eucalypts, specific cases of multipurpose trees have been treated inter alia by Brewbaker (1982, Leucaena in Hawaii), Leakey et al. (1982, Triplocitton in West Africa), Wattle Research Institute (1982, Acacia in South Africa). For rational and efficient breeding strategies, information is required on the extent and pattern of natural genetic variation (see Solbrig et al., 1977, for use of isozyme techniques in determining genic variation in Prosopis). Much of this information should be gathered at the exploration and evaluation phases described earlier in this document. Three main problems arise in breeding multipurpose trees in comparison with traditional industrial trees. Firstly the bases of genetic material and genetic information are restricted; many existing trees and plantations have been derived from parents of unknown origin or ancestry.

Secondly, the breeding of any crop for multiple characteristics is difficult in three aspects:- For a given selection intensity the rate of improvement of any one trait declines as additional characters are included; the derivation of selection indices is complex mathematically; techniques are not well developed for rapid assessment and large-scale screening of some traits.

Thirdly, the material must be bred for a range of environments and management conditions, i.e. it must be robust and stable without showing genotype-environment interaction effects.

Over all these problems lies the common constraint of inadequate professional and technical staff. Considerable enhancement of national capabilities is required and strategies should be developed for resource sharing through internationally coordinated breeding pools and programmes.

ELEMENTS OF POSSIBLE STRATEGIES IN MEETING INTERNATIONAL NEEDS FOR MULTIPURPOSE TREE GERMPLASM

It is not the purpose of this document to propose strategies; that is the object of the Workshop. However, it may be useful here to indicate some considerations to be borne in mind and some possible lines of action. Eventually any increased activity depends on more staff, skill, equipment and hence money. The following provides a checklist of opportunities for investing limited resources.

NATIONAL AND INTERNATIONAL PROGRAMMES

It is generally recognized that emphasis should be given to strengthening national capabilities and not to creating new international institutions (World Bank and FAO, 1981). However the value of internationally coordinated activities in exploration and evaluation can not be overstressed (e.g. FAO, IBPGR, CFI, CSIRO, NAS, NFTA).

TWINNING AND NETWORKS

Where a major international programme is impossible or inappropriate, twinning between two or more institutions with a common interest (species, technique or product) may economise on financial or skill resources. The coordination of such networks could be an activity of the proposed IUFRO technical secretariat or of existing agencies such as FAO and ICRAF.

GROUPING OF ACTIVITIES BY PLANT TYPE, SPECIES, GEOGRAPHY OR ENVIRONMENT

The Nitrogen Fixing Tree Association is an excellent example of a group of institutions and individuals working on a common set of species. The Neem Tree Institute is an example of single species concentration (see e.g. Kadwanski, 1981). The FAO/IBPGR project is an equivalent example of attacking a problem at the level of an environmental type (arid zone). When many potential species occur together within a country or region a geographic concentration of effort may be preferred (e.g. CATIE and CFI collecting many species in Central America). With such large numbers of multipurpose trees available, setting priorities for different environments is a major imperative. The special case of forage shrubs in arid zones needs particular group attention (see e.g. Goodin and Mckell, 1971; Mckell, 1975).

TAXONOMY IN EVALUATION

Adequate exploration requires taxonomic study in the natural range. Taxonomic support is also needed at the evaluation stage in exotic conditions. Good collaboration is required between staff in herbaria (e.g. Kew or New York Botanic Gardens) and foresters or agriculturists making field collections or assessments; some subcontracting of research may be appropriate, e.g. biochemical analysis.

ASSESSMENT

The ICRAF/NAS/CFI manual now in preparation describes a large number of characters that may be of interest in evaluating multipurpose trees. Research is needed on some of these to determine standardised methods of assessment (e.g. foliage production or chemical content). Research is also needed to determine the applicability of growth chambers or other controlled environments to measuring juvenile characters that are correlated with mature characters in the field and that permit early evaluation.

DATA AND INFORMATION MANAGEMENT

Consideration should be given to the development of standard formats for data collection and compatible methods of computer-based data exchange (for data on seed origins and on field trials). Encouragement should be given to publication and dissemination of results and the compilation of bibliographies, reviews and monographs. Also unpublished data or results from early research should be reviewed. Leading centres may be identified as the databanks for a given species or geographic region.

CONSERVATION

For the major species of interest efforts must be made to identify and conserve populations threatened with genetic improverishment, and to determine optimum strategies and funding for their genetic conservation whether in situ or ex situ. The latter may require development of storage methods for seed, pollen and/or tissue cultures (e.g. various IUFRO research groups or specialised centres).

INVENTORY OF ACTIVITIES

While the present document indicates the wide range of species and products available together with the future needs in terms of areas and numbers of trees, it is clearly not an exhaustive list of current activities. Such an inventory of institutions, their activities, their principal species and products, and their available information is desirable to publicise current knowledge and to minimise unnecessary duplication of research. The compilation and maintenance of the inventory would be done by expanding current organizations such as FAO, ICRAF, IUFRO Secretariat or NFTA. IBPGR already publishes directories of germplasm collections for its major crops (see e.g. Williams and Damania, 1981, for cacao, coconut, pepper, sugarcane and tea) and eventually similar directories will be required for multipurpose trees and shrubs.

STAFF DEVELOPMENT

In addition to current awareness that could be provided by the inventory suggested above, there is a need for additional staff and specialised training that can be offered by traditional university courses and by modern in-service training and short courses. The latter are particularly valuable for countries or departments with limited professional and technical staff who can not be spared for a full degree course. Provision should also be made for the attendance of staff from developing countries at IUFRO and other appropriate meetings.

GERMPLASM SUPPLY AND DEMAND

The literature reviewed for this study and the questionnaire distributed for it did not obtain meaningful data on global seed requirements. A more intensive survey is required which may be organised on a regional basis once major species of widespread application are identified. Similarly lists of suppliers are required. Consideration should be given to the creation of national and international seed banks.

QUARANTINE AND SEED CERTIFICATION

International agreements and rules exist but are not fully applied in tropical countries. The Workshop should consider means of publishing the benefits and encouraging/enforcing the use of such instruments.

CLONAL PROPAGATION

Organizations currently researching on rooted cuttings should be encouraged to expand their choice of species to include multipurpose trees.

GENETIC IMPROVEMENT

Once species of major importance have been identified, assistance should be given to national institutions in developing breeding programmes. Strategies must be developed for international cooperation in pooling improved genetic resources.

Table 1. Sources of lists of multipurpose species

Authors	Date	Scope	No. of genera or species	Appendix
Bauer	(1982)	Eight site types in Honduras	30 species 21 genera	
Camacho	(1981)	Costa Rica	68 species	8a
FAO/IBRD	(1978)	Nepal	91 species	
Koivisto	(1979)	Asia-Pacific region	5 genera trees 4 genera bamboos 2 agric. industrial woody spp. 13 potential untested spp.	8b
Laurie	(1974)	African savannahs		
		Subdesert	10 species, 6 genera	8c
		Dry tropical	9 species, 6 genera	
		Semi humid tropical	19 species, 6 genera	
		Humid and equatorial	13 species, 7 genera	
Fenton et al.	(1977)	Lowland tropical hardwoods	23 species, 14 genera	8d
Adams et al.	(1978)	Arid and saline	45 indigenous tree species 53 introduced tree species 65 indigenous } shrubs and cover 24 introduced } shrubs and cover	8e
FAO/IBPGR	(1980)	Arid and semi-arid	13 species, 4 genera	8f
von Maydell	(1981)	Sahel	116 species	8g
Delwaulle	(1979)	Dry tropical Africa	63 species, 43 genera	
Goor & Barney	(1976)	Arid	53 species	8h
Brewbaker et al.	(1981)	Tropical legumes in agroforestry	26 species, 12 genera	8i
Vergara	(1980)			
NAS	(1980)	Global firewood	60 species selected list	8j
Burley	(1980)		650 source list	
Boland and Turnbull	(1981)		111 species and genera	
Lavoie	(1981)	Energy biomass	31 genera, 288 species	
Webb et al.	(1979)	Global multipurpose	180 species	8k
Edwards	(1983)	Malawi multipurpose	66 species and/or genera	8l
Barrow	(1983)	Kenya multipurpose	57 species	
Owino	(1983)	Kenya nitrogen fixing and multipurpose	55 species, 4 genera	
NAS	(1982)	Sahel	54 species	8m
Lessard and Chouinard	(1980)	Bamboos	43 species, Malaysia 22 species, Indonesia Many species, A-P region	8n
Varmah and Pant	(1981)		Many species, India	
Le Houérou	(1980)	Browse species, North Africa	34 species	8o
Johnson	(1983)	Palms	4 species domesticated 19 species incipient domestication	Workshop Annex
IDRC	(1979)	Rattans	Various species for Asian countries	
Whitmore	(1980)	Many groups and purposes		
Halliday and Nakao	(1982)	Legumes	1000 species	8p
Brewbaker and Styles	(1982)	Nitrogen-fixing trees	43 species "A" list 50 species "B" list	8q
Okafor	(1980)	Food and fodder, Nigeria	51 species	8r
Kessler	(1981)	Fodder, Nepal	24 species	

Table 2. Types of institution that should be active in or able to provide information on various aspects of multipurpose trees (in the form of published or unpublished reports, abstracts, bibliographies, monographs, manuals and data bases)

	1	2	3	4					5			6	7	8
				A	B	C	D	E	A	B	C			
Natural range														
Species natural distribution		✓	✓	✓		✓	✓	✓		✓	✓		✓	✓
Population variation		✓		✓		✓	✓	✓		✓	✓		✓	✓
Species taxonomy	✓	✓	✓			✓	✓	✓		✓	✓		✓	✓
Physical exploration (map, seed, herbarium, samples, etc.)		✓												
Conservation	✓			✓				✓		✓	✓		✓	
Exotic conditions														
Seed/fruit problems					✓	✓	✓		✓	✓	✓		✓	✓
Seed/fruit needs					✓			✓		✓	✓	✓	✓	
Environment where planted					✓	✓		✓		✓	✓	✓	✓	
Trials of species	✓		✓		✓	✓		✓		✓	✓	✓	✓	✓
Trials of populations	✓		✓		✓	✓		✓		✓	✓		✓	
Growth and yield of products					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Other benefits					✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
Technical properties			✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
Managerial characters					✓	✓	✓	✓		✓	✓		✓	✓
Conservation	✓				✓			✓	✓	✓	✓	✓	✓	
Breeding														
Published and "grey" literature														
Publications of manuals, monographs, bibliographies, abstract services, reviews		✓	✓				✓	✓		✓	✓		✓	✓
Education and Training							✓	✓	✓	✓	✓			

Arboretum

Herbarium

Xylarium

4. National institutions
   - A. Seed bank
   - B. Forest department
   - C. Research Institute
   - D. University
   - E. International support programme e.g. ANU, CFI, CIFT, NAS, TPI

5. International institutions
   - A. Research institute e.g. CIAT, IITA
   - B. Regional organization e.g. CATIE
   - C. Specialised organization e.g. FAO, ICRAF, UNU

6. Donor agencies e.g. ADB, IDB, WB, bilaterals

7. Recognised information / documentation services e.g. ACRIS, CAB, CATIE, ICRAF

8. IUFRO

Table 3. Planned and completed provenance collections 1978-82 (FAO/IBPGR)

Source: FAO (1981c)

COUNTRY	SPECIES	OBSERVATIONS
Australia	Eucalyptus camaldulensis Dehnh. 1/	11 new provenances collected for project with special emphasis on arid zones.
	E. microtheca F. Muell. 1/	71 seedlots, grouped into 21 "provenance groups" for first-stage evaluation according to climatic conditions.
	Acacia aneura F. Muell. ex Benth.	3 provenances collected by early 1980
Chile	Acacia caven Mol. Atriplex repanda Phil. Prosopis tamarugo F. Philippi Prosopis spp. ("Algarrobo")	May include several species, P. alacaensis, P. siliquastrus, P. chilensis, P. burkartii.
India	Acacia nilotica (L.) Willd. ex Del.	ssp. indica/var. vediana var. jacquemontii var. cupressiformis
	A. senegal (L.) Willd.	"Land Race"
	A. tortilis Hayne	"Land Race"; according to some sources may in fact be A. raddiana Savi.
	Prosopis cineraria (L.) Druce (syn. P. spicigera L.)	
Israel	Acacia albida Del.	
	A. raddiana Savi (syn. A. tortilis (Forsk) Hayne ssp. raddiana (Savi) Brenan)	
	A. tortilis Hayne (syn. A. tortilis (Forsk) Hayne ssp. tortilis (Hayne) Brenan)	
Mexico	Atriplex canescens Prosopis spp. ("Mesquite")	May include several species, P. juliflora; P. glandulosa, P. alba, P. torreyana.
Peru	Prosopis spp. ("Algarrobo")	May include several species, P. chilensis, P. limensis, P. juliflora.
Senegal	Acacia albida Del. var. adansonii A. nilotica (L.) Willd. ex. Del. A. raddiana Savi A. senegal (L.) Willd. A. tortilis Hayne	
Sudan	Acacia nilotica (L.) Willd. ex. Del.	ssp. nilotica ssp. tomentosa ssp. astringens
	Acacia tortilis	
PDR Yemen	Prosopis cineraria (L.) Druce Acacia nilotica (L.) Willd. ex. Del. A. senegal (L.) Willd. A. tortilis Hayne	"Land Race"

1/ Collections completed and distributed for evaluation.

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Table 1.1

Regression of Tropical Moist Forests

SUBCONTINENT	Moist forest climax area	Moist forest actual area	Regression	Regression as percentage of climax area
	.....million hectares.....			
East Africa	25	7	18	72.0
Central Africa	269	149	120	44.6
West Africa	68	19	49	72.0
TOTAL AFRICA	362	175	187	51.6
South America	750	472	278	37.1
Central America	53	34	19	35.8
TOTAL LATIN AMERICA	803	506	297	37.0
Pacific Region	48	36	12	25.0
South East Asia.	302	187	115	38.1
South Asia	85	31	54	63.5
TOTAL ASIA	435	254	181	41.6
TOTAL WORLD	1600	935	665	41.6

Source: Sommer (1976)

Table 1.2 Tropical Lands Recently Undergoing Severe Desertification[1] and Estimated Annual Rates of Desertification[2] (ha x 10^3)

Region	Total Desertified Area	Land Type	Desertification p.a.
Latin America	701,800	Irrigated Land	500
Africa	685,000	Range	18,000
India & Pakistan	170,000	Rain-fed Crop Land	2,000
	1,556,800		20,500

Sources:
1. UN (1978)
2. Dregne (1980)

Table 1.3 Tropical Lands With Potential For Reforestation (ha x 10^3)

Region	Logged Forests (1)	Forest Fallow (2)	Deforested Watersheds (3)	Desertified Arid Lands (4)	All Lands
Latin America	53,487	65,732	27,500	701,800	848,519
Africa	42,848	58,725	3,000	685,000	789,573
Asia	59,847	56,567	56,500	170,000	342,934
	156,182	181,044	87,000	1,556,800	1,981,026

Sources: FAO (1981a), UN (1978)

1. Almost 90% of these are tropical moist forests (TRF + TMDF)
2. All are in tropical moist forest areas (TRF + TMDF)
3. MF. The area of Deforested Watersheds is only a rough estimate. It has been included in 'All Lands'.
4. SAV/ARID.

Table 1.4 Estimated areas by reforestation classes (million hectares)

		Latin America		Africa		Asia	
		Area (mha)		Area (mha)		Area (mha)	
		%	(53 mha)	%	(43 mha)	%	(60 mha)
Logged forest	Line planting	10	5.3	20	8.6	15	9
	Enrichment	-	-	30	12.9	10	6
	Dense planting	15	8	20	8.6	15	9
	Assisted regeneration	5	2.7	5	2.2	30	18
	Conservation	60	31.8	5	2.2	10	6
	Taungya	10	5.3	20	8.6	20	12
			(66 mha)		(59 mha)		(57 mha)
		%		%		%	
Fallow lands	Taungya	5	3.3	5	3.0	30	17.1
	Dense planting	20	13.2	40	23.6	35	20.0
	Assisted regeneration	10	6.6	10	5.9	5	2.9
	Conservation	0	-	20	11.8	0	-
	Social forestry	65	42.9	25	14.8	30	17.1
			(28 mha)		(3 mha)		(57 mha)
		%		%		%	
Watersheds	Dense planting	10	2.8	30	0.9	30	17.1
	Social forestry	10	2.8	20	0.6	50	28.5
	Conservation	80	22.4	50	1.5	20	11.4
			(702 mha)		(685 mha)		(170 mha)
		%		%		%	
Areas of desert-ification	Mountains	10	70.2	4	27.4	5	8.5
	Run off irrigation	0	-	5	34.3	5	8.5
	Full irrigation	0	-	1	6.9	5	8.5
	Social forestry	0	-	20	137.0	60	102.0
	Rain fed plantations	20	140.4	15	102.8	0	-
	Dune planting	0	-	5	34.3	5	8.5
	Conservation	70	491.4	50	342.5	20	34.0

Areas of the Tropics with Fuelwood Deficits, 1980 and 2000

			Deficit (million m^3)		& Equivalent Plantation Area (ha x 10^3)	
Africa				1980		2000
Acute Scarcity	(i)	Arid areas	-6	1200	-10	2000
	(ii)	Montane/island areas	-40	8000	-70	14000
Deficit	(i)	Savanna areas	-66	6600	-185	18500
	(ii)	High forest	-		-5	250
			-112	15800	-270	34750
Latin America						
Acute Scarcity	(i)	Andean plateau	-2	400	-4	800
	(ii)	Arid west S. America & densely populated areas	-9	1800	-15	3000
Deficit	(i)	Populated Semi-Arid areas & Andean zone	-36	7200	-117	23400
			-47	9400	-136	27200
Asia						
Acute Scarcity	(i)	Montane areas (mainly Himalayas)	-38	7600	-60	12000
Deficit	(i)	Plains (mainly Indo-Ganges)	-90	9000	-146	14600
	(ii)	Plains & Islands in S.E. Asia	-120	6000	-265	13200
	(iii)	Other areas with fast growing populations	-		-48	3200
			-248	22600	-519	43000
		ALL TROPICS	-407	47800	-925	104950

Source: FAO (1981b) and Wood *et al.* (1982)

N.B. Areas of fuelwood plantations equivalent to the above deficits have been calculated by the authors using assumptions as to practical productivity in different areas.

Appendix 3

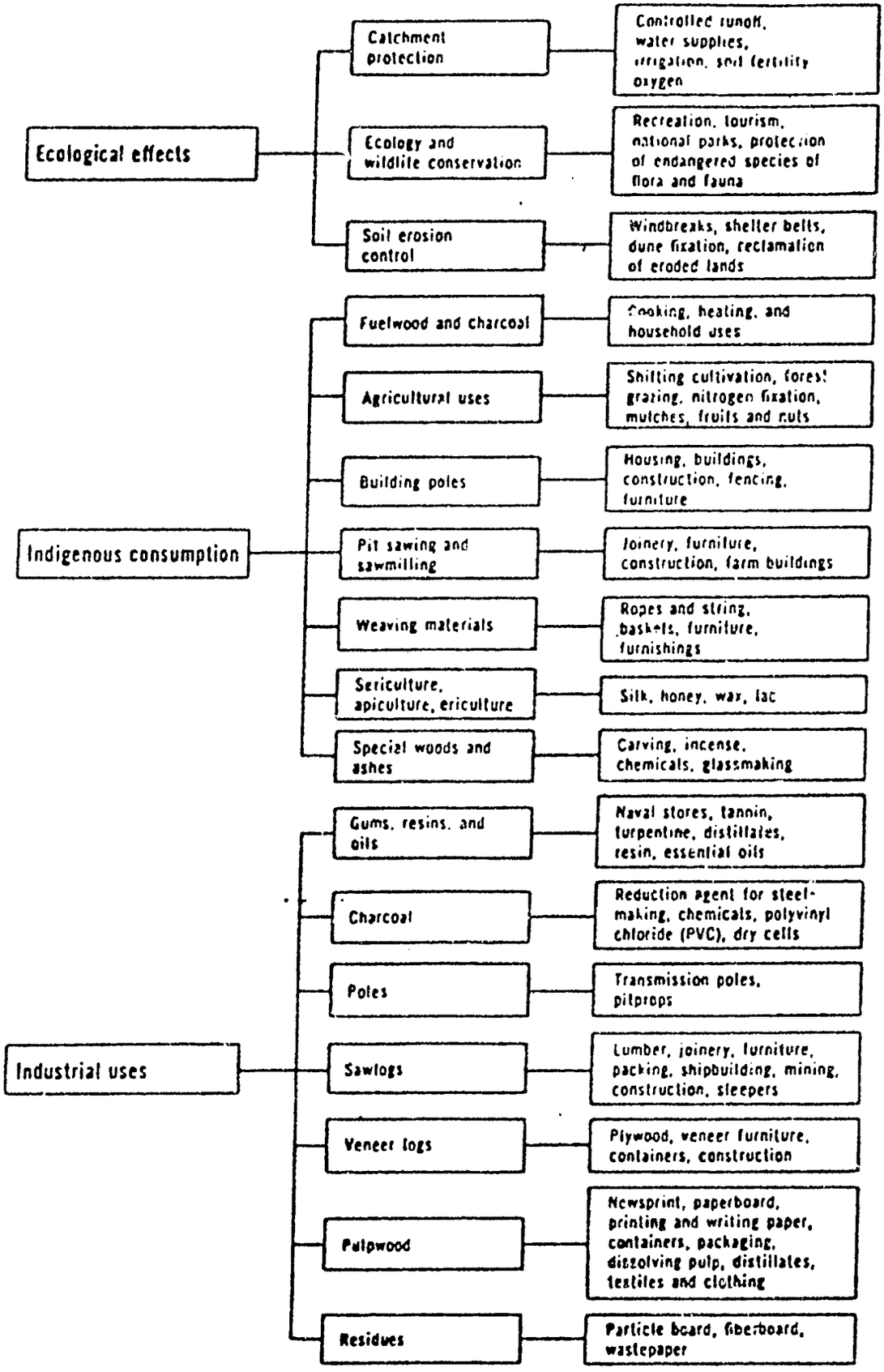
Areas of Tropical Forest Plantations 1980
(ha x 10^3)

	All Plantations	Industrial Plantations	Industrial Hardwood Plantations	Industrial Hardwood Plantations in the Humid Tropics	High Grade Industrial Hardwood Plantations in the Humid Tropics	Non-Industrial Plantations	Average Rate of Afforestation 1976-80 per annum (All Ptns)	Average Rate of Afforestation 1981-85 per annum (Projected)
Africa	1,779	996	456	345	203	783	93	126
Asia	5,111	3,502	2,896	1,175	1,103	1,609	419	438
Latin America	4,620	2,568	997	997	66	2,052	410	535
All Tropics	11,510	7,066	4,349	2,517	1,372	4,444	922	1,099

Source: FAO (1981a) and Wood *et al*. (1982)

The Role of Forests

Appendix 4



Source: World Bank (1978)

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FORESTRY RESEARCH NEEDS IN DEVELOPING COUNTRIES

(Source: World Bank and FAO, 1981)

This is an 'indicative' and 'non-comprehensive' listing of research priorities. The topics identified are given as examples of the likely main areas of concern in the coming decade.

(i) Forestry in relation to agriculture and rural development

(A) Sociological and institutional research

1. Knowledge of the natural environment by forest societies
2. Data on the infrastructure of human societies in the forests
3. Determination of perceived role of trees and forests in rural welfare
4. Origin and solution of conflicts for land
5. Determination of acceptability and response to innovative systems
6. Definition and testing of incentives to incorporate trees
7. Guidelines for project preparation
8. Extension methods
9. Institutional aspects
10. Economic returns from alternative farming systems incorporating trees

(B) Farming systems using trees

1. Effects and systems of intercropping, including animals; identification of potential agro-forest combinations
2. Mycorrhizal and other microbiological relations
3. Mulching effects on soil chemistry and structure
4. Impact on soil fertility of burning manure and crop residues
5. Ground preparation (especially arid and degraded sites)
6. Soil nutrients (especially nitrogen and phosphorus, salinity)
7. Moisture relations
8. Irrigation
9. Sand dune stabilization
10. Shelterbelts
11. Choice of species and provenance
12. Seed collection, storage, testing, zonation, certification
13. Silvicultural treatment (coppicing, pollarding)
14. Vegetative propagation
15. Potential of tree breeding

(C) Watersheds (catchments) and range management

1. Farming systems appropriate for upland areas
2. Alternatives for fodder production on and off farms
3. Improvement of alpine pasture lands
4. Impact of land use on water yield, quality and timing
5. Impact on stream flow patterns of shifting cultivation
6. Cost and effectiveness of watershed management
7. Determination of run-off rates and sediment yield
8. Carrying capacity and grazing control to maximize range production
9. Least cost approaches to range improvement
10. Improvement of savannah range lands
11. Improvement of arid zone range lands

(D) Wildlife in relation to rural welfare

1. Ecological monitoring of animal habitats
2. Animal population dynamics
3. Socioeconomic aspects of the place of animal products in rural life

(ii) Forestry in relation to energy production and use

(A) Silviculture of biomass/fuelwood species and systems

1. Choice of species and provenance
2. Tree breeding
3. Seed research
4. Vegetative propagation, tissue culture, cell genetics
5. Ground preparation methods
6. Silvicultural methods
7. Pests and diseases
8. Fire control systems
9. Effect of repeated cropping on soil

(B) Yield, harvesting and properties

1. Yield assessment
2. Harvesting and transport methods
3. Density and calorific value
4. Chemical content

(C) Industrial research related to village technology

1. Improved stove and crematorium design
2. Improved fuelwood and charcoal preparation methods
3. Small-scale crop processors, generators, wood preservation
4. Use of residues

(D) Comparison with alternative fuels (social, technical and economic efficiency)

(E) Wood-based derivatives

1. Pyrolysis
2. Gasification
3. Pelletization
4. Methanol, ethanol and liquid fuel technology

(iii) Management and conservation of existing resources (mainly natural forests)

(A) Resource survey

1. Land use planning methods
2. Soil and land use survey and evaluation
3. Land mapping according to the ecological potential to sustain population.
4. Monitoring changes of forest area
5. Inventories of accessible natural forest

(B) Conservation

1. Methods to identify and quantify unique biotic associations
2. Methods to conserve genetic resources and ecosystems
3. Monitoring changes within ecosystems and species
4. Policy and legal aspects of conservation
5. Underlying ecological and biological processes

(C) Silvicultural systems for natural forests

1. Biological limitations to the transformation of tropical forest ecosystems
2. Impact of different types of utilization
3. Natural regenaration
4. Artificial enrichment

(D) Whole tree use

1. Harvesting
2. Utilization
3. Effects on site

(E) Use and marketing of secondary species

1. Inventory
2. Properties
3. Information and market intelligence

(F) Wood preservation

(iv) Industrial forestry

(A) Silviculture and management

1. Choice of species and provenance
2. Seed collection, storage, testing, zonation, certification
3. Vegetative propagation, tissue culture, cell genetics
4. Tree breeding
5. Ground preparation
6. Spacing, weeding, thinning, pruning
7. Fertilization and soil nutrients
8. Mycorrhizal and microbial relations
9. Integrated pest management
10. Fire control systems

(B) Wood properties

1. Anatomical
2. Chemical
3. Physical/mechanical
4. Pulp, paper, boards
5. Composites

AFRICA	Deforestation	Regeneration	Plantations	Watersheds	Environmental	Fuelwood	Fodder
Angola						●	
Botswana	C		●		●	●	●
Burundi				●		●	
Cameroon	D	●		●		●	
Cen.Afr.Republic		●				●	
Chad	C		●		●	●	
Congo (People's Republic of)			●				
Benin	C		●		●	●	
Equat. Guinea		●				●	
Ethiopia	C		●	●	●	●	●
Gabon	D	●	●				
Gambia			●		●	●	
Ghana	C	●	●		●	●	
Guinea						●	
Guinea-Bissau							
Ivory Coast	C	●	●			●	
Kenya	E	●	●		●	●	●
Liberia	D	●	●				
Madagascar	C	●	●	●		●	
Malawi			●		●	●	
Mali	C				●	●	●
Mauritania							
Mauritius	C			●	●		
Mozambique					●	●	●
Niger	C				●	●	●
Nigeria	C	●	●	●	●	●	●
Zimbabwe			●	●	●	●	●
Rwanda	D		●	●		●	
Senegal						●	
Sierra Leone	D	●	●			●	●
Somalia	E				●	●	●
Sudan	E		●		●	●	●
Tanzania	E		●		●	●	●
Togo						●	●
Uganda	C	●	●			●	●
Upper Volta	C				●	●	●
Zaire		●				●	
Zambia			●			●	

LATIN AMERICA	Deforestation	Regeneration	Plantations	Watersheds	Environmental	Fuelwood	Fodder
Bolivia				●		●	
Brazil	D	●	●		●	●	●
Belize	D		●				
Colombia	D	●	●	●		●	
Costa Rica	E	●	●			●	●
Cuba	C	●	●			●	
Domin. Republic			●			●	
Ecuador	D	●	●	●		●	
El Salvador						●	
French Guyana		●					
Guatemala	C	●	●	●		●	
Guyana		●					
Haiti	C		●			●	
Honduras	D			●			
Jamaica	D		●	●			
Mexico	E	●	●	●	●	●	●
Nicaragua	C		●	●		●	
Panama	C	●		●			
Paraguay			●			●	
Peru	D	●	●	●		●	
Puerto Rico	D	●					
Surinam		●	●				
Trinidad & Tobago	C	●	●	●	●	●	
Venezuela	E	●	●	●			

ASIA	Deforestation	Regeneration	Plantations	Watersheds	Environmental	Fuelwood	Fodder
Bangladesh	C	●	●	●	●	●	●
Bhutan				●			
Brunei		●					
Burma		●	●			●	
Cambodia		●				●	
India	C	●	●	●	●	●	●
Indonesia	E	●	●	●		●	
Laos							
Malaysia	E	●	●	●			
Nepal	E		●	●		●	●
Pakistan	E	●	●	●		●	●
Papua New Guinea	D	●	●	●		●	
Philippines	C	●	●	●		●	
Sri Lanka	C		●	●	●	●	
Thailand	C	●	●	●		●	
Vietnam			●	●		●	

National Priorities For Reforestation

Some indication of the urgency of action in particular countries is given by the Deforestation rating: C (Critical) E (Endemic) or D (Developing) [Grainger (1980)]

N.B. Only priorities are highlighted here. Regeneration refers to natural forests in a degraded condition. Plantations to intensive timber plantations. Watersheds to reforestation of deforested watersheds. Environmental to afforestation of severely degraded/desertified arid lands. Fuelwood and Fodder to the establishment of plantations of multi-purpose trees producing fuelwood and fodder respectively (or both).

Source: Wood et al. (1982)

Definitions of terms associated with social forestry
(Based on Burley and Wood, 1983)

Social forestry can legitimately be applied to almost any type of forestry since some social benefits (employment, export earnings, etc.) may be obtained from even the most commercialised and industrialised production system. It is more generally applied, however, to enterprises conducted at a smaller scale, in which industrial timber production is usually not the sole objective and in which the benefits to the community are more tangible than such shadow-priced values.

Social forestry includes community forestry in which the planning, establishment, management, harvesting and marketing of forests, trees and their products are carried out either by the rural community members themselves or by a State Forestry Service on their behalf, with the proceeds going to benefit the community rather than individuals. It also includes farm forestry in which individual land owners (encouraged by training, extension programmes, demonstrations and incentives) plant trees in farm woodlots, contour or boundary lines, or intermixed with agricultural crops.

Strip planting (referred to in India as extension forestry) is also included in social forestry and refers most commonly to the planting of trees on the sides of roads, railways and canals.

Recreation and amenity forestry refers to the creation and maintenance of trees and forests for specialised recreational use or improvement of local amenity. Their value is difficult to quantify and they are more common in more developed economies where they have clear social benefits.

Rehabilitation forestry concerns degraded forests and soils and it may have both direct productive benefits and indirect social benefits (e.g. releasing more land for agriculture, renewing supplies for local industry, improving dry season grazing, reducing soil loss, etc.)

Compensatory plantations may improve conservation of natural forest with benefits for gene conservation, supplies of medicines, protection, etc.

All of these eight terms may be collectively called social forestry.

Agroforestry, embracing agrisilviculture and perhaps better called "land husbandry" (Stewart, 1981), is a collective term for systems of land management and technologies that incorporate mixtures of annual and perennial crops and animals (which may range from insects to mammals) in either space or time for sustained production with management practices that are compatible with local culture. (For further definitions of agroforestry see ICRAF, 1979; Anon., 1982; Lundgren, 1982.)

It is most unfortunate that in many countries the term has been taken to be synonymous with either social forestry or farm forestry (e.g. India; see National Commission on Agriculture, 1976; Joshi, 1982). Agroforestry is only one set of land management systems parallel with pure agricultural or pure silvicultural systems according to whether it is appropriate or inappropriate to local environmental and social conditions and it may or may not be used in social forestry.

Selection of species for reforestation in Honduras by Bauer (1982)

ESPECIE	FAMILIA	Aptitud para las principales zonas de vida (1)								Calidad de la madera (2)				
		bh-T	bs-T	bms-T	bmh-P	bh-P	bs-P	bh-MB	bmh-MB	Lc	As	Po	Ch	Pu
Acacia auriculiformis	*Leguminosae*	x	x		x					+	o			+
Albizia falcata	*Leguminosae*	x			x						o		+	+
Albizia lebbek	*Leguminosae*	x	x	x	x	x	x			+	+			
Alnus acuminata	*Betulaceae*				x			x	x	+	+		+	+
Azadirachta indica	*Meliaceae*		x	x						+	+	+		
Calliandra calothyrsus	*Leguminosae*	x	x		x	x				+	+			
Casuarina equisetifolia	*Casuarinaceae*	x	x	x	x	x	x			++	+	+		+
Cordia alliodora	*Boraginaceae*	x			x	x				+	++	·	+	
Enterolobium cyclocarpum	*Leguminosae*	x	x		x	x				o	+		+	
Eucalyptus camaldulensis	*Myrtaceae*		x	x		x	x			++	o	+		o
Eucalyptus citriodora	*Myrtaceae*		x			x				++	+	+		o
Eucalyptus grandis	*Myrtaceae*				x	x		x	x	++	o	+	o	+
Eucalyptus robusta	*Myrtaceae*		x			x				?+	+	+		o
Eucalyptus saligna	*Myrtaceae*				x	x		x	x	+	+	+	o	+
Eucalyptus tereticornis	*Myrtaceae*		x	x		x	x			+	+	o		o
Gliricidia sepium	*Leguminosae*	x	x	x	x	x	x			++	+	+		
Gmelina arborea	*Verbenaceae*	x	x		x	x				o	+		+	+
Grevillea robusta	*Proteaceae*				x	x	x	x		+	+		+	
Guazuma ulmifolia	*Sterculiaceae*	x	x	x	x	x				++	+			
Inga vera	*Leguminosae*	x	x		x	x				+	o			
Leucaena leucocephala	*Leguminosae*	x	x	x	x					++	o	+		+
Pinus caribaea var hondurensis	*Pinaceae*	x	x		x	x				o	+	+		+
Pinus maximinoi	*Pinaceae*				x	x		x		o	+			?+
Pinus oocarpa	*Pinaceae*		x		x	x	x	x		+	+	+		+
Sesbania grandiflora	*Leguminosae*	x	x		x					o				+
Swietenia macrophylla	*Meliaceae*	x	x		x	x					++		+	
Tabebuia pentaphylla	*Bignoniaceae*	x	x		x	x				+	+		+	
Tectona grandis	*Verbenaceae*	x	x		x	x				+	++	+	+	
Terminalia ivorensis	*Combretaceae*	x			x						+		+	o
Terminalia superba	*Combretaceae*	x			x						+		+	o

(1) Véanse las observaciones sobre el # 20 del formato, página

(2) Lc = Leña y/o carbón
As = Aserrío
Po = Postes
Ch = Chapas, láminas
Pu = Pulpa para papel

++ = muy buena
+ = buena
o = regular, con limitaciones

Species tested in Costa Rica

(Source: Camacho, 1981)

NOMBRE COMUN	NOMBRE TECNICO	FAMILIA BOTANICA
Albizia	Albizzia falcataria (L.) Fosberg.	Mimosaceae
Jaul	Alnus acuminata (HBK) O. Ktze.	Betulaceae
Espavel	Anacardium excelsum (Bert y Balb) Skeels	Anacardiaceae
Ron-Ron	Astronium graveolens Jacquin	Anacardiaceae
Pochote	Bombacopsis quinatum (Jacq) Dugand	Bombacaceae
Jiñocuabe	Bursera simaruba (L.) Sarg.	Anacardiaceae
María	Calophyllum brasiliense Camb.	Guttiferae
Cedro Macho	Carapa guianensis Aubl	Meliaceae
Casuarina	Casuarina equisetifolia L.	Casuarinaceae
Cedro amargo	Cedrela mexicana Roem	Meliaceae
Cedro dulce	Cedrela tonduzii C.DC.	Meliaceae
Ceiba	Ceiba pentandra (L.) Goerth	Bombacaceae
Laurel	Cordia alliodora (Ruíz y Pavón) Cham	Boraginaceae
Laurel venezolano	Cordia apurensis	Boraginaceae
Ciprés	Cupressus lusitanica Mill	Cupressaceae
Ciprés macrocarpa	Cupressus macrocarpa (Gord) Hartw.	Cupressaceae
Primavera	Cybistax donnell-smithii (Rose) Seibert	Bignoniaceae
Cocobola	Dalbergia retusa Hensl.	Caesalpiniaceae
Malinche	Delonix regia (Bojer) Raf.	Caesalpiniaceae
Papayillo	Didymopanax morototoni (Aubl) Dec y Planch	Araliaceae
Guachipelín	Diphysa robinioides Benth	Papilionaceae
Chilemuelo	Drymis granadensis L.	Winteraceae
Guanacaste	Enterolobium cyclocarpum (Jack) Griseb	Mimosaceae
Eucalypto	Eucalyptus deglupta Blume	Myrtaceae
Eucalypto	Eucalyptus globulus Labill	Myrtaceae
Eucalypto	Eucalyptus grandis Hillex Maiden	Myrtaceae

NOMBRE COMUN	NOMBRE TECNICO	FAMILIA BOTANICA
Eucalypto	Eucalyptus maculata Hook	Myrtaceae
Eucalypto	Eucalyptus saligna Smith	Myrtaceae
Manzana Rosa	Eugenia jambos Linn.	Rosaceae
Madero Negro	Gliricidia sepium (Jack) Stend	Papilionaceae
Melina	Gmelina arborea Roxb	Verbenaceae
Grevilia	Grevillea robusta A. Cunn	Proteaceae
Guácimo	Guazuma ulmifolia Lum.	Sterculiaceae
Guapinol	Hymenaea courbaril L.	Caesalpiniaceae
Jacaranda	Jacaranda copaia (Aubl) D. Don	Bignoniaceae
Jacaranda	Jacadanda mimosifolia D. Don	Bignoniaceae
Nogal	Juglans o anchanum Standl. y Will.	Juglandaceae
Ipil-Ipil	Leucaena leucocephala (Lam.) de Wit.	Mimosaceae
Manú	Minquartia quianensis Aubl	Olacaceae
Tobús	Montanoa dumicola Klatt	Compositae
Bálsamo	Myroxylon balsamum (L.) Harms	Papilionaceae
Gavilán	Pentaclethra macroloba (Wild) Ktze).	Mimosaceae
Pino	Pinus caribaea var. caribaea Barr y Golf.	Pinaceae
Pino engelmannii	Pinus engelmannii Carr.	Pinaceae
Pino oocarpa	Pinus oocarpa Schiede.	Pinaceae
Pino patula	Pinus patula Schl. y Cham.	Pinaceae
Cashá	Pithecolobium pseudo-tamarindus (Britt) Standl.	Mimosaceae
Cenízaro	Pithecolobium saman (Jack) Benth	Mimosaceae
Cristóbal	Platimyscium pleiostachyum Donn Sm.	Papili naceae
Cristóbal	Platimyscium pinnatum (Jack) Dugand	Papilionaceae
Cipresillo	Podocarpus oleifolius Don.	Podocarpaceae
Quibra	Pseudolmedia spurea (SW.)Grisebach.	Moraceae
Encino Blanco	Quercus seemannii sin. corrugata Hooker	Fagaceae
Gallinazo	Schizolobium parahybum (Vell) Blake	Caesalpiniaceae
Panamá	Sterculia apetala (Jack) Karst.	Sterculiaceae
Vainillo	Stryphnodendron excelsum Harms.	Mimosaceae

NOMBRE COMUN	NOMBRE TECNICO	FAMILIA BOTANICA
Come Negro	Swartzia panamensis Benth	Caesalpiniaceae
Caoba	Swietenia humilis Zucc.	Meliaceae
Caoba	Swietenia macrophylla G. King	Meliaceae
Corteza Amarilla	Tabebuia chrysantha (Jacq) Nichol.	Bignoniaceae
Roble Negro	Tabebuia palmeri Rose.	Bignoniaceae
Roble Sabana	Tabebuia rosea (vertol) DC.	Bignoniaceae
Teca	Tectona grandis Linn.	Verbenaceae
Amarillón	Terminalia amazonia (Gmel.) Exell.	Combretaceae
	Terminalia ivorensis A. Chev.	Combretaceae
Surá	Terminalia lucida Hoffm.	Combretaceae
Cedro Australiano	Toona ciliata M. Roem	Meliaceae
Capulín Rojo	Trichosperma mexicanum (DC.) Baill	Tiliaceae

List of Recommended Species of Trees and Shrubs for Nepal Community Forestry Development Project

Source: FAO/IBRD (1978)

Glossary of abbreviations on the use of tree species.

Capital letters = main use

Small letters = potential use

E	e	edible
F	f	firewood
G	g	gum/resin/tanning/lac/silk
H	h	hedges
I	i	small timber, implements
L	l	lopping for animal fodder (or breeding)
M	m	medicinal/religious material
O	o	oil seed
R	r	fibre/ropes
S	s	soil improvement/erosion control
T	t	timber

Distribution of species

X	mainly occurring in the ecological range
x	eventually occurring in the ecological range
(N)	new species to be introduced into Nepal

Latin Name	1 - Tree 2 - Small tree 3 - Shrub	Nepali Name (English name)	Ecology: Upper Tropical	Sub-tropical	Temperate	Sub-alpine	Dry sites	Rich sites	Utilization (see legend)
Abies spp.	1	Bunga salla			x	X	X	X	fT
Acer spp.	1, 2	Phangaru		x	x	X		X	LFt
Aesculus indica	1	Lampatte phangaru			X				LF
Albizzia mollis	1	Siris	x	X					Lft
Alnus nepalensis	1	Utis		X	X			X	LFts
Artocarpus lakoocha	1	Badahar	X	x				x	ELIf
Arundinaria spp.	(3)	Nigalo (mountain bamboo)			X	x			LIS
Bassia butyracea	1	Chiuri	X	x				x	EfION
Bassia latifolia	2	Mahuwa						x	EfOIM
Bauhinia purpurea	2	Tanki	X	x			X		LiFgS
Bauhinia variegata	2	Koiralo	X	x			X		ELFigS
Betula utilis	2	Bhuja patra				X	X		LFImrSt
Brassaiopsis alpina					x	X			Lf
Brassaiopsis nainla		Chuletro		X	x				Lf
Buchanania latifolia	2		X				X		EgS
Buddleia spp.		Dhurse		x	X				L
Butea frondosa	2	Palash	X					X	LfIRMGS
Corylus colurna	2	(hazelnut)				X		X	EftI
Corylus avellana (N)	3	(hazelnut)			x	X		X	EfltI
Castanea sativa (N)	1	(chestnut)		x	X				EFlT
Castanopsis histrix	1	Patle katus		X	X		X	x	elFTs
Castanopsis indica	1	Dalne katus		X			X	x	ElFTs
Castanopsis tribuloides	1	Musuri katus		X	x		X	x	elFTs
Cedrela toona	1		X	x				X	FT
Cedrus deodara	1.	Debdar			X		X	x	lfT
Choerospondias axillaris	1	Lapsi	X	X	x		x	X	Etf
Cupressus torulosa	1	Dhupi		x	X	x	X		FlT
Dendrocalamus hamiltonii	(2)	Bans (bamboo)	X	X					elfIMS
Elaeocarpus spp.	1		X	x					K
Erythrina arborescens	2	Phaledo	x	X			x	X	LFS
Eugenia jambolana	2		X	x				X	EF
Euphorbia spp.	3	Sihundi, sija	X	X	x		X	x	Hs
Euria cerasifolia		Pate		X					L
Ficus elavata		Borulo godilo	x	X				X	L
Ficus glaberrima		Pakhuri	X	x				X	L
Ficus nemoralis	1	Dudhilo	x	X	x			X	L
Ficus roxburghii		Nemarro	x	X	x			X	LE
Ficus semicordata		Khannim	x	X				X	LE
Fraxinus spp.	1	Lankuri		X	X			X	LTF

Latin Name	1 - Tree 2 - Small tree 3 - Shrub	Nepali Name (English name)	Ecology: Upper-tropical	Sub-tropical	Temperate	Sub-alpine	Dry sites	Rich sites	Utilization (see legend)
Grewia spp.	1, 3		x	X			X	X	EFLRIS
Hippophae salicifolia	3	Armalito		x	X		X		ERS
Ilex spp.	2	Bhokre		x	X		x	X	L
Juglans regia	1	Okhar		x	X	x		X	ETFM
Juniperus spp.	1, 3				x	X	X		tFS
Larix spp.	1					X	X	x	Tfs
Litsea citrata	2	Sil timur		X	x		X	x	elFM
Litsea polyantha	2	Kutmiro	X	x			x	X	LFt
Machilus odorotissima	1	Bhate kaulo	x	X					LF
Melia azedarach							x	X	Ft
Michelia champaca	1	Champ, Tsampo	X	X				X	LTMo
Michelia dottsopa	1	Sated champ		X	x			X	LTF
Moringa pterygosperma (N)	2		X	x			x	X	ELDa
Morus alba	1	Oeshi kimbu	x	X					ELfG
Morus nigra	1	Kimbu	X	x					ELfG
Mucuna macrocarpa	1	Baldyangro	X	x					L
Olea cuspidata	2, 3			x	X		X		LI(o)
Picea spp.	1				x	X	x	X	Tf
Pistacia integerrima	3					X	X		(e)Ifs
Pieris ovalifolia	2		x	X			X		fS
Pinus excelsa	1	Tingre sallo			X	X	x	X	fTg
Pinus roxburghii	1	Aule sallo	x	X			X	x	fTg
Pinus gerardiana	2	(Chilgoza)			X	X	X		EFS
Populus ciliata	1	Bhote pipal				X	x	X	tFS
Populus euphratica (N)	1, 2		x	x	x	X	X	x	tIFS
Premna barbata	2	Ginderi (?)		X			X		Lf
Princepia utilis	3	Dhatela		x	X		X		CSh
Prunus cerasoides	1	Painyu		X	x			X	LFt
Prunus padus	2	Dur kaphal			X	x			Lf
Pyracantha crenulata	3	Ghangaru		x	X		X		H
Pyrus pashya	1	Mayel, Naspati		x	X			X	Eft
Quercus incana	1, 2	Banj		X	x		X	x	LtF
Quercus lamellosa	1, 2	Falant		X	x		X	x	LtF
Quercus lanata	1, 2	Banj		X	x		X	x	LtF
Quercus semecarpifolia	1, 2	Khasru			X	x	X	x	LtF
Rhododendron spp.	2, 3				x	X			F
Rhus javanica	2, 3	Bhakimlo		X	x				Lf
Rhus succedana	2, 3	Bhalayo		x	X		X	x	LfG
Salamalia malabarica	1	Simal	X	x				X	TFM
Salix spp.	1, 3	Bains		x	X	X	x	X	Lif

Latin Name	1 - Tree 2 - Small tree 3 - Shrub	Nepali Name (English name)	Ecology: Upper-Tropical	Sub-tropical	Temperate	Sub-alpine	Dry sites	Rich sites	Utilization (see legend)
Saurauja nepalensis	1	Gogan		X					L
Schima wallichii	1	Chilaune		X				X	LItF
Schleicheria trijuga	1		X				x	X	EoGIFts
Shorea robusta	1	Sal	X				x	X	TlFm
Sorbus spp.	1, 2	Maile			x	X			LtF
Symplocos crataegoides	1	Lodh		x	X				LF
Tsuga dumosa	1				.X	x	X	X	Tif
Viburnum coriaceum	3	Pitho char		x	X				L
Vitex negundo	2, 3				X				lIh
Woodfordia floribunda	2, 3					X	X		fS
Xylosma controversum	2	Maidallo		X					L
Ziziphus jujuba	2	Bayer, Jujube	x	X			X		ELHtFSmg

Species or genera recommended by Koivisto (1979) for Asia Pacific region

A. Basically wood production species (known in the region)

Conifers	Pinus caribaea P kesiya P. merkusii P. oocarpa	Wetter, hotter tropics
	P. nigra var. maritima P. eldarica P. griffithii P. roxburghii	drier, West Africa
	P. densiflora P. koraiensis	Cooler, East Asia
	P. elliottii P. patula P. radiata	Cooler, higher altitudes
	Agathis dammara A. macrophylla A. obtusa A. robusta	
	Araucaria cunninghamii A. hunsteinii	
	Cunninghamia lanceolata	
Hardwoods	Albizia falcataria Gmelina arborea Eucalyptus camaldulensis E. deglupta E. grandis E. saligna E. tereticornis	
	Swietenia macrophylla	
	Tectona grandis	

B. Multipurpose forestry species (known in the region)

Acacia auriculiformis
A. catechu
A. confusa
A. dealbata
A. decurrens
A. mearnsii
A. melanoxylon

Dalbergia sissoo
Leucaena leucocephala
Terminalia spp.

C. Potential species (not widely tested in the region)

Aleurites spp.
Artocarpus utilis
Ceratonia siliqua
Durio zibethinus
Dyera costulata
Inocarpus edulis
Mangifera minor
Morus spp.
Parkia spp.
Pentadesma spp.
Pithecolobium spp.
Prosopis spp.
Tamarindus indica

D. Agricultural plantation tree species with secondary forestry uses

Cocos nucifera
Hevea brasiliensis

E. Bamboos

Bambusa arundinacea
Dendrocalamus strictus
Melocanna spp.
Oxytenanthera spp.
Phyllostachys edulis

Species for African savannas

(Source: Laurie, 1974)

Climatic type 1. Desert - omitted from consideration

2. Subdesert

Acacia albida
A. nilotica
A. senegal
Azadirachta indica
Conocarpus lancifolius
Dalbergia sissoo
Eucalyptus camaldulensis
E. microtheca
E. tereticornis
Prosopis chilensis

3. Dry tropical

Anacardium occidentale
Azadirachta indica
Callitris spp.
Cassia siamea
Dalbergia sissoo
Eucalyptus camaldulensis
E. citriodora
E. microtheca
E. tereticornis

4. Semihumid tropical

Acrocarpus fraxinifolius
Araucaria cunninghamii
Callitris calcarata
C. glauca
C. intratropica
C. robusta
Cassia siamea
Eucalyptus camaldulensis
E. citriodora
E. cloeziana
E. grandis
E. pilularis
E. propinqua
E. saligna
E. tereticornis
Pinus caribaea
P. kesiya
P. merkusii
P. cocarpa

5. Humid tropical and equatorial

Acrocarpus fraxinifolius
Araucaria cunninghamii
Chlorophora excelsa
C. regia
Eucalyptus citriodora
E. cloeziana
E. deglupta
E. grandis
E. propinqua
Gmelina arborea
Pinus caribaea
Pinus kesiya
Tectona grandis

(b) Hardwood species for lowland tropics recommended by Fenton et al. (1977)

Annotated bibliographies have been prepared for the following tropical hardwood species:-

1. *Acacia auriculiformis*
2. *Albizia falcataria*
3. *Anthocephalus chinensis*
4. *Campnosperma brevipetiolata*
5. *Cedrela odorata*
6. *Cordia alliodora*
7. *Eucalyptus alba*
8. *Eucalyptus deglupta*
9. *Eucalyptus torelliana*
10. *Eucalyptus urophylla* - not formally named
11. *Grevillea robusta*
12. *Melaleuca leucodendron*
13. *Maesopsis eminii*
14. *Octomeles sumatrana*
15. *Terminalia brassii*
16. *Terminalia calamansanai*
17. *Terminalia catappa*
18. *Terminalia ivorensis*
19. *Terminalia superba*
20. *Toona ciliata*
21. *Tetrameles nudiflora*
22. *Eucalyptus tereticornis*
23. *Eucalyptus robusta*

Plants for arid and semi-arid lands

(Source Adams et al., 1978)

2.1 THE SELECTION OF PLANTS FOR CENTRAL SAUDI ARABIA

The purpose of the following lists of plants is to define a range of species, based on one phytogeographical region. A list of possible plant introductions is also given that might be considered provided soil conditions, climate and water availability are not limiting. Whenever a final plant list is compiled, it is essential that all the environmental factors and the restrictions they might impose are analysed beforehand.

Phytogeographical zone: Saharo-Sindian

INDIGENOUS TREES

Acacia albida
A. arabica
A. gerradii
A. giraffae
A. gummifera
A. mellifera
A. nilotica
A. raddiana
A. senegal
A. seyal
A. tortilis
Albizzia julibrissim
A. lebbek
Eugenia jambolana
Eleagnus angustifolia
Ficus bengalensis
F. benjamina
F. retusa nitida
F. religiosa
Maerua crassifolia
Melia azedarach
Moringa aptera
Phoenix dactylifera
Pistacia atlantica
Prosopis cinerea
P. juliflora
P. spicigera
P. stephaniana
Salvadora oleoides
S. persica
Schinus terebinthifolius
Tamarix aphylla
T. articulata
T. gallica
T. ramosissima
T. passerinoides
T. stricta
Terminalia catappa
T. bellerica
Thespesia populnea
Vitex agnus-castus
Zizyphus jujuba
Z. lotus
Z. mauretania
Z. spina-christi

TREE INTRODUCTIONS

Acacia cyanophylla
A. farnesiana
Albizzia chinensis
Anona cherimifolia
Brachychiton acerifolia
B. gregorii
Callistemon citrinus
C. lanceolatus
Casuarina cristata
C. cunninghamiana
C. equisetifolia
C. glauca
C. lehmanii
C. stricta
C. torrulosa
Cupressus arizonica
Delonix regia
Duranta plumieri
Eucalyptus astringens
E. brockwayi
E. camaldulensis
E. campaspe
E. cladocalyx
E. coolabah
E. forrestiana
E. gomphocephala
E. intertexta
E. kruscana
E. landsdowneana
E. largiflorens
E. longicornis
E. microtheca
E. patellaris
E. pimpiniana
E. robusta
E. redunea
E. salubris
E. sargentii
E. spathulata
E. stricklandii
E. transcontinentalis
E. woodwardii
Ficus carica
F. sycomorus
Grevillea robusta
Hyphaene thebaica
Jacaranda mimosiaefolia
Melaleuca pauperifolia
Parkinsonia aculeata
Prosopis chilensis
P. tamarugo
Schinus molle
Washingtonia filifera

INDIGENOUS SHRUBS AND GROUND COVER PLANTS

Achillea fragrantissima
A. santolina
Anabasis articulata
A. setifera
Artemisia herba-alba
A. monosperma
Atriplex halimus
Balanites aegyptiaca
Caesalpinia gilliesii
C. pulcherrima
Calligonum arborescens
C. comosum
Calotropis procera
Capparis decidua
C. spinosa
Carex physodes
Cassia lanceolata
C. obovata
Clerodendrum inerme
Coronilla juncea
Cyperus conglomeratus
C. laevigatus
Dodonea viscosa
Ephedra alata
E. distachya
Euphorbia ceratoides
E. guyonianum
E. mauritanica
E. nereifolia
Genista saharae
Haloxylon aphyllum
H. articulatum
H. persicum
H. salicornicum
Heliotropium dasycarpum
Ipomoea pes-capre
Iris sisyrinchium
Lagerstroemia indica
Launea spinosa
Leptaderia pyrotechnica
Limoniastrum guyonianum
L. monopetalum
Lycium arabicum
L. persicum
Monsonia nivea
Nerium oleander
Phlomis brachyodon
Plumeria acutifolia
P. rubra
Punica granatum
Retama raetam
Rhanterium epapposum

Rhus oxyacantha
Salsola tetrandra
Salvia aegyptiaca
S. lanigera
Sesbania aegyptiaca
Siedlitzia rosmarinus
Tecoma stans
Tecomaria capensis
Thevetia nereifolia
Ziila macroptera
Z. spinosa
Zygophyllum coccineum
Z. dumosum

SHRUB AND GROUND COVER PLANT INTRODUCTIONS

Allamanda cathartica
Aloe spp.
Arundo donax
Atriplex nummularia
Bougainvillea spectabilis
Carpobrotus acinaciformis
C. edulis
Hibiscus rosa-sinensis
H. syriacus
Iris spp.
Jasminum arabicum
Lantana camara
Lavandula spica
L. stoechas
Lippia citriodora
Myoporum spp.
Myrtus communis
Pistacia lentiscus
P. vera
Plumbago capensis
Polygonum capitatum
Rosa spp.
Santolina chamaecyparissus
Yucca gloriosa

2.2 THE SELECTION OF SUCCULENT PLANTS FOR CENTRAL SAUDI ARABIA

Reference: Herman Jacobsen: *Handbook of Succulent Plants*, Blandford Press, London 1960

Sahara-Sindian zone

Aeonium leucoblepharum
Aloe eru
A. inermis
A. pendens
A. rubroviolacea
A. sabaea
A. tomentosa
A. vacillans
Caralluma adensis
C. anemoniflora
C. arabica
C. chrysostephana
C. cicatricosa
C. commutata
C. flava
C. luntii
C. penicilliata
C. quadrangula
C. subulata
Ceropegia rupicola
Echidnopsis bentii
E. planiflora
E. scutellata
Euphorbia animak
E. cactus
E. fruticosa
E. inarticulata
E. parciramulosa
Euphorbia tenuirama
E. tenuirama
Huernia macrocarpa var. *arabica*
Kalanchoe teretifolia
Opophytum forskhali
Rosularia hausknechtii
R. lineata
R. patviflora
R. persica
R. sempervivum
Sedum acre spp. *neglectum*
S. album
S. alpestre
S. bornmulleri
S. littoreum
S. lydium
S. microcarpum
S. obtusifolium
S. palaestinum
S. pilosum
S. sanguineum
S. tenuifolium
Sempervivum iranicum
Senecio euteuphorium var. *odorus*
S. pendulus
Suaeda fruticosa
Umbilicus intermedius
U. rupestris

Sudano-Deccanian Zone

Aloe perryi
A. tomentosa
A. vacillans
Caralluma adensis
C. anemoniflora
C. arabica
C. cicatricosa
C. penicilliata
C. quadrangula
C. socotrana
C. subulata
Cotyledon barleyi
Edithcolea sordida
Euphorbia arbuscula
E. fruticosa
E. inarticulata
E. parciramulosa
E. schimperi
E. spiralis
Kalanchoe abrupta
K. citrina
K. laciniata
K. robusta
K. rotundiflora
K. scapigera
Senecio anteuphorbium
S. pendulus

2.3 SELECTION OF PLANTS ACCORDING TO SALINITY TOLERANCE

Reference: R. Firmin *Afforestation*, Report to the Government of Kuwait, FAO, Rome 1971

Electrical conductivity in micromhos	Plant species
50,000+	*Avicennia marina, Nitraria retusa, Prosopis juliflora* (Kuwait strain), *Suaeda vermiculata, Zygophyllum coccineum*
40,000	*Casuarina glauca, Conocarpus lanciformis, Phoenix dactylifera, Tamarix maris-mortui, T. passerinoides*
35,000	*Atriplex nummularia, A. vesicaria, Juncus acutus, Prosopis stephaniana, P. tamarugo, Tamarix arvensis, T. deserti, T. dioica, T. florida, T. mannifera, T. meyeri, T. orientalis, T. pentandra*
30,000	*Acacia ligulata, Casuarina equisetifolia, Kochia indica, Phragmites communis, Prosopis juliflora, Tamarix aphylla, Zizyphus vulgaris*
25,000	*Acacia saudenii, Tamarix nilotica,*
18,000	*Acacia pendula, A. salicina, Casuarina glauca, Eucalyptus camaldulensis, E. sargentii, E. spathulata, Nerium oleander, Parkinsonia aculeata*
16,000	*Acacia farnesiana, A. salicina, Callistemon lanceolatus, Casuarina cristata, C. stricta, Eucalyptus calcicultrix, E. camaldulensis* var. *obtusa, E. coolabah, E. microtheca, Prosopis chilensis, P. juliflora* var. *velutina*
14,000	*Acacia arabica, Albizzia chinensis, Casuarina lehmanii, Clerodendrum inerme, Eucalyptus pimpiniana, Haloxylon salicornicum, Sesbania grandiflora*
12,000	*Acacia stenophylla, Nassia latifolia, Callitris glauca, Dodonea viscosa, Eucalyptus kruseana, Melaleuca pauperifolia, Melia azederach, Punica granatum, Thevetia nerifolia*
10,000	*Albizzia lebbek, Butea monosperma, Eucalyptus annulata, E. brachycorys, E. cornuta, E. melliodora, E. occidentalis, E. stricklandi, Ficus carica, F. religiosa, Hakea laurina, Lagenaria patterioni, Ricinus communis* var. *perucus, Salvadora oleoides, Thespesia populnea, Vitex agnus-castus*
8,500	*Caesalpinia gilliesii, Calligonum comosum, Casuarina cunninghamiana, Dalbergia sissoo, Dodonea attenuata, Eucalyptus cladocalyx, E. forestiana, E. grossa, E. lansdowneana, E. largiflorens, E. Le Souëffi, E. robusta, E. salubris, E. spathulata, Inga dulcis, Terminalia arjuna*
8,000	*Brachychiton gregorii, Eucalyptus brockwayi, E. dundasi, E. intertexta, E. woodwardii, Ficus bengalensis, Myrtus communis, Prosopis spicigera, Schinus molle, Terminalia catappa*
6,000	*Acacia deami, A. saligna, Agonis flexuosa, Balanites aegyptiaca, Cupressus arizonica, Eucalyptus oleosa, E. torquata, Grevillea robusta, Olea europea, Pritchardii filifera, Tamarindus indica, Tecoma stans*
5,000	*Cordia myxa, Cupressus sempervirens* var. *stricta, Elaeagnus angustifolia, Eucalyptus astringens, E. campaspe, E. longicornis, E. redunca, E. transcontinentalis, Lantana aculeata, Populus euphratica, Terminalia belerica*
4,500	*Bombax malabaricum, Eucalyptus citriodora, Populus bolleana*
3,000	*Acacia tortilis, Albizzia julibrissim, Ficus sycomorus, Robinia pseudoacacia, Salix alba*
2,500	*Acacia cyanophylla, A. cyclopis, A. mellifera, A. raddiana, A. forestiana, A. gerradii*
2,000	*Eucalyptus tereticornis, Hypheane thebaica, Poinciana (Delonix) regia, Duranta plumieri, Populus oblega*
1,000	*Azalea* spp., *Bougainvillea* spp., *Populus euramerica, P. thevestina*

2.5 RELATIVE TOLERANCE OF PLANTS TO BORON

Reference: *Saline and Alkali Soils*, U.S. Salinity Lab., 1969

Tolerant	Semi-tolerant	Sensitive
Athel (*Tamarix Aphylla*)	Sunflower (Native)	Pecan
Asparagus	Potato	Black walnut
Palm (*Phoenix canariensis*)	Acala cotton	Persian (English) walnut
Date palm (*P. dactylifera*)	Pima cotton	Jerusalem artichoke
Sugar beet	Tomato	Navy bean
Mangel	Sweetpea	American elm
Garden beet	Radish	Plum
Alfalfa	Field pea	Pear
Gladiolus	Ragged Robin rose	Apple
Broadbean	Olive	Grape (Sultanina and Malaga)
Onion	Barley	Kadota fig
Turnip	Wheat	Persimmon
Cabbage	Corn	Cherry
Lettuce	Milo	Peach
Carrot	Oat	Apricot
	Zinnia	Thornless blackberry
	Pumpkin	Orange
	Bell pepper	Avacoado
	Sweet potato	Grapefruit
	Lima bean	Lemon

(In each group the plants first named are considered as being more tolerant and the last named more sensitive.)

Natural distribution of species included in FAO/IBPGR trials in arid/semi-arid lands

(Source: FAO/IBPGR, 1980)

Species	Distribution
Acacia albida Del.	Senegal, Gambia, Portuguese Guinea, Sierra Leone, Liberia, Ivory Coast, Ghana, Togo, Dahomey, Nigeria and Cameroon, extending north throughout the drier parts of North Africa into Egypt, Israel, Lebanon and Cyprus, and from East Africa (Tanzania, Kenya, Uganda), to Zambia, Transvaal and Natal.
Acacia nilotica (L.)Willd.ex Del.	(including 3 varieties) extends from tropical and sub-tropical West Africa (Senegal, Gambia, Ivory Coast, Ghana, Togo, Dahomey, Nigeria, Cameroon) East Africa (Tanzania, Kenya, Uganda), and North Africa (the Sahel, Egypt) through eastern Sudan and Arabia as far eastwards as India.
Acacia senegal (L.) Willd.	(including 2 varieties), characteristic of the drier parts of Somalia, Ethiopia, the Sudan and Chad through to Mauritania, extending west to Senegal, Gambia, Ivory Coast, Ghana, Togo, Dahomey, Nigeria and Cameroon, east to Tanzania, Kenya and Uganda.
Prosopis cineraria (L.) Druce (syn. *P. spicigera* L.)	India, Pakistan, Iran, Arabian peninsula.
Prosopis alba Gris.	(including one variety), extends from the plains of subtropical Argentina to Uruguay, Paraguay, southern Bolivia and Peru.
Prosopis chilensis (Molina) Stuntz	(including 2 varieties), from Peru and Bolivia to Central Chile and north-western Argentina.
Prosopis juliflora (Swartz) DC	(including 2 varieties), from the coastal regions of Venezuela, Colombia and Panama, through Central America to Mexico, as well as in the Antillean Islands (perhaps introduced).
Prosopis nigra(Gris.)Hieronymus	(including 2 varieties), occurs in southern Bolivia, the Gran Chaco of Argentina, Paraguay and western Uruguay.
Prosopis tamarugo F. Philippi	arid mesetas in the northern provinces of Chile
Eucalyptus camaldulensis Dehnh.	a large part of inland Australia, with great climatic and genetic variation.
Eucalyptus microtheca F.Muell.	a large part of central and northern Australia with a separated occurrence on the west coast.
Acacia aneura F. Muell.	inland arid Australia.
Azadirachta indica Juss.	Burma, India (Siwalik Hills; Karnatic region; parts of the Deccan, south of the river Godavari).

NOTE:- A limited number of additional species within the same distribution areas as the above could be considered for the presently proposed phase of the Project, e.g. *Acacia tortilis*.

cies of trees and shrubs for the Sahel recommended by
n Maydell (1981)

ALPHABETISCHE LISTE DER BOTANISCHEN NAMEN UND SYNONYMA

LEITNAMEN	SYNONYMA	
ACACIA ALBIDA DEL.	Acacia adansonii Guill. et Perrott.	= A. nilotica var. adansonii
	Acacia adstringens (Schum. et Thonn.) Berhaut	= A. nilotica var. adansonii
ACACIA ATAXACANTHA DC.	Acacia arabica (Lam.)Willd.	= A. nilotica var. tomentosa
	Acacia arabica Willd.	= A. nilotica var. adansonii
	Acacia arabica var. adansoniana Dubard	= A. nilotica var. adansonii
	Acacia arabica var. adstringens (Schum. et Thonn.) Bak	= A. nilotica var. adansonii
	Acacia arabica (Lam.) Willd. var. nilotica (L.) Benth.	= A. nilotica var. nilotica
	Acacia arabica Willd. var. tomentosa (Benth.)	= A. nilotica var. tomentosa
ACACIA DUDGEONI CRAIB EX HOLL.	Acacia buchanani Harms	= A. macrothyrsa
ACACIA EHRENBERGIANA HAYNE	Acacia caffra Willd. var. campylacantha Aubrev.	= A. polyacantha var. campylacantha
	Acacia campylacantha Hochst. ex A.Rich.	= A. polyacantha var. campylacantha
	Acacia catechu Willd. var. campylacantha (Hochst. ex A.Rich.) Roberty	= A. polyacantha var. campylacantha
	Acacia catechu Oliv.	= A. polyacantha var. campylacantha
	Acacia delzielii Cruib	= A. macrothyrsa
ACACIA GOURMAENSIS A.CHEV.	Acacia fasciculata Guill. et Perrott.	= A. raddiana
	Acacia flava (Forsk.) Schweinf.	= A. ehrenbergiana
	Acacia glauca Moench	= Leucaena leucocephala
ACACIA LAETA R. BR. EX BENTH.	Acacia gyrocarpa Hochst.	= A. albida
	Acacia hockii De Wild.	= A. seyal
ACACIA MAC ROSTACHYA REICHENB. EX BENTH.	Acacia lebbeck (L.) Willd.	= Albizia lebbeck
ACACIA MACROTHYRSA HARMS	Acacia leucocephala	= A. albida
ACACIA MELLIFERA (VAHL) BENTH.		
ACACIA NILOTICA VAR. ADANSONII (GUILL. ET PERROTT.) O. KTZE.	Acacia nafezia Schweinf.	= A. sieberiana
	Acacia nilotica var. adansoniana (Dubard) A.F. Hill	= A. nilotica var. adansonii
	Acacia nilotica var. adstringens (Schum. et. Thonn.) Chiov.	= A. nilotica var. adansonii
ACACIA NILOTICA (L.) WILLD. EX DEL. VAR. NILOTICA		
ACACIA NILOTICA VAR. TOMENTOSA (BENTH.) A.F. HILL		
ACACIA PENNATA (L.) WILLD.		
ACACIA POLYACANTHA WILLD. VAR. CAMPYLACANTHA (HOCHST. EX.A.RICH.) BRENAN		
ACACIA RADDIANA SAVI	Acacia praesispinnata Stapf	= A. macrothyrsa
ACACIA SENEGAL (L.) WILLD.	Acacia suprestris Stokes	= A. senegal
	Acacia saccharata Benth.	= A. albida
	Acacia samaryana A. Chev.	= A. dudgeoni
	Acacia scarpioides (L.) W.F.Wight var. nilotica (L.) A. Chev.	= A. nilotica var. nilotica
	Acacia scarpioides (L.) W.F.Wight var. pubescens A.Chev.	= A. nilotica var. tomentosa
ACACIA SEYAL DEL.	Acacia senegal (L.) Willd. ssp. mellifera (Vahl) Roberty	= A. mellifera
ACACIA SIEBERIANA DC.	Acacia singulana Guill. et Perrott.	= A. sieberiana
	Acacia stenocarpa Hochst. ex A. Rich.	= A. seyal
	Acacia suma Benth.	= A. polyacantha var. campylacantha
	Acacia tortilis (Forsk.) Hayne ssp. raddiana (Savi) Brenan	= A. raddiana

LEITNAMEN	SYNONYMA	
ADANSONIA DIGITATA L.	Acacia fertilis Hayne	= A. raddiana
	Acacia tortilis Hayne var. pubescens A. Chev.	= A. raddiana
	Acacia trentinlenz A. Chev.	= A. laeta
	Acacia trispinosa Stokes	= A. senegal
	Acacia verek Guill. et Perrott.	= A. senegal
	Acacia verugera Schweinf.	= A. sieberiana
ADENIUM OBESUM (FORSK.) ROEM. ET SCHULT.	Adenonia sphaerocarpa A. Chev.	= A. digitata
	Adenium arabicum Balf. f.	= A. obesum
	Adenium coetaneum Stapf	= A. obesum
	Adenium honghel A. DC.	= A. obesum
ALBIZIA CHEVALIERI HARMS	Aglalida barteri Van Tiegh.	= Balanites aegyptiaca
ALBIZIA LEBBECK (L.) BENTH.	Aglalida senegalensis Van Tiegh.	= Balanites aegyptiaca
ANACARDIUM OCCIDENTALE L.	Aglalida tombouctensis Van Tiegh.	= Balanites aegyptiaca
ANNONA SENEGALENSIS PERS.	Annona chrysophylla Baj.	= A. senegalensis
	Annona senegalensis var. chrysophylla (Baj.) R. Sillans	= A. senegalensis
	Annona senegalensis var. latifolia Oliv.	= A. senegalensis
ANOGEISSUS LEIOCARPUS (DC.) GUILL. ET PERROTT.	Anogeissus leiocarpus var. schimperi (Hochst. ex Hutch. et Dal.) Aubrév.	= A. leiocarpus
	Anogeissus schimperi Hochst. ex Hutch. et Dalz.	= A. leiocarpus
AZADIRACHTA INDICA A. JUSS.	Anteleea azadirachta (L.) Adelbert	= Azadirachta indica
BALANITES AEGYPTIACA (L.) DEL.	Balanites ziziphoides Mildbr. et Schlechter	
	Balsamodendron africanum Arn.	= B. aegyptiaca
	Bassia parkii G. Don.	= Commiphora africana
	Bauhinia abyssinica Rich.	= Butyrospermum parkii
	Bauhinia adansoniana Guill. et Perrott.	= Piliostigma thonningii
	Bauhinia benzoin Kotschy	= B. rufescens
	Bauhinia glabra A. Chev.	= Piliostigma reticulatum
	Bauhinia glauca A. Chev.	= Piliostigma reticulatum
	Bauhinia pyrrhocarpa Hochst.	= Piliostigma reticulatum
	Bauhinia reticulata DC.	= Piliostigma thonningii
BAUHINIA RUFESCENS LAM.	Bauhinia thonningii Schum.	= Piliostigma reticulatum
	Bombax andrieui Pellegr. et Vuillet	= Piliostigma thonningii
	Bombax buonopozense P. Beauv.	= B. costatum
BOMBAX COSTATUM PELLEGR. ET VUILLET	Bombax hoverdii Pellegr. et Vuillet	= B. costatum
	Bombax vuilletii Pellegr.	= B. costatum
BORASSUS AETHIOPUM MART.	Borassus flabellifer L. var. aethiopum Warb.	= B. aethiopum
BOSCIA ANGUSTIFOLIA A. RICH.	Boscia octandra Hochst. ex Radlk.	= B. senegalensis
	Boscia patens Sprague et M.L. Green	= B. angustifolia
	Boscia powellii Sprague et M.L. Green	= B. salicifolia
BOSCIA SALICIFOLIA OLIV.	Boscia tenuifolia A. Chev.	= B. angustifolia
BOSCIA SENEGALENSIS (PERS.) LAM. EX POIR.	Brehmia spinosa (Lam.) Merr. ex DC.	= Strychnos spinosa
	Brehmia spinosa ssp. lokua (A.Rich.) E.A. Bruce	= Strychnos spinosa

LEITNAMEN	SYNONYMA	
	Butyrospermum paradoxum subsp. parkii (G. Don) Hepper	= B. parkii
BUTYROSPERMUM PARKII (G. DON) KOTSCHY		
CADABA FARINOSA FORSK.		
CADABA GLANDULOSA FORSK.		
	Cadaba mombassana Gilg et Benedict	= C. farinosa
	Caillieo dichrostachys Guill. et Perrott.	= Dichrostachys cinerea
CALOTROPIS PROCERA (AIT.) AIT. F.		
	Capparis aphylla Hayne ex Roth	= C. decidua
CAPPARIS CORYMBOSA LAM.		
CAPPARIS DECIDUA (FORSK.) EDGEW.		
	Capparis fischeri Pax.	= C. corymbosa
	Capparis persicifolia A. Rich.	= C. tomentosa
	Capparis puberula DC.	= C. tomentosa
CAPPARIS TOMENTOSA LAM.		
	Cassia florida Vahl	= C. sieberiana
	Cassia ketschyana Oliv.	= C. sieberiana
CASSIA OCCIDENTALIS L.		
CASSIA SIAMEA LAM.		
CASSIA SIEBERIANA DC.		
CASUARINA EQUISETIFOLIA J.R. ET G. FORST.		
	Celastrus coriaceus Guill. et Perrott.	= Maytenus senegalensis
	Celastrus senegalensis Lam.	= Maytenus senegalensis
CELTIS INTEGRIFOLIA LAM.		
	Combretum abbreviatum Engl. et Diels	= C. paniculatum
COMBRETUM ACULEATUM VENT.		
	Combretum altum Perr.	= C. micranthum
	Combretum elliotii Engl. et Diels	= C. nigricans
	Combretum floribundum Engl. et Diels	= C. micranthum
COMBRETUM GLUTINOSUM PERROTT. EX DC.		
	Combretum leucanthum Engl. et Diels	= C. nigricans
	Combretum leonense Engl. et Diels	= C. glutinosum
COMBRETUM MICRANTHUM G. DON		
COMBRETUM NIGRICANS LEPR. EX GUILL. ET PERROTT.		
COMBRETUM PANICULATUM VENT.		
	Combretum passargei Engl. et Diels	= C. glutinosum
	Combretum pinciorum Hook	= C. paniculatum
	Combretum raimbaultii Heck	= C. micranthum
	Combretum romosissimum Engl. et Diels	= C. paniculatum
COMMIPHORA AFRICANA (A. RICH.) ENGL.		
	Commiphora calcicola Engl.	= C. africana
	Commiphora pilosa Engl.	= C. africana
	Conocarpus leiocarpus DC.	= Anogeissus leiocarpus
CRATEVA ADANSONII DC.		
	Crateva religiosa Forst.	= C. adansonii
DALBERGIA MELANOXLON GUILL. ET PERROTT.		
	Dichrostachys arborea N.E. Br.	= D. cinerea
DICHROSTACHYS CINEREA (L.) WIGHT ET ARN.		
	Dichrostachys glomerata (Forsk.) Hutch et Dalz.	= D. cinerea
	Dichrostachys nutans (Pers.) Benth.	= D. cinerea
	Dichrostachys platycarpa Welw.ex Oliv.	= D. cinerea
DIOSPYROS MESPILIFORMIS HOCHST. EX A. DC.		
	Diospyros senegalensis Perrott. et A.DC.	= D. mespiliformis
	Eleyuna biloba Raf.	= Piliostigma reticulatum
ENTADA AFRICANA GUILL. ET PERROTT.		
	Entada sudanica Schweinf.	= E. africana
	Entada ubanguiensis De Wild.	= E. africana
	Entadopsis sudanica (Schweinf.) Gilbert et Boutique	= E. africana

LEITNAMEN	SYNONYMA	
ERYTHRINA SENEGALENSIS DC.		
EUCALYPTUS CAMALDULENSIS DEHNHARDT		
	Eucalyptus rostrata Schlecht.	= E. camaldulensis
EUPHORBIA BALSAMIFERA AIT.		
	Euphorbia rogeri M.E.Br.	= E. balsamifera
	Euphorbia sepium M.E.Br.	= E. balsamifera
	Faidherbia albida Del.	= Acacia albida
FERETIA APODANTHERA DEL.		
	Feretia canthioides Hiern	= F. apodanthera
	Ficus bibracteata Warb.	= F. platyphylla
	Ficus bongoensis Warb.	= F. iteophylla
FICUS CAPENSIS THUNB.		
	Ficus dekdekena (Miq.) A. Rich.	= F. iteophylla
FICUS GNAPHALOCARPA (MIQ.) STEUD. EX A. RICH.		
FICUS INGENS (MIQ.) MIQ.		
FICUS ITEOPHYLLA MIQ.		
	Ficus lutea Vahl	= F. ingens
	Ficus kawuri Hutch.	= F. ingens
FICUS PLATYPHYLLA DEL.		
	Ficus pseudovogelii A. Chev.	= F. vogelii
	Ficus persondensis A. Chev.	= F. iteophylla
	Ficus senegalensis Miq.	= F. vogelii
	Ficus sprengeana Hildbr. et Burret	= F. iteophylla
	Ficus sycomorus L.	= F. gnaphalocarpa
FICUS THONNINGII BLUME		
	Ficus umbrosa Warb.	= F. platyphylla
	Ficus trachyphylla Fenzl	= F. gnaphalocarpa
FICUS VOGELII (MIQ.) MIQ.		
	Fluggea microcarpa Bl.	= Securinega virosa
	Fluggea virosa (Roxb. ex Willd.) Baill.	= Securinega virosa
GARDENIA AQUALLA (SCHWEINF.) STAPF ET HUTCH.		
GARDENIA ERUBESCENS STAPF ET HUTCH.		
	Gardenia jovis-tonantis Hiern	= G. ternifolia
	Gardenia medicinalis Vahl ex Schum.	= G. ternifolia
GARDENIA SOKOTENSIS HUTCH.		
GARDENIA TERNIFOLIA K. SCHUM. ET THONN.		
	Gardenia thunbergia Hiern	= G. ternifolia
	Gardenia triacantha var. parvilimbis F.N Williams	= G. erubescens
	Grewia betulifolia Juss.	= G. tenax
GREWIA BICOLOR JUSS.		
	Grewia corylifolia Guill. et Perrott.	= G. villosa
GREWIA FLAVESCENS JUSS.		
	Grewia grisea M.E.Br.	= G. bicolor
	Grewia guazumifolia A. Chev.	= G. flavescens
	Grewia kwebensis N.E.Br.	= G. bicolor
	Grewia miniata Mast. ex Hiern	= G. bicolor
GREWIA MOLLIS JUSS.		
	Grewia mossambicensis Burret	= G. bicolor
	Grewia pilosa Lam.	= G. flavescens
	Grewia pseudifolia Vahl	= G. tenax
	Grewia salvifolia Hayne ex Roth	= G. bicolor
GREWIA TENAX (FORSK.) FIORI		
	Grewia venusta Fres.	= G. mollis
GREWIA VILLOSA WILLD.		
GUIERA SENEGALENSIS J.F. GMEL.		
	Gymnosporia dinturi Loes	= Maytenus senegalensis
	Gymnosporia senegalensis (Lam.) Loes	= Maytenus senegalensis
	Hexadelitia africana A. Rich.	= Commiphora africana
HYPHAENE THEBAICA (L.) MART.		
KHAYA SENEGALENSIS (DESR.) A. JUSS.		

LEITNAMEN	SYNONYMA	
LANNEA ACIDA A. RICH.		
	Lannea djalensis A. Chev.	= L. microcarpa
LANNEA MICROCARPA ENGL. ET K. KRAUSE		
LEPTADENIA PYROTECHNICA (FORSK.) DECNE.		
	Leptadenia spartium Wight	= L. pyrotechnica
	Leucaena glauca (Moench) Benth.	= L. leucocephala
LEUCAENA LEUCOCEPHALA (LAM.) DE WIT.		
	Leucaena salvadorensis Standley	= L. leucocephala
MAERUA ANGOLENSIS DC.		
MAERUA CRASSIFOLIA FORSK.		
	Maerua rigida R.Br.	= M. crassifolia
	Maerua senegalensis R.Br.	= M. crassifolia
MANGIFERA INDICA L.		
MAYTENUS SENEGALENSIS (LAM.) EXELL		
	Melia azadirachta L.	= Azadirachta indica
	Melia indica Brandis	= Azadirachta indica
	Mimosa adstringens	= Acacia nilotica var. andansonii
	Mimosa arabica Lam.	= Acacia nilotica
	Mimosa asperata L.	= M. pigra
	Mimosa biglobosa Jacq.	= Parkia biglobosa
	Mimosa cinerea L.	= Dichrostachys cinerea
	Mimosa glauca L.	= Leucaena leucocephala
	Mimosa glomerata Forsk.	= Dichrostachys cinerea
	Mimosa juliflora Swartz.	= Prosopis juliflora
	Mimosa lebbeck L.	= Albizia lebbeck
	Mimosa leucocephala Lam.	= Leucaena leucocephala
	Mimosa mellifera Vahl	= Acacia mellifera
	Mimosa nilotica L.	= Acacia nilotica
	Mimosa nutans Pers.	= Dichrostachys cinerea
	Mimosa pennata L.	= Acacia pennata
MIMOSA PIGRA L.		
	Mimosa scorpioides L.	= Acacia nilotica
	Mimosa senegal L.	= Acacia senegal
	Mitragyna africana (Willd.) Korth	= M. inermis
MITRAGYNA INERMIS (WILLD.) O. KTZE.		
MORINGA OLEIFERA LAM.		
	Moringa pterygosperma Gaertn.	= M. oleifera
	Nauclea africana Willd.	= Mitragyna inermis
	Nerium obesum Forsk.	= Adenium obesum
	Odina acida (A.Rich.) Oliv.	= Lannea acida
PARKIA BIGLOBOSA (JACQ.) BENTH.		
PARKINSONIA ACULEATA L.		
PHOENIX DACTYLIFERA L.		
	Phyllanthus virosus Roxb. ex Willd.	= Securinega virosa
PILIOSTIGMA RETICULATUM (DC.) HOCHST.		
PILIOSTIGMA THONNINGII (SCHUM.) MILNE-REDH.		
	Piliostigma rufescens (Lam.) Benth.	= Bauhinia rufescens
	Poderia senegalensis (Pers.) Lam. ex Poiret	= Boscia senegalensis
	Pouparti birrea (A.Rich.) Aubr.	= Sclerocarya birrea
PROSOPIS AFRICANA (GUILL., PERROTT. ET RICH.) TAUB.		
	Prosopis chilensis	siehe Prosopis juliflora
	Prosopis dulcis Guill. et Perrott.	= Acacia nilotica
	Prosopis glandulosa U.A.	siehe Prosopis juliflora
PROSOPIS JULIFLORA (SW.) DC.		
	Prosopis lanceolata Benth.	= P. africana
	Prosopis oblonga Benth.	= P. africana
	Prosopis velutina	siehe P. juliflora
	Pterocarpus abbyssinicus Hochst.	= P. lucens
	Pterocarpus angolensis DC.	= P. erinaceus
	Pterocarpus echinatus DC.	= P. erinaceus

LEITNAMEN	SYNONYMA	
PTEROCARPUS ERINACEUS POIR.		
PTEROCARPUS LUCENS LEPR. EX GUILL. ET PERROTT.		
	Pterocarpus lucens var. simplicifolius (Bak.) A. Chev.	= P. lucens
	Pterocarpus simplicifolius Bak.	= P. lucens
SALVADORA PERSICA L.		
SCLEROCARYA BIRREA (A.RICH.) HOCHST.		
SECURIDACA LONGEPEDUNCULATA FRESEN		
	Securidaca pallida Klotzsch	= S. longepedunculata
	Securidaca spinosa Sim.	= S. longepedunculata
SECURINEGA VIROSA (ROXB. EX WILLD.) BAILL.		
	Securinega microcarpa (Blume) Pax et Hoffm.	= S. virosa
	Bodaio decidua Forsk.	= Capparis decidua
	Spondias birrea A. Rich.	= Sclerocarya birrea
	Sterculia cinerea A. Rich.	= S. setigera
STERCULIA SETIGERA DEL.		
	Sterculia tomentosa Guill. et Perrott.	= S. setigera
	Stereospermum dentatum A. Rich.	= S. kunthianum
STEREOSPERMUM KUNTHIANUM CHAM.		
	Strychnos buettneri Gilg.	= S. spinosa
	Strychnos djalonis A. Chev.	= S. spinosa
	Strychnos courtii Chev.	= S. spinosa
	Strychnos emarginata Bak.	= S. spinosa
	Strychnos dulcis Chev.	= S. spinosa
	Strychnos gracillima Gilg.	= S. spinosa
	Strychnos lana Solered.	= S. spinosa
	Strychnos lokwa A. Rich.	= S. spinosa
STRYCHNOS SPINOSA LAM.		
	Strychnos spinosa var. pubescens Bak.	= S. spinosa
	Strychnos volkensii Gilg.	= S. spinosa
	Suletania senegalensis Desr.	= Khaya senegalensis
	Sycomorus gnaphalocarpa Miq.	= Ficus gnaphalocarpa
TAMARINDUS INDICA L.		
TAMARIX SENEGALENSIS DC.		
	Terminalia adamaouensis Engl.	
TERMINALIA AVICENNIOIDES GUILL., ET PERROTT.		
	Terminalia chevalieri Diels	= T. macroptera
	Terminalia dewei Rolfe	= T. macroptera
	Terminalia dictyanoura Diels	= T. avicennioides
	Terminalia elliotii Engl. et Diels	= T. macroptera
	Terminalia lecardii Engl. et Diels	= T. avicennioides
TERMINALIA MACROPTERA GUILL. ET PERROTT.		
	Terminalia suberosa Chev.	= T. macroptera
	Uncaria inermis Willd.	= Mitragyna inermis
	Urostigma dekdekena Miq.	= Ficus itacphylla
	Urostigma ingens Miq.	= Ficus ingens
	Urostigma vogelii Miq.	= Ficus vogelii
	Vitellaria flavescens (Juss.) Berret	= Gossia flavescens
	Vitellaria paradoxa Gaertn.	= Butyrospermum parkii
	Vitex chariensis Chev.	= V. doniana
	Vitex cienkowski Katschy et Peyr.	= V. doniana
	Vitex cuneata Schum. et Thonn.	= V. doniana
VITEX DIVERSIFOLIA BAK.		
VITEX DONIANA SWEET		
	Vitex paludosa Vatke	= V. doniana
	Vitex simplycifolia Oliv.	= V. diversifolia
	Vitex umbrosa G. Don ex Sabine	= V. doniana
XIMENIA AMERICANA L.		
	Ximenia aegyptiaca L.	= Balanites aegyptiaca
	Ziziphus amphibia A. Chev.	= Z. spina-christi
	Ziziphus jujuba (L.) Lam.	= Z. mauritiana
ZIZIPHUS MAURITIANA LAM.		
ZIZIPHUS MUCRONATA WILLD.	Ziziphus mitis A.Rich.	= Z. mucronata
ZIZIPHUS SPINA-CHRISTI (L.) DESF.	Ziziphus orthocantha DC.	= Z. mauritiana

Appendix 8g
Page 4

Species under trial for plantations in dry tropical Africa

Source: Delwaulle (1979)

(* = not promising)

Eucalyptus alba (and hybrids)
E. camaldulensis (and hybrids)
E. citriodora
E. crebra
E. microtheca
E. paniculata
E. saligna
E. sideroxylon
E. tereticornis
E. tesselaris
E. torreliana

Euphorbia balsamifera
E. kamerunica
E. tirucalli

Faidherbia albida

Ficus spp.

* *Funtumia elastica*

* *Gleditsia triacanthos*

Gmelina arborea

Grevillea pyramidalis
* *G. refracta*

Guaiacum officinale

Guiera senegalensis

Gyrostemon spp.

* *Hakea* spp.

Holarrhena spp.

* *Hura crepitans*

* *Hyphaene thebaica*

Isoberlinia doka

Jacaranda acutifolia

Jatropha curcas

Khaya senegalensis

* *Lamarkea acheifolia*

Lawsonia inermis

Leucaena leucocephala

Lonchocarpus sericeus

Markhamia tomentosa

Melaleuca spp.

Melia azedarach
* *M. dubia*

* *Milletia laurentii*

Mimosa pigra

Mitragyna inermis

Moringa oleifera

Nauclea diderichii

Nerium oleander

* *Opuntia ficus indica*

* *Parinari macrophylla*

Parkia africana
P. filicoides

Parkinsonia aculeata

* *Peltophorum ferrugineum*

* *Petalostylis labicheoides*

Piliostigma monandra
* *P. reticulatum*

Pinus caribaea
* *P. halepensis*
* *P. pinaster*
* *P. pinea*

Pithecellobium dulce

* *Populus* spp.

Prosopis africana
P. chilensis
P. cineraria
P. tamarugo

* *Pterocarpus erinaceus*

Ptilotus exaltatus

Ricinodendron heudelotii

Robinia pseudoacacia

Salvadora persica

Samanea saman

Schinus molle
* S. terebinthifolius

Sclerocarya birrea

* *Simmondsia chinensis*

Spondias monbin

Sterculia tomentosa
* *S. urens*

Stylobasium spatulatum

Sweetia panamensis

Tamarindus indica

Tamarix spp.

Tecoma stans

Tectona grandis

Terminalia arjuna
* *T. carpentariae*
* *T. catappa*
T. ivorensis
T. mantaly
T. superba

Thevetia peruviana

* *Thuja orientalis*

* *Vitex doniana*

* *Ximenia americana*

* *Ziziphus mauritiana*

Appendix 8h

Species recommended for arid zones by Goor and Barney(1976)

Abies cilicica

Acacia cyanophylla

Acacia tortilis
Acer negundo
Ailanthus altissima
Alnus orientalis
Araucaria excelsa
Aspidosperma quebracho-blanco
Azadirachta indica
Bulnesia retamo
Calligonum comosum

Casuarina equisetifolia
Casuarina glauca
Cedrus libani
Celtis australis
Ceratonia siliqua

Crataegus azarolus
Cupressus sempervirens
Dalbergia sissoo

Elaeagnus angustifolia

Eucalyptus camaldulensis

Ficus sycomorus
Fraxinus syriaca
Gleditsia triacanthos
Grevillea robusta
Haloxylon ammodendron
Juglans regia

Juniperus excelsa
Melia azedarach

Morus alba
Parkinsonia aculeata
Pinus brutia
Pinus canariensis
Pinus halepensis
Pinus nigra
Pinus pinaster
Pinus pinea

Pistacia atlantica
Platanus orientalis

× *Populus euramericana*
Prosopis juliflora
Prosopis spicigera

Quercus suber
Rhus coriaria

Robinia pseudoacacia
Salix spp.
Schinopsis lorentzii

Schinus molle

Tamarix articulata
Taxodium distichum
Tetraclinis articulata
Ulmus pumila
Zizyphus spina-christi

Tropical tree legumes of special significance as fuelwood

From Brewbaker *et al.* (1981)

Genus	Species adapted to: Humid tropics	Arid tropics
Acacia	auriculiformis, mearnsii*	brachystegia, cambagei, cyclops, nilotica, saligna, senegal, seyal, tortilis
Albizia	—	lebbek
Calliandra	calothyrsus	—
Cassia	—	siamea
Derris	indica	—
Gliricidia	sepium	—
Inga	vera*	—
Leucaena	leucocephala	—
Mimosa	scabrella	—
Pithecellobium	—	dulce
Prosopis	—	alba, chilensis, cineraria, juliflora**, pallida, tamarugo
Sesbania	grandiflora	—

* Highland-adapted species

** Mesquite is widely considered an undesirable thorny pest

(a) Firewood species described in NAS (1980)

FUELWOOD SPECIES FOR HUMID TROPICS 32
Acacia auriculiformis 34
Calliandra calothyrsus 36
Casuarina equisetifolia 38
Derris indica 42
Gliricidia sepium 44
Gmelina arborea 46
Guazuma ulmifolia 48
Leucaena leucocephala 50
Mangroves 52
Mimosa scabrella 56
Muntingia calabura 58
Sesbania bispinosa 60
Sesbania grandiflora 62
Syzygium cumini 64
Terminalia catappa 66
Trema spp. 68

FUELWOOD SPECIES FOR TROPICAL HIGHLANDS 70
Acacia mearnsii 72
Ailanthus altissima 74
Alnus acuminata 76
Alnus nepalensis 78
Alnus rubra 80
Eucalyptus globulus 82
Eucalyptus grandis 84
Grevillea robusta 86
Inga vera 88

FUELWOOD SPECIES FOR ARID AND SEMIARID REGIONS
Acacia brachystachya 92
Acacia cambagei 94
Acacia cyclops 96
Acacia nilotica 98
Acacia saligna 100
Acacia senegal 102
Acacia seyal 104
Acacia tortilis 106
Adhatoda vasica 108
Albizia lebbek 110
Anogeissus latifolia 112

Azadirachta indica 114
Cajanus cajan 118
Cassia siamea 120
Colophospermum mopane 122
Emblica officinalis 124
Eucalyptus camaldulensis 126
Eucalyptus citriodora 128
Eucalyptus gomphocephala 130
Eucalyptus microtheca 132
Eucalyptus occidentalis 134
Haloxylon aphyllum 136
Haloxylon persicum 138
Parkinsonia aculeata 140
Pinus halepensis 142
Pithecellobium dulce 144
Prosopis alba 146
Prosopis chilensis 148
Prosopis cineraria 150
Prosopis juliflora 152
Prosopis pallida 154
Prosopis tamarugo 156
Tamarix aphylla 158
Zizyphus mauritiana 160
Zizyphus spina-christi 162

(b) Master list of firewood species prior to selection of 60 species for NAS (1980)

The following species received the highest rating in replies to the inquiry sent to several hundred plant scientists and foresters before the panel met to write this report. Species chosen by the panel for inclusion in the report are marked with an asterisk.

Humid Tropics

*Acacia auriculiformis**
A. eulacocarpa
A. crassicarpa
A. flava
A. koa
A. leucophloea
A. polyacantha
A. siamensis
A. tomentosa
Acrocarpus fraxinifolius
Adansonia digitata
Adina cordifolia
Afzelia africana
A. xylocarpa
Aglaia spp.
Albizia falcata
*A. lebbek**
A. moluccana
A. odoratissima
A. procera
Aleurites moluccana
*Alnus jorullensis**
Alstonia spp.
Anacardium occidentale
*Anogeissus latifolia**
*A. leiocarpus**
Anthocephalus cadamba
Antidesma ghaesembilla
Artocarpus spp.
Aspidosperma spp.
Astronium urundeuva
Aucoumea spp.
Avicennia spp.*
*Azadirachta indica**
Bambusa spp.
Raphia kirkii
Bauhinia malabarica
B. tomentosa
Bischoffia javanic.
Bixageopsis multi
Bombax spp.
Bruguiera spp.*
Caesalpinia sappan
*Cajanus cajan**
*Calliandra calothyrsus**

Callicarpa arborea
Caloncoba gilgiana
Cananga odorata
Capparis spp.
Carapa guineensis
Carinianа pyriformis
Casearia spp.
Cassia macrantha
*C. siamea**
*C. spectabilis**
*Casuarina cunninghamiana**
*C. equisetifolia**
*C. lepidophloia**
C. nobile
Cecropia spp.
Cedrela spp.
Ceiba pentandra
Celtis spp.
Ceriops spp.
Chilopsis linearis
Chlorophora tinctoria
C. excelsa
Chloroxylon swietenia
Citrus spp.
Coccoloba sp.
Cocos nucifera
Coffea spp.
Combretum spp.
Conocarpus erectus
Cordia spp.
C. alliodora
Cratoxylon spp.
Crescentia cujete
Croton spp.
Cupressus lusitanica
Cynometra cauliflora
Daniella oliveri
Dendrocalamus strictus
Derris microphylla
Detarium senegalense
Dialium guineensis
D. ovoideum
Dichrostachys glomerata
Dillenia spp.
Diospyros spp.
Diphysa robinioides
Dinizia excelsa

D. moluccana
Elateriospermum spp.
Enterolobium cyclocarpum
Erythrina spp.
Erythrophleum spp.
Eschweilera mexiana
Eucalpytus alba
E. botryoides
E. brassiana
*E. camaldulensis**
*E. citriodora**
E. cloeziana
E. deglupta
*E. grandis**
*E. microtheca**
E. moluccana
E. pellita
E. resinifera
E. robusta
*E. saligna**
*E. tereticornis**
E. tornelliana
E. urophylla
Eugenia jambos
Ficus benghalensis
Garuga pinnata
*Gliricidia maculata**
*G. sepium**
*Gmelina arborea**
*Grevillea robusta**
Grewia spp.
Guatteria ferruginea
*Guazuma ulmifolia**
Haematoxylon campechianum
Hevea brasiliensis
Holoptelea integrifolia
Hymenocardia acida
Inga spp.
I. alba
*I. edulis**
I. laurina
*I. vera**
Inocarpus edulis
Intsia bijuga
Iryanthera hostmani
Khaya senegalensis
Kydia calycina

Lantana spp.
*Leucaena leucocephala**
Libidibia corymbosa
Licania spp.
Lindackeria maynensis
Lumnitzera racemosa
Macaranga spp.
Machaerium nictitans
Madhuca latifolia
Malmea spp.
Mammea americana
Mangifera indica
Mangroves*
Melaleuca leucadendron
Melastoma spp.
Melia azedarach
M. composita
Michelia champaca
Moringa oleifera
Morus mesozygia
Muntingia calabura *
Murraya paniculata
Musanga cecropioides
Myristica spp.
Nauclea diderrichii
Nectandra spp.
Ocotea spp.
Octomeles sumatrana
Olea africana
Ouratea calophylla
Parinari excelsa
Parkia spp.
*Parkinsonia aculeata**
Peltophorum pterocarpum
Pentaclethra macrophylla
Pentadesma butyracea
Persea spp.
Phyllanthus discoideus
Pinus caribaea
P. insularis
P. kesiya
P. merkusii
Piptadenia spp.
*Pithecellobium dulce**
P. jiringa
P. lobatum
Platonia insignis
*Pongamia glabra**
Populus euphratica
Pourouma spp.
Pseudosamanea guachapele
Psidium guajava
P. cattleianum
Pterocarpus erinaceus
P. indicus
Pterygota alata
Quercus spp.
Q. oocarpa
Q. penduncularis
Q. sapotaefolia
Rhamnus spp.
Rhizophora apiculata
R. candelaria
*R. mangle**
*R. mucronata**
Salix humboldtiana
Salvadora persica
Samanea saman
Schleichera oleosa
Schizolobium parahyba
Securinega virosa
Serialbizzia splendens
Sesbania aegyptica
*S. grandiflora**
Sterculia urens
Swartzia sp.
S. fistuloides
S. madagascariensis
Swietia brachystachya
Swietenia macrophylla
S. mahogani
Symphonia globulifera
*Syzygium cummii**
S. guineense
Tamarindus indica
Tamarix passerinoides
Tectona grandis
Terminalia spp.*
T. paniculata
T. tomentosa
Tetragastris altissima
Tetrameles nudiflora
Thespesia populnea
*Trema guineensis**
*T. micrantha**
*T. orientalis**
other *Trema* spp.*
Trichilia hirta
Triplaris guayaquilensis
Triplochiton scleroxylon
Tristania obovata
Vitex spp.
Ximenia americana
Xylia kerrii
Xylocarpus spp.
Zanthoxylum spp.
Z. xanthoxyloides
Zizyphus spp.
Z. thyrsiflora

Tropical Highlands

Acacia acuminata
A. baileyana
A. cavenia
*A. dealbata**
*A. decurrens**
A. elata
A. macracantha
*A. mearnsii**
A. melanoxylon
A. pycnantha
A. visco
Acer negundo
A. obtusifolium
A. pseudoplatanus
Ailanthus glandulosa
Alnus formosana
*A. glutinosa**
*A. jorullensis**
*A. nepalensis**
A. nitida
A. orientalis
*A. rubra**
Altingia excelsa
Amorpha fruticosa
Aristotelia chilensis
Araucaria spp.
Aspidosperma quebracho-blanco
Baeckea frutescens
Bambusa sp.
Bauhinia retusa
Brachychiton populneum
Buddleia spp.
Callitris macleayana
Calycophyllum multiflorum
Carya spp.
Castanopsis spp.
C. acuminatissima
*Casuarina cunninghamiana**
*C. equisetifolia**
*C. junghuhniana**
*C. luehmannii**
Ceanothus spp.
Cedrela spp.
Cercocarpus
Cestrum spp.
Cinnamomum camphora
Citrus spp.
Coffea arabica
Commiphora spp.
Croton glabellus
Cupressus benthamii
C. cashmeriana
C. forbesii
C. goveniana
C. lusitanica
C. macnabiana
C. macrocarpa
C. sempervirens
C. torulosa
Dendrocalamus strictus
Didymopanax morototoni
Drimys winteri
Elaeagnus angustifolia
Escallonia spp.
Eucalyptus albens
*E. bicostata**
E. blakelyi
E. botryoides
E. calophylla
*E. camaldulensis**
*E. citriodora**
E. cladocalyx
E. cloeziana
E. deanei
E. delegatensis
E. diversicolor
*E. globulus**
*E. gomphocephala**
*E. grandis**
E. gummifera
E. largiflorens
E. leucoxylon
*E. macarthuri**
E. maculata
*E. maidenii**
E. melanoxylon
E. melliodora
E. microcorys
E. neglecta
E. nova-anglica
E. odorata
E. ovata
E. paniculata
E. resinifera
E. robusta
*E. saligna**

a2'

E. tereticornis
E. trabutii
*E. viminalis**
E. wandoo
Eugenia sp.
Ficus palmata
F. salicifolia
Fraxinus sp.
Gleditsia triacanthos
*Grevillea robusta**
Grewia spp.
Leptospermum spp.
Lespedeza bicolor
L. cyrtobotrya
L. maximowiczii
Ligustrum lucidum
Liquidambar formosana
L. styraciflua
Liriodendron tulipifera
Lithocarpus spp.
Maclura pomifera
Maytenus boaria
Melaleuca leucadendron
M. pubescens = M. preissiana
Melia azedarach
Nyssa aquatica
Olea africana
O. chrysophylla
O. cuspidata
O. europaea
Peumus boldus
Pinus canariensis
P. caribaea
P. elliottii
P. excelsa
P. kesiya
P. merkusii
P. nigra
P. oocarpa
P. pinea
P. pseudostrobus
P. radiata
P. rigida
Platanus occidentalis
P. orientalis
Podocarpus oleifolius
Polylepis spp.
P. tomentella
Populus balsamifera
P. betulifolia x *P. trichocarpa*
P. deltoides
P. grandidentata
P. nigra
P. tremuloides
Quercus sp.
Q. dilatata
Q. incana
Q. virginiana
Robinia pseudoacacia
Salix babylonica
S. caprea
S. humboldtiana
Schinopsis spp.
Schinus molle
Sophora japonica
Styrax sp.
Tecoma spp.
T. stans
Teijsmanniodendron ahernianum
Tetraclinis articulata
*Trema orientalis**
Tipuana tipu
Trevoa trinervis
Ulmus pumila
U. wallichiana
Vernonia baccharoides
Wendlandia spp.

Arid and Semiarid Regions

Acacia spp.
A. acuminata
A. albida
A. aneura
*A. arabica**
*A. auriculiformis**
A. baileyana
*A. brachystachya**
A. caffra
*A. cambagei**
A. catechu
A. cibaria
A. concinna
*A. cyanophylla**
*A. cyclops**
A. dealbata
*A. decurrens**
A. drepanolobium
A. elata
A. excelsa
A. farnesiana
A. giraffae
A. greggii
A. harpophylla
A. heteracantha
A. heterophylla
A. hockii
*A. holosericea**
A. homalophylla
A. karroo
A. kempeana
A. lasiopetala
A. leenthamii
A. leucophloea
A. litakunensis
A. longifolia
A. macracantha
A. melanoxylon
A. modesta
*A. mollissima**
*A. nilotica**
A. nilotica subsp. *adansonii*
A. nilotica var. *tomentosa*
A. oswaldii
A. pallacantha
A. pendula
A. peuce
A. planifrons
A. polyacantha subsp. *campylacantha*
A. pycnantha
*A. raddiana**
A. senegalensis
*A. seyal**
A. siamensis
A. tomentosa
*A. tortilis**
A. victoriae
*Albizia lebbek**
*Anogeissus leiocarpus**
*A. pendula**
Argania sideroxylon
Artemisia herba-alba
A. monosperma
A. scoparia
Aspidosperma quebracho-blanco
Atriplex bracteosa
A. canescens
A. leucoclada
*Azadirachta indica**
Balanites aegyptiaca
Bauhinia reticulata
B. thonningii
Bombacopsis quinata
Brasilettia mollis
Bunchosia armeniaca
Burkea africana
Caesalpinia paraguariensis
*Cajanus cajan**
Calliandra spp.
Calligonum comosum
Callistemon sp.
Carapa guineensis
Cassia garrettiana
*C. siamea**
C. sturtii
*Casuarina cristata**
*C. decaisneana**
*C. equisetifolia**
*C. glauca**
*C. stricta**
Cedrela odorata
Celtis integrifolia
C. spinosa
Ceratonia siliqua
Chloroxylon swietenia
*Colophospermum mopane**
Combretum ghasalense
C. glutinosum
Commiphora spp.
C. africana
Cordeauxia edulis
Cupressus arizonica
Cybistax donnell-smithii
Dalbergia sissoo
Diospyros spp.
Dodonaea viscosa
Erythrina senegalensis
Erythrophleum africanum
Eucalyptus alba
E. astringens
E. bicolor
E. blakelyi
E. brockwayi
E. calycogona
*E. camaldulensis**
E. cambageana
*E. citriodora**
E. crebra
E. flocktoniae
E. gardneri
E. glaucina
*E. gomphocephala**
E. gracilis
E. intertexta
E. melliodora
*E. microtheca**
*E. occidentalis**

E. oleosa
E. pilularis
E. platypus
E. populnea
E. pyriformis subsp. *youngiana*
E. robusta
E. rudis
E. salmonophloia
E. salubris
E. stricklandii
*E. tereticornis**
E. tetrodonta
E. torquata
*E. viminalis**
Ficus spp.
Geoffraea decorticans
Gleditsia triacanthos
*Gmelina arborea**
Grevillea pterosperma
Hakea leucoptera
Haloxylon spp.
*H. aphyllum**
*H. persicum**
Heterotheca abaxillaris
Hyphaene thebaica
Inga feyillei
Isoberlinia dalzielii
I. doka
Jacaranda acutifolia
Juglans neotropica
Krugeodendron ferreum
Lannea coromandelica
L. schimperi
Leucodendron argenteum
Lophira lanceolata
Lucuma paradoxa
Lysiloma sabicu
Maerua cressefolia
Melaleuca leucadendron
Melia azedarach
Mitragyna africana
Monotes kerstingii
Morus nigra
Olea europaea
Olneya tesota
Parkia clappertoniana
*Parkinsonia aculeata**
*Pinus brutia**
P. canariensis
P. edulis
*P. eldarica**
*P. halepensis**
P. pinea
Pistacia lentiscus
P. palaestina
P. terebinthus
*Pithecellobium dulce**
Popehax macrantha
Prosopis africana
*P. alba**
P. blanca
*P. caldenia**
*P. chilensis**
*P. cineraria**
*P. farcta**
P. ferox
P. glandulosa
P. inermis
*P. juliflora**
P. nigra
*P. pallida**
P. palmeri
P. pubescens
P. spicigera
P. stephaniana
*P. tamarugo**
P. torquata
Prunus andersoni
Pterocarpus erinaceus
P. lucens
Quercus spp.
Q. coccifera
Q. farnetta
Q. pubescens
Retama roetam
Rhanterium epapposum
Salvadora persica
Schinus molle
Sclerocarya birrea
Sterculia setigera = *S. tomentosa*
Tamarix spp.*
*T. aphylla**
*T. articulata**
T. gallica
T. meyeri
T. passerinoides
T. stricta
*Terminalia glaucescens**
T. tomentosa
Zizyphus abyssinica
*Z. jujuba**
*Z. mauritiana**
*Z. nummularia**
*Z. spina-christi**
Z. vulgaris

Some Australian species, other than eucalypts, with potential for fuelwood (and multiple-use) in humid tropics, tropical highlands and the sub-tropical arid/semi-arid regions.

Source: Boland and Turnbull (1981)

1. Humid tropics

Acacia aulacocarpa+
A. auriculiformis+
A. bakeri
A. cincinnata
A. crassicarpa
A. hylonema
A. mangium+
Acmena smithii
Agathis robusta
Ailanthus spp.
Albizia spp.+
Alphitonia petriei+
A. whitei
Alstonia muellerana
Argyrodendron spp.
Banksia dentata+
B. integrifolia+
Capparis sp.
Cardwellia sublimis
Casuarina equisetifolia+
Cassia spp.+
Comminsonia bartramia
Celtis sp.
Croton spp
Diospyros spp.
Elaeocarpus grandis
Euroschinus falcata
Macaranga tanarius+
M. subdentata
Pithecellobium spp.+
Pleiogynium timorense
Terminalia sericocarpa
Tieghemopanax murrayi
T. elegans
Trema orientalis+
Vitex spp.

2. Tropical highlands

Acacia dealbata
A. decurrens
A. mearnsii
Agathis spp
Aleurites moluccana
Alphitonia excelsa+
A. petriei
Alstonia scholaris+
Araucaria bidwillii•
Backhousia anisata
Callicoma serratifolia
Callistemon salignus
Callitris macleayana
Casuarina cunninghamiana+
C. glauca
C. torulosa
Choricarpa subargentea
Diploglottis australis•
Flindersia bourjotiana
Grevillea robusta
G. baileyana+
G. pinnatifida+
Macadamia spp.•
Mallotus paniculatus
M. philippensis
M. ricinoides
Melaleuca leucadendron
Oreocallis wickhamii+
Orites excelsa+
Syncarpia glomulifera
Trema orientalis
Tristania conferta
T. laurina
T. neriifolia
Xanthostemon spp.

3. Arid/semi-arid sub-tropical regions

Acacia aneura••
A. brachystachya
A. cambagei
A. cyclops
A. estrophiolata••+
A. fasciculifera
A. holosericea
A. plectocarpa
A. polystachya+
A. shirleyi
A. tumida
Alphitonia excelsa+
A. philippense
Alstonia actinophylla
A. constricta
Atalaya hemiglauca
Brachychiton populneus••
B. gregorii••
Callitris spp.
Casuarina cristata
C. luehmannii
Codonocarpus spp.
Dodonaea viscosa
Erythrina vespertilio
Erythrophleum chlorostachys
Flindersia maculosa
Grevillea parallela+
Grevillea striata••+
G. pteridifolia
Hakea leucoptera
H. suberea••+
Lysiphyllum cunninghamii
Melaleuca viridiflora
Melia azedarach
Parinari nonda•
Syzygium suborbiculare•
Terminalia platyphylla
T. volucris
Tristania suaveolens
T. grandiflora

• fruit, •• fodder, + high priority species for seed collection and testing overseas.

Species for tropical plantations (included in Webb *et al.* (1979) and to be included in second edition, mid-1983)

Acacia albida
Acacia auriculiformis
Acacia cyanophylla
Acacia cyclops
Acacia decurrens
Acacia farnesiana
Acacia mangium
Acacia mearnsii
Acacia melanoxylon
Acacia nilotica
Acacia pendula
Acacia salicina
Acacia senegal
Acacia tortilis
Acrocarpus fraxinifolius
Agathis dammara
Albizia falcataria
Albizia lebbek
Alnus acuminata
Alnus nepalensis
Alnus rubra
Anacardium occidentale
Anthocephalus chinensis
Araucaria angustifolia
Araucaria cunninghamii
Araucaria hunsteinii
Aucoumea klaineana
Azadirachta indica
Bombacopsis quinata
Brachychiton populneum
Butyrospermum paradoxum
Calliandra calothyrsus
Callitris glauca
Callitris columellaris
Campnosperma brevipetiolata
Cariniaria pyriformis
Cassia siamea
Casuarina decaisneana
Casuarina equisetifolia
Casuarina glauca
Casuarina junghuhniana
Cedrela odorata
Ceratonia siliqua
Chlorophora excelsa
Cleistopholis glauca
Colophospermum mopane
Conocarpus lancifolius
Cordia alliodora
Cryptomeria japonica
Cunninghamia lanceolata
Cupressus arizonica
Cupressus lusitanica (including C. benthamii)
Cupressus macrocarpa
Cupressus torulosa
Dalbergia sissoo
Delonix regia

Elaeagnus angustifolia
Eucalyptus botryoides
Eucalyptus brockwayi
Eucalyptus camaldulensis (Northern Provenances)
Eucalyptus camaldulensis (Southern Provenances)
Eucalyptus citriodora
Eucalyptus cladocalyx
Eucalyptus cloeziana
Eucalyptus crebra (Inland Provenances)
Eucalyptus dalrympleana
Eucalyptus deglupta
Eucalyptus delegatensis
Eucalyptus fastigata
Eucalyptus globulus
Eucalyptus globulus subsp. maidenii
Eucalyptus gomphocephala
Eucalyptus grandis
Eucalyptus intertexta
Eucalyptus largiflorens
Eucalyptus maculata
Eucalyptus melliodora
Eucalyptus microcorys
Eucalyptus microtheca
Eucalyptus nitens
Eucalyptus obliqua
Eucalyptus occidentalis
Eucalyptus paniculata
Eucalyptus pellita
Eucalyptus propinqua
Eucalyptus regnans
Eucalyptus resinifera
Eucalyptus robusta
Eucalyptus st. johnii
Eucalyptus saligna
Eucalyptus salmonophloia
Eucalyptus sargentii
Eucalyptus sideroxylon (Inland Victoria Provenances)
Eucalyptus tereticornis (Queensland and New Guinea Provenances)
Eucalyptus torelliana
Eucalyptus urophylla
Eucalyptus viminalis
Euphorbia tirucalli
Ficus benghalensis
Gleditsia triacanthos
Gliricidia sepium
Gmelina arborea
Grevillea robusta
Haloxylon aphyllum
Jacaranda copaia — Hieronyma chocoensis
Jacaranda mimosifolia
Khaya senegalensis
Leucaena leucocephala (Hawaiian type)
Leucaena leucocephala (Salvador type)
Liquidambar styraciflua
Maesopsis eminii
Melaleuca leucadendron
Musanga cecropioides
Nauclea diderrichii

Ochroma pyramidale
Octomeles sumatrana
Parkia biglobosa
Parkinsonia aculeata
Paulownia tomentosa
Peltophorum pterocarpum
Pericopsis elata
Pinus ayacahuite
Pinus brutia
Pinus canariensis
Pinus caribaea var. bahamensis
Pinus caribaea var. caribaea
Pinus caribaea var. hondurensis
Pinus chiapensis
Pinus elliottii var. elliottii
Pinus greggii
Pinus halepensis
Pinus kesiya
Pinus merkusiana (Continental Provenances)
Pinus merkusii (Island Provenances)
Pinus michoacana
Pinus montezumae
Pinus occidentalis
Pinus oocarpa
Pinus palustris
Pinus patula subsp. patula
Pinus patula var. tecummanii
Pinus pinaster (Portuguese Provenances)
Pinus pinea
Pinus ponderosa var. arizonica
Pinus pseudostrobus
Pinus radiata
Pinus roxburghii
Pinus taeda
Populus deltoides var. deltoides
Prosopis chilensis
Prosopis cineraria
Prosopis juliflora
Prosopis tamarugo
Robinia pseudoacacia
Roseodendron donnell-smithii
Salix babylonica var. sacramenta
Samanea saman
Schinus molle
Schizolobium parahybum
Sesbania grandiflora
Simmondsia chinensis
Swietenia macrophylla
Tabebuia rosea
Tamarix aphylla
Taxodium distichum
Tectona grandis
Terminalia brassii
Terminalia calamansanai
Terminalia ivorensis
Terminalia superba
Toona ciliata var. australis
Triplochiton scleroxylon
Zizyphus spina-christi

Trees and bamboos for integrated landuse systems in Malawi

(Source: Personal communication, I.D. Edwards, Forestry Research Institute of Malawi)

Acacia
A. albida
A. polycantha
Acrocarpus fraxinifolius
Adina microcephala
Afzelia quanzensis
Albizia
A. amara
A. glaberrima
A. gummifera
A. lebbekk
A. versicolor
Amblygonocarpus andongonsis
Azadirachta indica
Bambusa vulgaris
Bauhinia petersiana
Bauhinia thonnigii
Borassus aethiopum
Brachystegia
B. floribunda
Burkea africana
Caesalpinia decapetala
Cassia siamea
Cassia spectabilis
Cinchona sp.
Colophospermum mopane
Combretum
C. imberbe
C. ternifolium
Cordyla africana
Cupressus lusitanica
Dalbergia sissoo
Diplorhynchus condylocarpon
Entada abyssinica
Erythrina abyssinica
Eucalyptus spp.
Euphorbia turicalli
Gliricidia sepium
Gmelina arborea
Grevillea robusta
Hardwickia binata
Hyphaene Spp.
Idermitis
Julbernardia paniculata
Kigelia africana
Kirkia acuminata
Leucaena leucocephala
Lonchocarpus cappassa
Maesopsis eminii
Markhamia obtusifolia
Melia azedarach
Monotes africanus
Morus spp.
Oxythenanthera abyssinica
Parinari curatifolia
Parkia filicoidea
Pericopsis angolensis
Pinus spp.
Pseudolachnostylis mapronueifolia
Pterocarpus angolensis
Pterocarpus rotundifolius
Sclerocarya caffra
Solanum aculeastrum
Strychnos innocua
Strychnos spinosa
Terminalia sericea
Toona ciliata
Uapaca kirkiana
Ziziphus mauritiana

East Pokot agricultural project: tree planting summary 1978-1982

(Personal communication, E. Barrow)[1]

Species	Comments	Species	Comments[2]
°Acacia albida*		Zizyphus mauritiana*	1,3,6
°Acacia tortilis*	2,3,4	Zizyphus mucronata	
°Acacia senegal*	2,3,6	Ceiba pentandra	
Acacia cyanophylla	1,3,4	°Balanites aegyptiaca*	2,3,4,5
Acacia halosericea**	1,3,4	°Balanaites orbicularis	
Acacia aneura	2,3,4	Leucaena leucocephala K8*	1,4,5
Acacia salicana	2,3,4	°Adansonia digitata	1,3,4
°Acacia eliator*	2,3,5	Ceratonia siliqua	2,3
Acacia victoria		Bauhinea purpurea	
°Acacia mellifera*	2,3,6	°Tamarindus indica*	2,3,4
Eucalyptus camaldulensis	1,3,5	Erythrina rotunda	
Eucaluptus citriodora		°Salvadora perssa	
Eucalyptus microtheca	1,5	Atriplex nummularia	1,3,4
Eucalyptus wandoo		Atriplex halimus	
Eucalyptus astringens		Simmondsia chinesis	
Eucalyptus torquata		Casuarina equisetifolia	1,5
Eucalyptus fernestina		Schinus molle	
Eucalayptus torquata woodwardii		Stylosanthes scabra	
		Conocarpus lancifolius	
Prosopis cineraria		Moringa stenopecla	
Prosopis juliflora		°Delonix elata*	
(Baobab Farm, Mombasa)	1,3,4,5	°Diospyros scabra	
Prosopis juliflora (Israel,Ben Gurion)	1,3,4,5	Bombax spp	
		Guava	
Prosopis chilensis*	1,3,4,5	Cashew	
Prosopis pallida	1,3,4,5	Mango, Orange, Pawpaw	
Cassia sturtii*	2,3,4		
Cassia siamea*	1,3,7		
Cassia spectabilis			
Parkinsonia aculeta	1,3,7		
Azadirachta indica			

° = indigenous * = lots of seed available ** = some seed available

[1] E. Barrow, East Pokot Agricultural Project, Kositei, Nginyang, P.O. Marigat, Nakum, Kenya.

[2] No comment = not worth commenting on!

Comments Code

1.....Fast growing
2.....Slow growing
3.....Drought resistant
4.....Fodder
5.....Timber and fuel
6.....Live fencing
7.....Shade

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List of Indigenous Species for Kenya

(Source: Owino, 1983)

LEGUMINOSAE

Acacia albida
Acacia abyssinica
Acacia adenocalyx
Acacia brevispica
Acacia clavigera
Acacia etbaica
Acacia lahai
Acacia mellifera
Acacia nilotica
Acacia polyacantha
Acacia recifiens
Acacia senegal
Acacia seyal
Acacia tortilis
Acacia xanthophloea
Albizia anthelmintica
Albizia coriaria
Albizia grandibracteata
Albizia gummifera
Albizia zygia
Enteda abyssinica
Mimosa pigra
Newtonia buchanani
Newtonia paucijuga
Parkia filicoidea
Adenocarpus mannii
Cordyla africana
Craibia brownii
Dalbergia melanoxylon
Dalbergia microcarpa
Erythrina abyssinica
Erythrina burtii
Erythrina excelsa
Indigofera arrecta
Lonchocarpus bussei
Milletia dura
Milletia usambarensis
Mundulea sericea
Ormocorpum kirkii
Sesbania sesban
Tephrosia elata
Tamarindus indica
Trachylobium verrucosum
Julbernardia magnistipulata
Erythrophleum guineense
Cynometra webberi
Delonix elata
Cassia petersiana
Brachystegia spiciformis
Bauhinia tomentosa
Afzelia quanzensis
Acacia gerrardii
Acacia kirkii
Crotelaria laburnifolia
Piliostigma thonningii

MULTI-PURPOSE SPECIES

Adansonia digitata
Anacardium occidentale
Balanites aegyptiaca
Borassus aethiopium
Casuarina equisetifolia
Chlorophora excelsa
Chrysophyllum albidum
Commiphora africana
Commiphora trothae
Cordia abyssinica
Cordia milleni
Euphorbia tirucelli
Ficus sycomorus
Markhamia hildebrandtii
Markhamia platycalyx
Markhamia zanzibarica
Morinfa oleifera
Terminalia catappa
Trema guineensis

Seed available from National Academy of Sciences for Sahel trials

	Species	Common Name	Supplier	Number	Origin	Comments
Field Crops						
*1.	*Amaranthus cruentus*	Grain Amaranth	Rodale Research Center	R104	Mexico	Mexican grain-type amaranth. High-protein grain, protein-rich leaves; fast growing; daylength neutral.
*2.	*Amaranthus hypochondriacus*	Grain Amaranth	Rodale Research Center	R103	Mexico	Mercado grain-type amaranth. High-protein grain, protein-rich leaves; fast growing.
3.	*Phaseolus acutifolius*	Tepary Bean	Meals for Millions		Sells, Arizona	Drought-tolerant crop.
4.	*Psophocarpus tetragonolobus*	Winged Bean	University of Florida	Tpt-1		Edible seeds, pods, leaves, and roots; edible seed oil; livestock feed; relatively high water requirements.
5.	*Tylosema esculentum*	Morama Bean	Southwest Texas State University		Kalahari desert	Edible tuber and seeds, oil, browse; drought tolerant.
6.	*Zea mays*		University of Florida		Southern Arizona	Currently out of stock.
Trees and Shrubs						
7.	*Acacia albida*	Apple-ring Acacia	ISRA/CNRF, Senegal	82/598	Nayobe region, Senegal	Comes into leaf at the end of the rainy season and remains green during the dry season. Soil conservation, livestock feed, tannin, easily carved wood.

* New Accessions

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8.	A. aneura	Mulga	CSIRO, Australia	12791	New South Wales, Australia	Currently out of stock.
9.	A. berlandieri	Huajillo	Texas Department of Health		McMullen County, Texas	Browse, honey production, fuel.
10.	A. cambagei	Gidgee	CSIRO, Australia	13485	Queensland, Australia	Currently out of stock
11.	A. farnesiana	Sweet Acacia	CSIRO, Australia	11147	New South Wales, Australia	Wood for fuel and posts, tannin, gum for making mucilage, fodder, living fences.
12.	A. ligulata	Umbrella Bush	CSIRO, Australia	13425	Northern Territory, Australia	Currently out of stock.
13.	A. linarioides		CSIRO, Australia	11506	Western Australia	Soil conservation.
14.	A. nilotica var. adansonii	Egyptian Thorn	ISRA/CNRF, Senegal	81/443	Bondia area, Senegal	Fuel, construction, fodder, tannin, gum.
15.	A. nilotica var. tomentosa		ISRA/CNRF, Senegal	82/597	Mayobe region, Senegal	Fuel, living fences and windbreaks, fodder tannin, gum.
16.	A. raddiana	Umbrella Thorn	ISRA/CNRF, Senegal	82/599	Mayobe region, Senegal	Fuel, construction, fodder, sand control.
17.	A. salicina	Cooba	CSIRO, Australia	13379	Western Australia	Fuel, soil conservation.
18.	A. senegal	Gum Arabic	ISRA/CNRF, Senegal	82/593	Northern Ferlo, Senegal	Fuel, construction, gum arabic, fodder, soil conservation, edible seeds.
19.	A. tumida		CSIRO, Australia	11496	Western Australia	Currently out of stock.
20.	A. victoriae	Prickly Wattle	CSIRO, Australia	13271	Queensland, Australia	Currently out of stock.
21.	Adansonia digitata	Baobab	ISRA/CNRF, Senegal	82/603	Bandia, Senegal	Food, bark used to make mats and paper.
22.	Anogeissus leiocarpus		ISRA/CNRF, Senegal	82/571	Boulal, Senegal	Fence posts, construction and wood-working, ashes, yield potash.

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23.	Argania spinosa	Argan Tree	Forest Service, Morocco	77307	Tamanar, Morocco	Oil, construction, charcoal, fruit and foliage eaten by cattle and goats.
24.	Atriplex canescens	Four-Wing Saltbush	Texas Tech University		Western, Texas	Browse, ground cover.
25.	A. nummularia	Old-man Saltbush	Western Australia Dept. of Agriculture	Acc WA-/1981	Western Australia	Browse, ground cover.
26.	Balanites aegyptiaca	Desert Date	ISRA/CNRF, Senegal	82/602	Louga region, Senegal	Construction, edible fruit, browse; emulsion from the fruit is lethal to the snails which are intermediary hosts of schistosomiasis and to the water flea that carries the Guinea-worm disease, is used to poison fish.
27.	Centrosema sp.	Centro	CSIRO, Australia	65967	Progreso, Equador	Currently out of stock.
28.	C. brasilianum		CSIRO, Australia	55696	Petrolina, Brazil	Browse shrub.
29.	C. pascuorum		CSIRO, Australia	55697	Petrolina, Brazil	Browse shrub.
30.	Conocarpus lancifolius	Damas	Baobab Farm, Kenya		Mombasa, Kenya	Construction, charcoal, fodder.
31.	Cordeauxia edulis	Ye-eb	Baobab Farm, Kenya		Mombasa, Kenya	Currently out of stock.
32.	Desmanthus virgatus		CSIRO, Australia	65947	Salinas, Equador	Currently out of stock.
33.	Eucalyptus brockwayi	Dundas Mahogany	CSIRO, Australia	12266	Western Australia	Sawlogs, posts, firewood.
34.	E. camaldulensis	River Red Gum	CSIRO, Australia	12184	Northern Territory, Australia	Coppices well; posts, poles, piles, fuel, honey production.
35.	E. camaldulensis	River Red Gum	CSIRO, Australia	12346	Western Australia	Same as above.
36.	E. camaldulensis	River Red Gum	CSIRO, Australia	13476	Queensland, Australia	Same as above.

37.	E. intertexta	Inland Red Box	CSIRO, Australia	11735	New South Wales, Australia	Fuel, shelterbelts.
38.	E. melanophloia	Silver-Leaved Ironbark	CSIRO, Australia	13158	Queensland, Australia	Fuel, honey production.
39.	E. microthaca	Flooded Box	CSIRO, Australia	12846	Queensland, Australia	Fuel, poles and posts, conservation.
40.	E. microthaca	Flooded Box	CSIRO, Australia	13360	Western Australia	Same as above.
41.	E. occidentalis	Flat-Topped Yate	CSIRO, Australia	9806	Western Australia	Fuelwood, timber, shade.
42.	E. oleosa var. oleosa	Narrow-Leaved Giant Mallee	CSIRO, Australia	12310	South Australia	Construction, fuel, essential oil, honey.
43.	E. terminalis		CSIRO, Australia	11966	Queensland, Australia	Fuelwood, honey.
44.	E. tessellaris	Carbeen	CSIRO, Australia	12967	Queensland, Australia	Fuelwood, honey production.
45.	E. torquata	Coral-Flowered Gum	CSIRO, Australia	10186	Western Australia	Ornamental plantings, honey production.
46.	Geoffroea decorticans		SAONR, CHILE	BL-7463	Chilean coastal desert	Multiple use.
47.	Leucaena leucocephala	Leucaena	University of Hawaii	K6		Currently out of stock.
48.	L. leucocephala	Leucaena	University of Hawaii	K8	Zacatecas, Mexico	Fuelwood, forage, construction, soil improvement.
49.	L. leucocephala	Leucaena	University of Hawaii	K30	Merida, Mexico	Fuelwood, forage, soil conservation.
50.	L. leucocephala	Leucaena	University of Hawaii	K67	Santa Cruz Porillo, Salvador	Same as above.
51.	L. leucocephala	Leucaena	University of Hawaii	K500	Australia	"Cunningham" forage cultivar.
52.	Macroptilium atropurpureum	Siratro	CSIRO, Australia	85002	Cabo San Lucas, Mexico	Currently out of stock.
53.	M. atropurpureum	Siratro	CSIRO, Australia	Siratro		Browse shrub.

54.	*M. martii*		CSIRO, Australia	49780	Bahia, Brazil	Browse shrub.
55.	*M. martii*		CSIRO, Australia	55783	Petrolina, Brazil	Currently out of stock.
56.	*Mitragyna inermis*		ISRA/CNRF, Senegal	82/604	Bandia, Senegal	Firewood, medicine, fish baskets.
57.	*Parkinsonia aculeata*	Horse-Bean Tree	ISRA/CNRF, Senegal	80/258	Bandia, Senegal	Fuel, erosion control, fodder.
58.	*Phaseolus filiformis*		CSIRO, Australia	85005	La Paz, Mexico	Currently out of stock.
59.	*Prosopis* sp.		University of California, Riverside	PC 004		Currently out of stock.
60.	*Prosopis* sp.		University of California, Riverside	PC 005		Currently out of stock.
61.	*P. africana*		ISRA/CNRF, Senegal	106	Kaur-Mactar, Senegal	Charcoal, tannin, construction.
62.	*P. alba*	Algarrobo Blanco	Texas A&I University	0166	Argentina (?)	Fuel, timber, fodder, food, amenity planting.
63.	*P. alba*	Algarrobo Blanco	Texas A&I University	0388	Argentina (?)	Same as above.
64.	*P. alba*	Algarrobo Blanco	University of California, Riverside	JO 053	Argentina	Currently out of stock.
65.	*P. glandulosa*	Honey Mesquite	University of Arizona	A	Yuma, Arizona	Currently out of stock.
66.	*P. glandulosa*	Honey Mesquite	University of Arizona	B	Yuma, Arizona	Currently out of stock.
67.	*P. glandulosa* var. *glandulosa*	Honey Mesquite	University of California	PC 032	Santa Ana, Mexico	Currently out of stock.
*68.	*P. glandulosa* var. *glandulosa*	Honey Mesquite	Texas Department of Health		Southern Texas	Browse, food for human consumption, fuel, posts, honey production.
69.	*P. juliflora*	Mesquite	ISRA/CNRF, Senegal	79/194		Fuelwood, construction, fodder, food for human consumption, gum, honey.

70.	P. velutina	Velvet Mesquite	University of Arizona	162	Tucson, Arizona	Currently out of stock.
71.	P. velutina	Velvet Mesquite	University of Arizona	163	Tucson, Arizona	Currently out of stock.
72.	P. velutina	Velvet Mesquite	University of Arizona	164	Tucson, Arizona	Currently out of stock.
73.	P. velutina	Velvet Mesquite	University of Arizona	165	Tucson, Arizona	Currently out of stock.
74.	P. velutina	Velvet Mesquite	University of Arizona	171	West of Tucson, Arizona	Currently out of stock.
75.	P. velutina	Velvet Mesquite	University of Arizona	172	Tucson, Arizona	Currently out of stock.
76.	P. velutina	Velvet Mesquite	Texas A&I University	0457	Kingsville, Texas	Currently out of stock.
77.	P. velutina	Velvet Mesquite	University of California Riverside	PC 035	Arizona	Currently out of stock.
78.	Simmondsia chinensis	Jojoba	University of Arizona		Southern Arizona	Liquid wax; browse; salt tolerant, drought tolerant.
79.	Stylosanthes hamata		CSIRO, Australia	Verano	Coastal South America	Browse shrub.
80.	S. scabra		CSIRO, Australia	Q10042	Bahia, Brazil	Browse shrub.
81.	S. scabra		CSIRO, Australia	Fitzroy		Browse shrub.
82.	S. scabra		CSIRO, Australia	Seca		Browse shrub.
83.	S. sympodialis		CSIRO, Australia	67703	Coastal Equador	Browse shrub.
84.	Tarchonanthus camphoratus	Camphor Bush	Bolus Herbarium		Bloemfontein, South Africa	Fuelwood, fodder, windbreaks, termite-resistant wood, medicinal uses.

Species and uses of bamboos in Asia
(Source: Lessard and Chouinard, 1980)

Uses, local names, and location of some species in Malaysia. Table 8n.1

Species	Present/suggested uses	Local name	Location
Bambusa arundinacea	—	—	Penang, Singapore Botanic Gardens
B. blumeana	—	Buloh duri	Penang, Selangor (Kepong), Pahang (Pekan)
B. burmanica	—	Buloh aloh bukit	Kedah, Alor Star, Singapore
B. glaucescens	Picket fences, garden stakes, trellises, baskets, ornamental and hedge plants [a]	Buloh pagar	Originally from Japan and China
B. heterostachya	—	Buloh tilan/minyak/pering/pengat	Perak, N. Sembilan, Melaka, Johore, Singapore
B. klossii	—	—	Kedah, Perak (1000 m)
B. magica	—	Buloh perindu	Pahang, Cameron Highland, Selangor, Ulu Semangkok
B. montana	—	—	Penang Hill, Kedah
B. pauciflora	—	Buloh padi	Pahang, Fraser Hill
B. ridleyi	—	Buloh akar	Pahang, Singapore
B. spinosa	Building purposes, baskets, mats, hats [a]	—	—
B. ventricosa	—	—	Originally from China
B. vulgaris	Furniture, paper, pulp, shoots, landscaping [a,b]	Buloh minyak aao/aro/beting/pan	All over Malaysia
B. wrayi	—	Buloh sumpitan	Perak-Gunong Inas (1500-2000 m)
Dendrocalamus asper	Laminated trays, plywood, veneer, bridges, fences, water vessels, racks, tables, chairs, cages, fish traps, shoots [a,b]	Buloh beting	Cultivated for shoots all over; Peninsular Malaysia
D. dumosus	—	—	Kedah (Baling Hill), Langkawi
D. elegans	—	—	Kedah, Pulau Langkawi, Penang
D. giganteus	—	Buloh betong	Originally from Burma
D. hirtellus	—	Buloh kapur	Johore, Perak (Taiping), Kedah, Kelantan
D. pendulus	Basket making	—	Perak, Selangor, N. Sembilan
D. sinuatus	—	Buloh akar	Perak, N. Sembilan, Trengganu, Pahang
D. strictus	—	—	Originally from India
Dendrochloa scandens	Rope making [b]	Buloh akar	Perak
Gigantochloa sp	Structures [b]	—	—
G. apus	—	—	Selangor (Serdang), Singapore Botanic Gardens
G. hasskarliana	—	—	Penang, Singapore
G. latifolia	—	Buloh pahit	Kedah, Perak, Pahang
G. levis	—	Buloh bisa	Selangor, Melaka, Johore, Singapore
G. ligulata	—	Buloh tikus/bilalai	Perlis, Kedah, Perak, Pahang, Selangor, Kelantan
G. maxima	—	—	Selangor (Serdang)
var. *viridis*	—	—	Johore Kota Tinggi
var. *minor*	—	—	FRI, Kepong
var. *ridley*	—	—	Province Wellesley, Singapore Botanic Gardens
G. wrayi	—	Buloh semantan, telur, rayah, Pa-aao/gala, seremai	Kedah, Penang, Perak, Selangor, N. Sembilan, Kelantan, Pahang
Schizostachyum aciculare	Handicrafts	Buloh beti	Kedah, Pahang, Province Wellesley, Perak, Selangor
S. brachycladum	—	Buloh padi/akar	Johore, Selangor, N. Sembilan, Melaka
S. gracile	—	Buloh nipis/lemang/padi/urat/rusa/pelang	Kedah, Penang, Perak, Pahang, Johore
S. grande	Rims for large baskets [b]	Buloh rupen/akar	Johore: Selat Teberau, Kota Tinggi, Segamat, Sg. Sedili; Melaka: Bukit Tungal, Air Panas Selangor: Sungai Labu; Pahang: Kuala Bera, Pekan
S. insulare	—	Buloh semeling/semenyeh	Kedah: Grik; Perak: Cameron Highland; Pahang: Kuala Lipis, Kelantan, Selangor
S. jaculans	Wind instruments, handicrafts [a]	—	Pulau Langkawi, Kedah, Penang, Johore
S. longispiculatum	—	Buloh sumpitan/temiang/kerap/tikus	Pahang, Selangor, Melaka, Johore, Singapore, Perak
S. terminale	—	—	In all states except Perlis, Kedah, P. Pinang, Trengganu, Province Wellesley
S. zollingeri	Handicrafts, baskets, traps, hats, woven wares, rafts, floors, walls, partitions, cooking vessels [a]	—	Kedah: Inchong Estate, Sg. Kenan
		Buloh telor/pelang nipis/dinding/kasap/lemang/aur	Perak, Selangor, N. Sembilan, Pahang, Johore

[a] Kiang Tao and Lin Wei-Chin (196).
[b] Holttum, R.E. (166).

Species of bamboos and their uses in Indonesia. Table 8n.2

Species	Building material	Smokehouses for tobacco	Baskets	Furniture	Handicraft	Fishing tool	Firewood	Water pipe	Traditional customs	Edible shoot	Musical instrument	Paper industry	Medicine	Ornamental plant
Arundinaria japonica							•			•				•
Bambusa arundinacea	•						•			•		•		
B. atra	•		•				•							•
B. blumeana	•		•			•	•			•				
B. glaucescens					•		•							•
B. polymorpha	•						•			•				
B. vulgaris	•			•	•		•			•			•	•
Dendrocalamus asper	•		•	•	•	•	•	•		•	•			
Dendrochlia scandens					•		•							
Gigantochloa apus	•	•	•	•	•	•	•	•	•		•			
G. atter	•		•	•	•	•	•	•		•	•			
G. atter atter	•		•	•	•		•	•		•	•			
G. verticillata	•		•	•	•		•	•		•	•			
Nastus elegantissimus	•	•												
Phyllostachys aurea					•									•
Pseudosasa														•
Schizostachyum blumei	•	•			•	•	•			•	•			
S. brachycladum	•	•	•	•	•	•	•			•	•			
S. caudatum	•								•					
S. lima	•				•	•	•			•	•			
S. sulingensis														

Table 8n.3

Consumption (%) of bamboos in the Asia-Pacific Region by end-use and a breakdown of the uses by species (country codes in the breakdown are India, In; Bangladesh, Ba; Burma, Bu; Philippines, Ph; Indonesia, Ind; Thailand, Th; Japan, Ja; Taiwan, Tai; Korea, Ko).

Country	Construction		Rural uses	Packaging	Pulp manufacture	Other uses
	Housing	Others				
Bangladesh	50	10	20	5	10	5
Burma	33	32	32	5	-	1
India	16	16	30	7	17	14
Japan	24	7	18	7	4	41
Philippines	80	-	15	2	-	3
Thailand	33	20	6	-	8	33

Walling of native huts
Bambusa tulda (Bu, Ba, Ind)
B. polymorpha (Bu)
B. blumeana (Ph)
B. atra (Ind)
Dendrocalamus asper (Ind)
Gigantochloa nigrociliata (Ind)
Melocanna baccifera (Ba)
Neohouzeoua dulloa (Bu, Ba)
Sinobambusa elegans (In)
Schizostachyum lumampao (Ph)
Thyrsostachys siamensis (Ph)
T. oliveri (Th)

Lance staves
Bambusa blumeana (Ph)
Dendrocalamus strictus (In, Bu)
Ochlandra travancorica (In)
O. scriptorica (In)
Schizostachyum lima (Ind)
Thyrsostachys siamensis (Th)
T. oliveri (Th)

Thatching and roofing
Bambusa arundinacea (In, Ba, Bu, Ind)
B. tulda (In, Ba, Bu)
B. vulgaris (Ind)
B. blumeana (Ph)
B. polymorpha (In, Bu, Ba)
Dendrocalamus strictus (In, Ind)
D. longispathus (Ba, Bu)
D. membranaceus
D. brandisi
D. hamiltonii
Gigantochloa atter (Ind)
Chimonobambusa falcata (In)
Melocanna baccifera (Ba, Bu)
Neohouzeoua dulloa (Ba, Bu)
Oxytenanthera monodelpha (In)
Schizostachyum brachycladum (Ind)

Tea estates
Pseudostachyum polymorphum (In)

Constructions
Bambusa polymorpha (In, Ba, Bu, Ind, Th)
B. balcoa (In)
B. tulda (In, Ba, Bu, Ind)
B. arundinacea (In, Ba, Ind, Th)
B. rutans (In, Bu, Th)
B. khasiana (In)
B. vulgaris (In, Ba, Ph, Ind)
B. burmanica (Ba)
B. pallida (Bu)
B. blumeana (Ph, In)
B. atra (Ind)
Cephalostachyum pergracile (In, Ba, Bu)
Dendrocalamus membranaceus (In, Ba, Bu)
D. hamiltonii (In, Ba, Th, Bu)
D. giganteus (In, Ba, Ind, Bu)
D. longispathus (In, Ba, Th)
D. strictus (In, Bu)
D. calostachyus (Bu)
D. merrillianus (Ph)
D. asper (Ind)
Gigantochloa nigrociliata (In, Ind)
G. verticillata (Bu, Ind)
G. levis (Ph)
Melocanna baccifera (In, Ba, Bu)
Neohouzeoua dulloa (In, Bu)
Oxytenanthera nigrociliata (Ba, Bu)
Schizostachyum lumampao (Ph)
S. brachycladum (Ind)
S. lima (Ind)
Teinostachyum beddomei (In)
Thyrsostachys oliveri
Phyllostachys sp. (Ja, Tai, Ko)

Walking sticks
Arundinaria armata (In)
Dendrocalamus strictus (In, Bu)
Oxytenanthera nigrociliata (Ba, Bu)
Phyllostachys manni

(continued)

Table 8n.3 continued

Basket making
Arundinaria intermedia (In)
Bambusa nutans (In, Bu)
B. pallida (In, Th)
B. khasiana (In)
B. arundinacea (In, Bu. Ind, Th)
B. tulda (Ba. Bu, Ind, Th)
B. vulgaris (Ba, Bu, Ph, Ind)
B. villulosa (Bu)
B. flexuosa (Th)
B. polymorpha (Ba, Ind, Th)
B. blumeana (Ph, Ind)
Chimonobambusa falcata (In)
Cephalostachyum pergracile (Ba, Bu)
Dendrocalamus hamiltonii (In, Bu)
D. longispathus (In, Ba, Bu, Th)
D. strictus (In, Bu)
D. giganteus (In, Ba, Ind)
D. merrillianus (Ph)
D. asper (Ind, Th)
Dinochloa compactiflorus (Bu)
Gigantochloa nigrociliata (In, Bu)
G. macrostachya (Bu)
Indocalamus wightiana (In)
Melocanna baccifera (Ba, Bu)
Neohouzeoua helferi (In)
N. dulloa (Bu)
Oxytenanthera ritcheyi (In)
O. nigrociliata (Ba, Bu)
O. monostigma (Bu)
Pseudostachyum polymorphum (Bu)
Schizostachyum diffusum (Ph)
S. lumampao (Ph)
Thamnocalamus spathiflora (In)
Teinostachyum helferi (Bu)
T. griffithii (Bu)
Phyllostachys sp. (Ja, Ko, Tai)

Loading vessels
Neohouzeoua dulloa (In)
Teinostachyum dulloa

Bows and arrows
Bambusa flexuosa (Th)
B. arundinacea (In)
Cephalostachyum capitatum (In)
C. pergracile
Dendrocalamus strictus (In)
Schizostachyum rogersii (Bu)
S. lima (Ind)

Cooking utensils
Bambusa arundinacea (Ind, Ba, Bu, Th)
B. blumeana (Ph)
Cephalostachyum pergracile (In, Ba, Bu, Th)
Gigantochloa atter (Ind)
Neohouzeoua dulloa
Schizostachyum zollingeri

Mats
Arundinaria intermedia (In)
Bambusa nutans (In, Bu)
B. teres (In, Bu)
B. tulda (In, Ba, Bu, Ind, Th)
B. pallida (In, Ba, Th)
B. arundinacea (In, Ba, Bu, Ind, Th)
B. blumeana (Ph, In)
Cephalostachyum pergracile (In, Ba, Bu)
Dendrocalamus strictus (In)
D. hamiltonii (In, Ba, Bu, Th)
D. merrillianus (Ph)
D. membranaceus (Th)
D. brandisi (Th)
Dinochloa distans (Bu)
Gigantochloa levis (Ph)
G. atter (Ind)
G. macrostachya (Bu)
G. apus (Ind)
Indocalamus wightiana (In)
Melocanna baccifera (Ba)
Pseudostachyum polymorphum (Bu)
Schizostachyum lumampao (Ph)
Teinostachyum dulloa (In, Bu)
Thyrsostachys siamensis (Th)

Water and milk vessels (*Chunga*); water buckets; cups; containers
Bambusa pallida (In, Ba)
B. tulda (Ba, Bu)
B. blumeana (Ph)
Dendrocalamus sikkimensis (In)
D. giganteus (In, Ba, Bu, Ind, Th)
D. hookeri (In, Bu)
D. brandisi (Bu)
D. asper (Ind)
D. hamiltonii (Th)
Gigantochloa levis (Ph)
G. asper (Ph)
Melocanna baccifera (Ba, Bu)

Hedges
Bambusa nana (In, Ba, Bu, Th)
B. vulgaris (Ba, Ind)
B. balcoa (Ba, Ind)
B. arundinacea (Bu)
Cephalostachyum pergracile (Bu)
Cephalostachyum burmanicum (Bu)
Dendrocalamus giganteus (In, Ba, Bu, Ind, Th)
Gigantochloa atter (Ind)
G. nigrociliata (Ind)
Oxytenanthera nigrociliata (Ba)
Thyrsostachys siamensis

Fuel
All bamboos and rhizomes of bamboos (In, Ba, Bu, Ind)

(continued)

Table 8n.3 continued

Seed food
Bambusa arundinacea (In, Ba, Bu)
Cephalostachyum pergracile (In, Ba, Bu)
Dendrocalamus strictus (In)
Dinochloa compactiflora (Bu)
Melocanna baccifera (Ba, Bu)
Thyrsostachys oliveri (Ba, Bu)

Furniture
Bambusa tulda (Ba, Bu)
B. glaucescens (Ind)
B. vulgaris (Ind)
B. arundinacea (Th)
Dendrocalamus strictus (In, Ba, Bu)
D. membranaceus (Th)
D. brandisi (Th)
D. latiflorus
D. longispathus (Th)
D. asper (Th)
Gigantochloa atter (Ind)
G. apus (Ind)
Melocanna baccifera (Ba, Bu)
Schizostachyum diffusum (Ph)
Thyrosostachys siamensis (Ind, Th)
All thick-walled species (Ph, Ind)
Phyllostachys sp. (Ja, Ko, Tai)

Agricultural implements
Bambusa vulgaris (Ba, Bu, Ind, Ph)
B. balcoa (Ba, Bu, Ind)
B. blumeana (Ph, Th)
B. flexuosa (Th)
Dendrocalamus strictus (In, Bu, Th)
D. merrillianus (Ph)
D. asper (Th)
Ochlandra travancorica (In)
Thyrsostachys siamensis (Th)
T. oliveri (Th)
All thinner varieties (In, Ba, Bu)

Fodder
Arundinaria racemosa (In)
Chimonobambusa densifolia (In)
Cephalostachyum pergracile (In)
Dendrocalamus strictus (In)
D. sikkimensis (In)
Leaves of all bamboos (Ba, Bu, Ind)

Floats for timber; rafts
Bambusa arundinacea (In, Bu, Th)
B. blumeana (Ph, Ind)
Dendrocalamus hamiltonii (In, Bu)
D. longispathus (Ba)
D. distans
D. asper (Ind)
D. membranaceus (Th)
Ochlandra scriptoria (In)
Melocanna baccifera (Ba, Bu)
M. compactiflorus (Th)
Neohouzeoua dulloa (Ba)

Tool handles
Bambusa blumeana (Ph, Th)
B. flexuosa (Th)
B. polymorpha (Ba, Bu, Ind)
Dendrocalamus asper
D. strictus (In, Th)
D. merrillianus (Ph)
Ochlandra travancorica (In)
Teinostachyum griffithii (Ba, Bu)
Thyrsostachys siamensis (Th)
Solid varieties (Ind)

Fencing
Indocalamus wightianus (In, Ba, Bu, Ind, Ph, Th)
All bamboos (In, Ph, Ba, Bu, Ind, Th, Ja, Ko, Tai)

Hookah pipes
Chimonobambusa falcata (In)
Phyllostachys sedan (Bu)
Thamnocalamus spathiflora (In)
T. aristatus
Teinostachyum griffithii

Fishing rods
Arundinaria amabilis (In)
Bambusa glaucescens (Ind)
B. atra (Ind)
Chimonobambusa falcata (In)
C. khasiana (In)
C. intermedia (In)
Dendrocalamus strictus (In)
Schizostachyum zollingeri (Ind)
S. blumei (Ind)
S. lima (Ph)
Thyrsostachys siamensis (Th, Ind)
T. oliveri (Th)
Phyllostachys nigra (Ja)

Shoots for food
Bambusa tulda (In, Ba, Bu, Ph, Ind)
B. arundinacea (In, Ba, Bu, Ind)
B. nana (Bu)
B. vulgaris (Bu, Ph, Ind)
B. blumeana (Ph)
B. glaucescens (Ind)
Dendrocalamus hamiltonii (Ba, Bu)
D. latiflorus (Tai)
D. giganteus (In, Ind)
D. longispathus (Ba)
D. flagellifer (Bu)
D. merrillianus (Ph)
D. asper (Ind, Th)
Dinochloa scandens (Ind)
Gigantochloa nigrociliata (Ind)
G. hasskarliana (Ind)
G. verticillata (Bu, Ind)
G. levis (Ph)

(continued)

Table 8n.3 continued

G. atter (Ind)
G. albociliata (Th)
Phyllostachys edulis (Ta, Ja, Ko)
Schizostachyum brachycladum (Ind)
S. blumei (Ind)
S. zollingeri (Ind)
Sinobambusa elegans (In)
Thyrsostachys siamensis (Th)
All large bamboos - shoots (Th)

General utility
Bambusa arundinacea (In, Ba, Bu)
B. tulda (Bu)
B. pallida (Bu)
B. blumeana (Ph)
B. vulgaris (Ph)
Cephalostachyum pergracile
C. burmanicum
Dendrocalamus strictus (In, Bu)
D. hookeri (In, Bu)
D. hamiltonii (Ba)
D. calostachyus (Bu)
D. merrillianus (Ph)
Dinochloa sp. (Ph)
Gigantochloa levis (Ph)
G. asper (Ph)
Neohouzeoua dulloa
All strong bamboos (Ind, Th, Ja, Ko, Tai)

Punting poles
Oxytenanthera stocksii (In)
Solid varieties (Ba, Bu)
Phyllostachys nigra (Ja)

Sericultural industry — trays for silkworms
Bambusa arundinacea (In)
Dendrocalamus strictus (In)
Thyrsostachys siamensis (Th)
All bamboos (Ba, Ind)

Chicks for doors and windows
Bambusa arundinacea (In, Bu, Ind, Th)
B. polymorpha (Ba, Bu)
B. blumeana (Ph, Ind)
B. vulgaris (Ind)
Dendrocalamus strictus (In)
D. longispathus (Th)
D. membranaceus (Th)
Melocanna bambusoides
Neohouzeoua dulloa (Ba, Bu)
Schizostachyum lumampao (Ph)
S. zollingeri (Ind)
Thyrsostachys siamensis (Th)
T. oliveri (Th)
All bamboos (Ta, Ko, Tai)

Pipes
Bambusa arundinacea (Bu)
Neohouzeoua dulloa (Bu)
Teinostachyum griffithii (In, Ba)

Haystack stabilizers
Bambusa vulgaris (Ba, Bu)
B. tulda (Ba, Bu)
B. blumeana (Ph)
Dendrocalamus strictus (In)
All bamboos can be used (Ind)

Horticultural pursuits
Bambusa arundinacea (In, Bu)
B. polymorpha (Ba)
B. blumeana (Ph)
Dendrocalamus strictus (In)
Melocanna baccifera (Ba, Bu)
All bamboos (Ind, Th)
Other strong species (Ph)

Cremation; coffins
Bambusa arundinacea (In)
Dendrocalamus strictus (In)
All bamboos

Cradles
Bambusa arundinacea (In)
Dendrocalamus strictus (In)

Scaffolding
Bambusa arundinacea (In)
Dendrocalamus strictus (In)

Cart yokes
All large-sized, hard and solid bamboos (In)

Ladders
Bambusa arundinacea (In)
Dendrocalamus strictus (In)

Musical instruments (flutes; marimba; horns; clarinets; flageolets; saxophones; piccolos; drums; etc.)
Arundinaria sp.
Arundinaria mitskayamensis (Ph)
Dendrocalamus strictus (In, Th)
D. longispathus (Th)
Gigantochloa atter (Ind)
Schizostachyum lima (Ind)
S. blumei (Ind)
All small-sized bamboos (Ph)

Containers for cleaning grains
All bamboos (In)

Protection during grain pounding
Bambusa arundinacea
All large-sized bamboos (In)

Cart sheds; roofs
Bambusa blumeana (Ph)
Dendrocalamus merrillianus (Ph)
All bamboos (In)

Stakes for foresters
Thyrsostachys siamensis (Th)
T. oliveri (Th)
All bamboos (In)

(continued)

Table 8n.3 continued

Country tiles
Bambusa arundinacea (In)
Pan trays
Neohouzeoua dulloa (In)
Teinostachyum dulloa (Bu)
Seed drills
Dendrocalamus strictus
Containers to administer medicine to animals
Bambusa arundinacea (In)
Fishing implements; floats; pens; traps
Bambusa polymorpha (Ba, Bu, Ind)
B. atra (Ind)
B. vulgaris (Ba, Bu)
B. blumeana (Ph)
Gigantochloa levis (Ph)
Melocanna baccifera (Ba, Bu)
Neohouzeoua dulloa (Ba, Bu)
Schizostachyum blumeana (Ind)
S. lumampao (Ph)
Boat roofs
Bambusa arundinacea (In)
B. tulda (Ba, Bu)
B. blumeana (Ph)
Melocanna baccifera (Ba, Bu)
Ornaments
Bambusa vulgaris (Ind, Ba, Bu, In, Ph)
B. nana (Ph)
B. vulgaris var. *striata* (Ph)
B. glaucescens (Ph)
B. polymorpha (Ind)
B. atra (Ind)
Cephalostachyum pergracile (In)
Dendrocalamus giganteus
Phyllostachys aurea (Ind)
Schizostachyum brachycladum (Ind)
S. zollingeri (Ind)
Thyrsostachys siamensis
Culm sheaths (irrigation)
Bambusa blumeana (Ph)
Climbing species of bamboos (Ph)
Dendrocalamus longispathus (Bu)
Gigantochloa macrostachya (Bu)
G. levis (Ph)
Cordage
Bambusa vulgaris (Ph)
B. atra (Ind)
Dendrocalamus strictus (Bu)
D. merrillianus (Ph)
Dinochloa scandens (Ind)
Pseudostachyum polymorphum (Bu)
Inner layer of culm sheath as cheroot wrapper
Dendrocalamus hamiltonii (Bu)
Plaited shoes
Dinochloa compactiflora (Bu)

Umbrella handles
Melocanna baccifera (Ba, Bu)
Oxytenanthera stocksii (Ind)
Teinostachyum griffithii (Ba, Bu)
Thyrsostachys siamensis (Bu)
Shuttles
Bambusa blumeana (Ph)
Piculan
Bambusa glaucescens (Ind)
Tobacco drying
Dinochloa scandens (Ind)
Nastus elegantissimus (Ind)
Phyllostachys edulis (Jap)

Boat masts
Bambusa blumeana (Ph)
Dendrocalamus brandisi
Gigantochloa levis (Ph)
Joints for cooking glutinous rice
Cephalostachyum pergracile (Bu)
C. burmanicum (Bu)
Bridges
Bambusa blumeana (Ph)
B. vulgaris (Ph)
E. arundinacea (Ph)
Boat plying rods
Bambusa polymorpha (Ba, Bu, Ind)
B. glaucescens (Ind)
Melocanna baccifera (Ba, Bu)
Rickshaw hoods
Bambusa vulgaris (Ba)
Pea sticks
Thamnocalamus spathiflora (In)
Barbecue skewers
Bambusa blumeana
Trellises
Bambusa arundinacea (In)
B. blumeana (In)
All large-sized bamboos
Flues
Bambusa blumeana (Ph)
B. glaucescens (Ph)
Schizostachyum lumampao (Ph)
Hats
Bambusa blumeana (Ph)
B. vulgaris (Ph)
Barrels for toy cannons
Bambusa blumeana (Ph)
Gigantochloa levis (Ph)
Sledges (transport)
Bambusa blumeana (Ph)
Dendrocalamus merrillianus (Ph)
Handicrafts
Bambusa blumeana (Ph, Ind)
B. vulgaris
Dendrocalamus asper (Ind)
Dinochloa scandens (Ind)
Gigantochloa verticillata
G. atter
G. apus
Nastus elegantissimus
Schizostachyum lima (Ph)
S. brachycladum
S. blumei (Ind)
All bamboos (Th)
Sprayers
Bambusa blumeana (Ph)
Polo mallets
Bambusa blumeana (Ph)

Eyeliner
Dinochloa scandens(Ind)
Jaundice treatment
Bambusa vulgaris (Ind)
Ladders
Bambusa arundinacea (Ind)
Dendrocalamus strictus (Ind)
Afforestation of riverbanks and soil conservation areas; shelter belts; windbreaks
All bamboos

Afforestation of river banks and soil conservation areas, shelter belts and wind belts : all bamboos.

Agricultural implements : *Bambusa balcooa, Bambusa vulgaris, Dendrocalamus strictus' Ochlandra travancorica*, all thinner varieties.

Bamboo hats : *Bambusa blumeana, Bambusa vulgaris.*

Basket making : *Arundinaria intermedia, Bambusa arundinacea, Bambusa nutans, Bambusa pallida, Bambusa khasiana, Bambusa tulda, Bambusa vulgaris, Bambusa polymorpha, Chimonobambusa falcata, Dendrocalamus giganteus, Dendrocalamus longispathus, Dendrocalamus hamiltonii, Dendrocalamus strictus, Gigantochloa nigrociliata, Indocalamus wightiana, Neohouzeaua helferi, Oxytenanthera ritchevi, Thamnocalamus spathiflora.*

Boat plying rod : *Bambusa glaucescens* and *Bambusa polymorpha.*

Bows and arrows : *Bambusa arundinacea, Cephalostachyum capitatum, Cephalostachyum pergracile, Dendrocalumus strictus.*

Bridges : *Bambusa arundinacea, Bambusa vulgaris.*

Cart containers and roof : All bamboos.

Cart yokes : All large sized hard and solid bamboos.

Chicks for doors and windows : *Bambusa arundinacea, Dendrocalamus strictus.*

Combs : *Oxytenanthera bourdillonii.*

Containers for cleaning grains : All bamboos.

Containers to carry maps : *Oxytenanthera bourdillonii.*

Constructions : *Bambusa polymorpha, Bambusa balcooa, Bambusa tulda, Bambusa arundinacea, Bambusa nutans, Bambusa khasiana, Bambusa vulgaris, Bambusa blumeana, Cephalostachyum capitatum, Cephalostachyum pergracile, Dendrocalamus membranaceus, Dendrocalamus hamiltonii, Dendrocalamus giganteus, Dendrocalamus longispathus, Dendrocalamus strictus, Gigantochloa nigrociliata, Melocanna baccifera, Neohouzeaua dullooa, Oxytenanthera stocksii, Teinostachyum beddomei, Thyrosostachys oliverii.*

Containers to administer medicine to Bulls and animals : *Bambusa arundinacea.*

Country tiles : *Bambusa arundinacea.*

Cooking utensils : *Bambusa arundinacea, Cephalostachyum pergracile.*

Cradles : *Bambusa arundinacea, Dendrocalamus strictus.*

Cremation & Coffins : *Bambusa arundinacea, Dendrocalamus strictus* and all bamboos.

Fencing : *Indocalamus wightianus, Oxytenanthera monodelpha, Oxytenanthera ritchevi* and all bamboos.

Fishing rods : *Arundinaria amabilis, Chimonobambusa falcata, Chimonobambusa khasiana, Chimonobambusa intermedia, Dendrocalamus strictus.*

Floating timber and rafting : *Bambusa arundinacea, Dendrocalamus hamiltonii, Ochlandra scriptoria.*

Flooring : *Bambusa polymorpha.*

Fodder : *Arundinaria racemosa, Chimonobambusa densifolia, Cephalostachyum capitatum, Cephalostachyum pergracile, Dendrocalamus sikkimensis, Dendrocalamus strictus, Ochlandra travancorica, Bambusa arundinacea* and leaves of all bamboos.

For Jaundice : *Bambusa vulgaris.*

Fuel : All bamboos and rhizomes of bamboos.

Furniture : *Bambusa arundinacea, Bambusa glaucescens, Bambusa tulda, Bambusa vulgaris*, all thick walled species.

General utility : *Bambusa arundinacea, Bambusa tulda, Cephalostachyum burmanicum, Cephalostachyum pergracile, Dendrocalamus hamiltonii, Dendrocalamus hookeri, Dendrocalamus strictus*, all bamboos which are strong.

Handicrafts : *Bambusa blumeana, Bambusa vulgaris.*

Hedges : *Bambusa nana, Dendrocalamus giganteus.*

Hookah pipes : *Chimonobambusa falcata, Thamnocalamus aristatus, Teinostachyum griffithii, Thamnocalamus spathiflora.*

Horticultural pursuits : *Bambusa arundinacea, Dendrocalamus strictus*, all bamboos and other strong species.

Ladders : *Bambusa arundinacea* and *Dendrocalamus strictus.*

Uses of bamboos in India Source: Varmah and Pant (1981)

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Lance staves : *Dendrocalamus strictus, Ochlandra scriptorica, Ochlandra travancorica.*

Lattle shats : *Dendrocalamus strictus, Ochlandra* species.

Leading vessels : *Neohauzeaua dulloa.*

Mats : *Arundinacia intermedia, Arundinacia racemosa, Bambusa arundinacea, Bambusa blumeana, Bambusa nutans, Bambusa pallida, Bambusa teres, Bambusa tulda, Cephalostachyum pergracile, Dendrocalamus hamiltonii, Dendrocalamus strictus, Indocalamus wightiana, Neohauzeaua dulloa, Ochlandra scriptorica, Ochlandra travancorica, Oxytenanthera nigrociliata, Teinostachyum dulloa.*

Match boxes and splints : *Ochlandra travancorica.*

Musical instruments : (Flutes, mariba, horns, clarionets, flagerlets, saxophones, piccolos, drums, etc.) : *Arundinaria* spp., *Dendrocalamus strictus*, all small sized bamboos.

Ornamental purposes : *Bambusa vulgaris, Cephalostchyum pergracile, Dendrocalamus giganteus, Phyllostachys aurea, Oxytenanthera monadelpha, Thyrsostachys siamensis.*

Pandals for shade : All bamboos.

Pan trays : *Neohauzeaua dulloa.*

Paper and Pulp :—An idea about the changes in the utilisation pattern of bamboo in the production of paper and paper board can be had from Table 1.

Table 1

Production of Paper and Paper Board and Consumption of the Raw Material for the Industry

Year	Total Production of Paper & Board in '000 tons	Name of the Raw material and its percentage (by weight) use in the manufacture						
		Grass	Rags	Waste Paper	Agricultural waste	Bamboo	Hard wood	Imported wood
1936	40	29.31	7.27	5.01	0	49.08	0	9.33
1952	130	12.86	6.30	6.30	0	73.59	0	0.95
1958	203	8.23	4.11	4.11	3.29	74.13	1.15	4.98
1970	758	9.75	4.87	7.31	2.43	56.09	19.51	0.04
1975	959	9.83	4.09	6.55	2.45	47.54	29.54	0.00
1980 (estimated)	2001	6.42	3.66	6.42	2.75	29.35	51.37	0.03

Source : Pant, M.M., 1977 : 'Socio-Economic Returns of Applied Research in the Cellulose and Paper Branch of Forest Research Institute'.

The country's paper industry mainly depends upon *Dendrocalamus strictus* and *Bambusa arundinacea*. The mills in the north mainly use the former species while those in the east and the south use both. *Bambusa nutans, Bambusa tulda, Dendrocalamus hamiltonii* and *Melocanna baccifera* are some of the other bamboo species with limited uses. Presently, nearly 3 million tons of bamboos are used annually by the paper industry with possibilities of a substantial rise in the intake if economically available.

Other suitable species are :—*Neohauzeaua dulloa, Ochlandra brandisii, Ochlandra reheedii, Ochlandra scriptoria, Ochlandra setigera, Ochlandra wightii, Oxytenanthera nigrociliata, Bambusa arundinacea, Bambusa nutans, Bambusa polymorpha, Bambusa tulda, Dendrocalamus asper, Dendrocalamus brandisii, Dendrocalamus hamiltonii, Dendrocalamus longispathus, Dendrocalamus membranceus, Thyrsostachys oliveri, Thyrsostachys siamensis.*

Pea sticks : *Thamnocalamus spathiflora.*

Pipes : *Bambusa arundinacea, Dendrocalamus hamiltonii* and *Teinostachyum griffithii.*

Polomallets : *Bambusa blumeana* (Basal portion of culm).

Protection while pounding grain : *Bambusa arundinacea* and all big sized bamboos.

Punting poles : *Oxytenanthera stocksii, Oxytenanthera ritcheri*, solid varieties.

Riekshaw hoods : *Bambusa vulgaris, Dendrocalamus* species.

Roofing of boats : *Bambusa arundinacea, Bambusa tulda.*

Scaffolding : *Bambusa arundinacea, Bambusa vulgaris, Dendrocalamus strictus.*

Seed food : *Bambusa arundinacea, Cephalostachyum pergracile* and *Dendrocalamus strictus.*

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Seed drills : *Dendrocalamus strictus.*

Sericultural Industry : Trays for rearing silk worms : *Bambusa arundinacea, Dendrocalamus strictus, Thyrsostachys siamensis.*

Shoots as vegetables and food : *Bambusa arundinacea, Bambusa nana, Bambusa tulda, Bambusa vulgaris, Dendrocalamus giganteus, Dendrocalamus hamiltonii, Dendrocalamus longispathus, Sinobambusa elegans* and all large bamboo shoots.

Stablishing haystocks : *Bambusa blumeana, Bambusa tulda, Bambusa vulgaris, Dendrocalamus strictus* (All bamboos can be used).

Stakes in Forestry practices : All bamboos.

Tea estates : *Pseudostachyum polymorphum.*

Thatching and roofing : *Bambusa arundinacea, Bambusa polymorpha, Bambusa tulda, Bambusa vulgaris, Chimnobambusa falcata, Dendrocalamus brandisii, Dendrocalamus hamiltonii, Dendrocalamus longispathus, Dendrocalamus membranaceus, Gigantochloa attar, Oxytenanthera monodelpha, Dendrocalamus strictus.*

Tool handles : *Dendrocalamus merrillianus. Dendrocalamus strictus, Ochlandra travancorica* and all solid varieties.

Trellis work : *Bambusa arundinacea, Bambusa blumeana* and all big sized bamboos.

Umbrella handles : *Melocanna baccifera, Neohauzeaua dullooa, Oxytenanthera ritchevi. Oxytenanthera stocksii, Teinostachyum griffithii.*

Working sticks : *Arundinaria armata, Dendrocalamus strictus, Ochlandra travancorica, Oxytenanthera nigrociliata. Oxytenanthera ritchevi. Phyllostachys manni.*

Walling of native huts : *Arundinaria racemosa, Bambusa atra, Bambusa polymorpha, Bambusa tulda, Gigantochloa nigrociliata, Neohauzeaua dullooa, Oxytenanthera nigrociliata, Sinobambusa elegans.*

Water and milk vessels (Thunga), water buckets, cups and containers : *Bambusa pallida, Bambusa tulda, Dendrocalamus asper, Dendrocalamus giganteus, Dendrocalamus hamiltonii, Dendrocalamus hookeri, Dendrocalamus sikkimmensis, Gigantochloa aspera, Gigantochloa levis, Melocanna baccifera.*

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Ecological requirements of some artificially established browse species in North Africa

(Source: Le Houérou, 1980)

Species	Rainfall in mm	Mean minimum t° of January in °C	Soils
Acacia cyanophylla	> 250	> 3	Deep sandy
" ligulata	> 150	> 3	"
" salicina	> 150	> 3	"
" victoriae	> 150	> 3	Silty to sandy
Artemisia herba alba	> 150	>-2	Silty, Shallow
Atriplex canescens	> 200	>-5	Sandy to Silty
" glauca	> 150	> 1	Silty to clayey, saline EC < 30 mmhos
" halimus	> 150	> 1	
" nummularia	> 200	> 1	Silty to clayey EC < 20 mmhos
Brachychyton populneum	> 300	> 3	Various
Broussonetia papyrifera	> 400	>-1	Various
Calligonum comosum	> 80	>-1	Drifting sand
Cassia sturtii	> 150	> 3	Silty-Sandy
Celtis australis	> 700	> 1	Various
Ceratonia siliqua	> 300	> 3	Silty-sandy Rocky
Chenopodium auricomum	> 200	> 3	Various
Coronilla glauca	> 300	> 2	Silty, Shallow
Eleagnus angustifolia	> 300	>-2	Various
Fraxinus oxyphylla	> 500	> 1	Various
Gleiditshia triacanthos	> 400	>-5	Various
Haloxylon ephyllum	> 80	>-10	Silty-clayey.
" persicum	> 80	>-10	Sandy
Medicago arborea	> 300	> 2	Silty, Shallow
Morus alba	> 350	>-5	Various
Olea europaea	> 200	> 2	Deep sandy
Opuntia ficus-indica inermis	> 200	> 2	Deep sandy
" fusicaulis	> 200	> 1	" "
" inermis	> 200	> 1	" "

Prosopis	juliflora	>200	2	Sandy
Vitis	berlandieri	>200	-5	Various
"	riparia	>200	-5	"
"	rupestris	>400	-5	"
"	vinifera	>200	-5	"

From the above table it is obvious that with the available plant material, of some 35 species, one can meet most of the ecological conditions prevailing in northern Africa, except in the desert where rainfall does not reach the 100 mark.

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MASTERLIST OF WOODY SPECIES UNDER CONSIDERATION AS NITROGEN-FIXING TREES

(J. Halliday and P.L. Nakao, eds.,
Prepared for Bellagio Workshop; Document #1)

1. The NFT Masterlist includes:

   -- 997 species

   -- all woody species of the legume family even though confirmation that they individually nodulate and fix nitrogen may be lacking

   -- all species of all other genera in which a species has been confirmed to nodulate or fix nitrogen.

2. The masterlist is abstracted from a larger data base maintained by the University of Hawaii NiFTAL Project. The complete data base includes a general characterization of each species, and specifies its microsymbiotic affinities, both rhizobial and mycorrhizal. The complete data base also cites the scientific literature that substantiates that a listed species does or does not fix nitrogen.

3. The Masterlist is actually the first section of a more complete publication available directly from NiFTAL (P.O. Box O, Paia, Hawaii 96779, USA):

   Halliday, J., and P.L. Nakao. 1982. The symbiotic affinities of woody species under consideration as nitrogen-fixing trees. University of Hawaii NiFTAL Project. 85 pages.

Acacia abyssinica
Acacia acinacea
Acacia acuminata
Acacia adenocalyx
Acacia adunca
Acacia alata
Acacia albida
Acacia anceps
Acacia aneura
Acacia arabica (nilotica)
Acacia arenaria
Acacia armata
Acacia aroma
Acacia aspera
Acacia atamacantha
Acacia aulacocarpa
Acacia auriculiformis
Acacia baileyana
Acacia berlandieri
Acacia berteriana
Acacia bidentata
Acacia biflora
Acacia blakelyi
Acacia boeriensis
Acacia borlaea
Acacia brachybotrya
Acacia brachystachya
Acacia burkei
Acacia buxifolia
Acacia byoneana
Acacia caffra
Acacia calamifolia
Acacia calcina
Acacia cambagei
Acacia cana
Acacia cardiophylla
Acacia catechu
Acacia cavan
Acacia cavenia
Acacia celastrifolia
Acacia chariessa
Acacia cognata
Acacia colletoides
Acacia coeplanata
Acacia confusa
Acacia constricta
Acacia crassicarpa
Acacia cultriformis
Acacia cunninghacii
Acacia cupressiformis

Acacia cyanophylla (saligna)
Acacia cyclops
Acacia davyi
Acacia dealbata
Acacia deamii
Acacia deanei
Acacia decora
Acacia decurrens
Acacia diptera
Acacia doratoxylon
Acacia drummondii
Acacia ehrenbergiana
Acacia elata
Acacia eremophila
Acacia ericifolia
Acacia erinacea
Acacia erubescens
Acacia estrophiolata
Acacia excelsa
Acacia extensa
Acacia exuvialis
Acacia farnesiana
Acacia filifolia
Acacia fimbriata
Acacia fistula
Acacia flava
Acacia fleckii
Acacia flexuosa
Acacia floribunda
Acacia galpinii
Acacia genistoides
Acacia georginae
Acacia giraffae
Acacia gladiiformis
Acacia glaucescens
Acacia glaucescens
Acacia glaucoptera
Acacia glomerosa
Acacia goetzii
Acacia grandicornuta
Acacia granitica
Acacia greggii
Acacia haleoides
Acacia harpophylla
Acacia harveyi
Acacia hastulata
Acacia hebeclada
Acacia hereroensis
Acacia heteracantha
Acacia heterophylla

Acacia holosericea
Acacia homalophylla
Acacia horrida
Acacia horridula
Acacia huegelii
Acacia instia
Acacia jonesii
Acacia juniperina
Acacia karoo
Acacia kauaiensis
Acacia keppeana
Acacia kirkii
Acacia koa
Acacia koaia
Acacia kraussiana
Acacia latifolia
Acacia leptoneura
Acacia leucophloea
Acacia linearis
Acacia lineata
Acacia lingulata
Acacia loderi
Acacia longifolia
Acacia luederitzii
Acacia lunata
Acacia macrantha
Acacia macrathyrsa
Acacia mangium
Acacia mearnsii
Acacia melanoxylon
Acacia mellei
Acacia mellifera
Acacia microbotrya
Acacia mollissima
Acacia mollissima
Acacia mooreana
Acacia myrtifolia
Acacia nebrownii
Acacia neriifolia
Acacia nervosa
Acacia nigrescens
Acacia nigricans
Acacia nilotica
Acacia nubica
Acacia obliqua
Acacia obscura
Acacia orfoto
Acacia oswaldii
Acacia parramattensis
Acacia pence

Acacia pennata
Acacia pentadenia
Acacia pentagona
Acacia permixta
Acacia podalyriaefolia
Acacia polyacantha
Acacia pravissima
Acacia prominens
Acacia pubescens
Acacia pulchella
Acacia pumila
Acacia pycnantha
Acacia raddiana
Acacia reficiens
Acacia rehmanniana
Acacia restiacea
Acacia rhetinodes
Acacia richii
Acacia rigens
Acacia robusta
Acacia rostellifera
Acacia rubida
Acacia salicina
Acacia saligna
Acacia schweinfurthii
Acacia scorpoides
Acacia senegal
Acacia seyal
Acacia siamensis
Acacia sieberana
Acacia silvicola
Acacia spadicigera
Acacia spathulata
Acacia spinescens
Acacia spirocarpa
Acacia squamata
Acacia stenophylla
Acacia stenoptera
Acacia strigosa
Acacia stuhlmanii
Acacia suavolens
Acacia subcaerulea
Acacia suffructescens
Acacia sulcata
Acacia swazica
Acacia tamminensis
Acacia tennispina
Acacia tetragonocarpa
Acacia tomentosa
Acacia tortilis

Acacia triptera
Acacia tucumanensis
Acacia unicifera
Acacia urophylla
Acacia verek
Acacia verticillata
Acacia victoriae
Acacia visco
Acacia visite
Acacia volubilis
Acacia welwitscii
Acacia xanthophloea
Acrocarpus fraxinifolius
Adenanthera bicolor
Adenanthera intermedia
Adenanthera pavonina
Afzelia africana
Afzelia quanzensis
Airyantha borneensis
Airyantha schweinfurthi
Albizia acle
Albizia adianthifolia
Albizia amara
Albizia anthelmintica
Albizia antunesiana
Albizia brevifolia
Albizia carbonaria
Albizia chinensis
Albizia distachya
Albizia ealensis
Albizia falcataria
Albizia forbesii
Albizia glaberrima
Albizia gummifera
Albizia harveyi
Albizia julibrissin
Albizia katangensis
Albizia lebbek
Albizia lebbekoides
Albizia lophantha
Albizia moluccana
Albizia odoratissima
Albizia petersiana
Albizia procera
Albizia retusa
Albizia saponaria
Albizia schimperana
Albizia stipulata
Albizia tanganyicensis
Albizia versicolor

Albizia zimmermannii
Aldina insignis
Alexa imperatricis
Alnus acuminata
Alnus cordata
Alnus crispa
Alnus firma
Alnus formosana
Alnus fructicosa
Alnus glutinosa
Alnus hirsuta
Alnus incana
Alnus jorullensis
Alnus maritima
Alnus mollis
Alnus multinervous
Alnus nepalensis
Alnus nitida
Alnus orientalis
Alnus rubra
Alnus serrulata
Alnus sieboldiana
Alnus sinuata
Alnus tenuifolia
Alnus tinctoria
Alnus undulata
Alnus viridis
Amblygonocarpus andongensis
Amburana acreana
Amburana cearensis
Amherstia nobilis
Amphimas ferrugineus
Anadenanthera colubrina
Anadenanthera peregrina
Androcalymma glabiforum
Angylocalyx oligophyllus
Angylocalyx zenkeri
Antheroporum pierrei
Anthonotha macrophylla
Apaloxylon madagascariensis
Aphonocalyx cynometroides
Apoplanesia paniculata
Aprevalia floribunda
Apuleia praecox
Arthrocarpum gracile
Arthrosamanea pistaciaefolia
Ateleia pterocarpa
Baikiaea insignis
Baikiaea plurijuga
Baphiopsis parviflora

Barklya syringifolia
Batesia floribunda
Bathiaea rubiflora
Baudouinia sollyiformis
Bauhinia acuminata
Bauhinia benthamiana
Bauhinia bidentata
Bauhinia binata
Bauhinia blakeana
Bauhinia candicans
Bauhinia carronni
Bauhinia corymbosa
Bauhinia cumingiana
Bauhinia diphylla
Bauhinia excisa
Bauhinia galpinii
Bauhinia kirkii
Bauhinia kochiana
Bauhinia kunthiana
Bauhinia macrantha
Bauhinia malabarica
Bauhinia megalandra
Bauhinia monandra
Bauhinia pauletia
Bauhinia petersiana
Bauhinia purpurea
Bauhinia racemosa
Bauhinia reticulata
Bauhinia tomentosa
Behaimia cubensis
Belairia spinosa
Bergeronia sericea
Berlinia acuminata
Berlinia confusa
Berlinia grandiflora
Bolusanthus speciosus
Bowdichia virgilioides
Brachystegia allenii
Brachystegia appendiculata
Brachystegia boehmii
Brachystegia glaberrima
Brachystegia glaucescens
Brachystegia kennedyi
Brachystegia laurentii
Brachystegia leonensis
Brachystegia manga
Brachystegia microphylla
Brachystegia nigerica
Brachystegia spiciformis
Brachystegia utilis
Brachystegia wangermeeana
Brandzeia filicifolia
Breniera insignis
Brongniartia minutifolia
Brongniartia podalyroides
Brownea ariza
Brownea capitella
Brownea coccinea
Brownea crawfordii
Brownea grandiceps
Brownea latifolia
Browneopsis ucayalina
Brya ebenus
Burkea africana
Bussea occidentalis
Butea eggelingii
Butea massaiensis
Butea monosperma
Cadia purpurea
Caesalpinia echinata
Caesalpinia peltophoroides
Caesalpinia pulcherrima
Cajanus cajan
Calliandra affinis
Calliandra calothyrsus
Calliandra eriophylla
Calliandra foliosa
Calliandra grandiflora
Calliandra guildingii
Calliandra haematocephala
Calliandra haematoma
Calliandra houalis
Calliandra inaequilatera
Calliandra parvifolia
Calliandra selloi
Calliandra surinamensis
Calliandra tweedii
Calpocalyx brevibracteatus
Campsiandra angustifolia
Campsiandra comosa
Campsiandra laurifolia
Caragana arborescens
Caragana aurantiaca
Caragana frutescens
Caragana pekinensis
Cascaronia astragalina
Cassia fistula
Cassia grandis
Cassia javanica
Cassia leiandra
Cassia nodosa
Cassia siamea
Castanospermum australe
Casuarina cristata (C. lepidophloia)
Casuarina cunninghamiana
Casuarina equistifolia
Casuarina fraseriana
Casuarina glauca
Casuarina grandis
Casuarina huegeliana
Casuarina junghuhniana (C. montana)
Casuarina littoris
Casuarina muellerana
Casuarina muricata
Casuarina nodiflora
Casuarina obesa
Casuarina ologodon
Casuarina pusilla
Casuarina quadrivalis
Casuarina stricta
Casuarina sumatrana
Casuarina tenuissima
Casuarina torulosa
Cathormion leptophyllum
Cathormion moniliforme
Cedrelinga catenaeformis
Cenostigma macrophyllum
Centrolobium robustum
Ceanothus americanus
Ceanothus azurens
Ceanothus cordulatus
Ceanothus crassifolius
Ceanothus cuneatus
Ceanothus delilianus
Ceanothus divaricatus
Ceanothus diversifolius
Ceanothus fendleri
Ceanothus foliosus
Ceanothus fresnensis
Ceanothus glabra
Ceanothus gloriosa
Ceanothus gregoii
Ceanothus griseus
Ceanothus impressus
Ceanothus incana
Ceanothus integerrimus
Ceanothus intermedius
Ceanothus jepsonii
Ceanothus leucodermis
Ceanothus microphyllus

Ceanothus oliganthus
Ceanothus ovatus
Ceanothus parvifolius
Ceanothus prostratus
Ceanothus rigidus
Ceanothus sanguineus
Ceanothus sorediatans
Ceanothus thyrsiflorus
Ceanothus velutinus
Ceratonia siliqua
Cercidium floridum
Cercidium praecox
Cercidium torreyanum
Cercis siliquastrum
Cercocarpus betuloides
Chidlowia sanguinea
Chordospartium stevensonii
Cladrastis platycarpa
Cladrastis sinensis
Clathrotropis brachypetala
Clathrotropis macrocarpus
Clathrotropis nitida
Colophospermum mopane
Colvillea racemosa
Comptonia peregrina (M. asplenifolia)
Cordeauxia edulis
Cordyla africana
Coriaria angustissima
Coriaria arborea
Coriaria intermedia
Coriaria japonica
Coriaria kingiana
Coriaria lurida
Coriaria myrtifolia
Coriaria plumosa
Coriaria pottsiana
Coriaria pteridoides
Coriaria sarmentosa
Coriaria thymifolia
Craibia baptisarum
Craibia brevicaudata
Craibia grandiflora
Crudia gabonensis
Crudia parivoa
Cyclobium brasiliense
Cyclolobium vecchii
Cylicodiscus gabunensis
Cynometra alexandri
Cynometra ananta
Cynometra bauhiniaefolia
Cynometra cauliflora
Cynometra hankei
Cynometra leonensis
Cynometra ramiflora
Cynometra retusa
Dalbergia baroni
Dalbergia cearensis
Dalbergia cochinchinensis
Dalbergia cubilquitensis
Dalbergia greveana
Dalbergia latifolia
Dalbergia melanoxylon
Dalbergia nigra
Dalbergia retusa
Dalbergia sissoo
Dalbergia spruciana
Dalbergia stevensonii
Dalbergiella nyasae
Dalea spinosa
Daniellia ogea
Daniellia olivera
Daniellia thurifera
Dansera procera
Delaportea armata
Delonix baccal
Delonix elata
Delonix regia
Denistophytum madagascariense
Derris indica
Detarium senegalense
Dewevrea bilabiata
Dialium englerianum
Dialium pachyphyllum
Dialium zenkeri
Dichrostachys cinerea
Dichrostachys glomerata (D.cinera)
Dichrostachys spicata
Dicorynia guianensis
Dicraeopetalum stipulare
Dicyme altsoni
Dicymbe corymbosa
Didelotia africana
Dimorphandra davisii
Dinizia excelsa
Diphysa floribunda
Diphysa robinoides
Diplotropis purpurea
Dipteryx odorata
Dipteryx trifoliata
Diptychandra epunctata
Discaria toumatou
Disteamonanthus benthamianus
Dryas drummondii
Dryas integrifolia
Dryas octopetalia
Duparquetia orchidacea
Dussia discolor
Dussia martinicensis
Elaeagnus angustifolia
Elaeagnus argentea
Elaeagnus commutata
Elaeagnus edulis
Elaeagnus longipes
Elaeagnus macrophylla
Elaeagnus multiflora
Elaeagnus pungens
Elaeagnus rhamnoides
Elaeagnus umbellata
Eligmocarpus cynometroides
Elizabetha durissima
Elizabetha princeps
Endertia spectabilis
Englerodendron usambarense
Entada abyssinica
Entada phaseoloides
Entada sudanica (E. africanum)
Enterolobium cyclocarpum
Enterolobium schomburgkii
Enterolobium timbouva
Eperua falcata
Eperua jenmani
Eperua purpurea
Erythrina abyssinica
Erythrina berteroana
Erythrina caffra
Erythrina crista-galli
Erythrina fusca
Erythrina glauca
Erythrina indica
Erythrina lithosperma
Erythrina monosperma
Erythrina orientalis
Erythrina poeppigiana
Erythrina suberosa
Erythrophleum africanum
Erythrophleum ivorense
Erythrophleum suaveolens
Etaballia dubia
Europetalum batesii

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Eurypetalum tessmanii
Exostyles venusta
Eysenhardtia amorphoides
Eysenhardtia peninsularis
Eysenhardtia texana
Ferreirea spectabilis
Fillaeopsis discophora
Fissicalyx fendleri
Fordia cauliflora
Gagnebina tamariscina
Genista sp.
Geoffroe decorticans
Geoffroea spinosa
Gilbertiodendron demonstrans
Gilletiodendron klanei
Gleditsia amorphoides
Gleditsia caspica
Gleditsia japonica
Gleditsia sinensis
Gleditsia triacanthos
Gliricidia ehrenbergii
Gliricidia laebii
Gliricidia sepium
Goldmania foetida
Gossweilerodendron balsamiferum
Gourliea decorticans
Guibourtia coleosperma
Guibourtia conjugata
Guibourtia demeusei
Guibourtia schliebenii
Gymnocladus dioica
Haematoxylon brasiletto
Haematoxylon campechianum
Haplormosia monophylla
Hardwickia binata
Hardwickia pinnata
Harpalyce cubensis
Hebestigma cubense
Hesperolaburnum platycarpum
Hesperothamnus littoralis
Heterostemon mimosoides
Hippophae rhamnoides
Holocalyx balansae
Humboldtia laurifolia
Hylodendron gabunense
Hymenaea confertiflora
Hymenaea courbaril
Hymenolobium excelsum
Hymenolobium nitidum
Hymenostegia floribunda
Indopiptadenia oudhensis
Inga altissima
Inga edulis
Inga feuillei
Inga laurina
Inga oerstediana
Inga paterna
Inga vera
Inocarpus edulis
Instia acuminata
Instia bakeri
Instia bijuga
Instia palembanica
Instia plurijuga
Instia retusa
Isoberlina schefflera
Isoberlinia argotensis
Isoberlinia dalzielii
Isoberlinia doka
Isoberlinia tomentosa
Isomacrolobium leptorrachis
Jacqueshuberia quinquangulata
Julbernardia globiflora
Julbernardia hochreutineri
Julbernardia magnistipulata
Julbernardia paniculata
Julbernardia seretii
Julbernardia unijugata
Kalappia celebica
Kingiodendron alternifolium
Kingiodendron pinnatum
Koompassia excelsa
Koompassia malaccensis
Laburnum alpinum
Laburnum anagyroides
Laburnum pratense
Lebruniodendron lepthanthum
Lecointea amazonica
Lennea robinioides
Leonardoxa africana
Leucaena collinsii
Leucaena diversifolia
Leucaena esculenta
Leucaena lanceolota
Leucaena leucocephala
Leucaena macrophylla
Leucaena pulverulenta
Leucaena retusa
Leucaena shannoni
Leucaena trichodes
Leucostegane latistipulata
Librevillea klainei
Loesenera kalantha
Lonchocarpus capassa
Lonchocarpus latifolius
Lonchocarpus punctatus
Lonchocarpus utilis
Lonchocarpus violaceus
Lysidice rhodostegia
Lysiloma auritum
Lysiloma bahamensis
Lysiloma divaricata
Lysiloma latisiliqua
Lysiloma thornberi
Maackia amurensis
Maackia chinensis
Maackia floribunda
Machaerium robinifolium
Machaerium schomburgkii
Macroberlinia bracteosa
Macrozamia communis
Macrozamia riedlei
Manilkoa grandiflora
Manilkoa scheffera
Marmaroxylon racemosum
Martiodendron excelsum
Melanoxylon brauna
Michelsonia microphylla
Microberlinia brazzavillensis
Milbraediodendron excelsum
Millettia dubia
Millettia grandis
Millettia laurentii
Millettia rubiginosa
Millettia stuhlmannii
Millettia thonningii
Millettia usaramensis
Mimosa bracaatinga
Mimosa scabrella
Mimosa tenuiflora
Mimozyganthus carinatus
Moldenhauera floribunda
Monopetalanthus pteridophyllus
Monopteryx angustifolia
Monoschisma leptostachyum
Mora excelsa
Mora gonggrijpii
Muellera frutescens
Mundulea sericea
Myrica adenophora

Myrica asplenifolia
Myrica carolinensis
Myrica cerifera
Myrica gale
Myrica javanica
Myrica pensylvanica
Myrica pilulifera
Myrica pubescens
Myrica rubra
Myrica sapida
Myrica serrata
Myrocarpus fastigiatus
Myrocarpus frondosus
Myrospermum frutescens
Myroxylon balsamum
Myroxylon pereirae
Myroxylon peruiferum
Neochevalierodendron stephanii
Neodunnia atrocyanea
Neoharmsia madagascariensis
Newtonia buchananii
Newtonia hildebrandtii
Notodon gracilis
Notospartium glabrescens
Oddoniodendron micranthum
Oleiocarpon panamense
Olneya tesota
Ormosia coccinea
Ormosia hosei
Ormosia monosperma
Ostryoderris gabonica
Ostryoderris stuhlmannii
Dugeinia oojeinensis
Oxystigma mannii
Oxystigma msoo
Pachyelasma tessmannii
Pahudia galedupa
Pahudia rhomboidea
Paloue guianensis
Paloveopsis emarginata
Pancrea longifolia
Paramachaerium schomburgkii
Paramacrolobium coeruleum
Parapiptadenia rigida
Parasponia andersonii
Parasponia parviflora
Parasponia rugosa
Parkia africana
Parkia biglandulosa
Parkia biglobosa

Parkia clappertoniana
Parkia filicoidea
Parkia javanica
Parkia roxburghii
Parkia speciosa
Parkia timoriana
Parkinsonia aculeata
Parkinsonia africana
Pellegriniodendron diphyllum
Peltogyne catingue
Peltogyne densiflora
Peltogyne excelsa
Peltophorum adnatum
Peltophorum dasyrrhachis
Peltophorum pterocarpum
Peltophorum vogelianum
Pentaclethra eetveldeana
Pentaclethra macroloba
Pentaclethra macrophylla
Pericopsis angolensis
Pericopsis elata
Pericopsis mooniana
Petaladenium urceoliferum
Phyllocarpus riedelii
Phyllocarpus septentrionalis
Phylloxylon xiphoclada
Phylloxylon xylophylloides
Pictetia aculeata
Piliostigma malabaricum
Piliostigma reticulatum
Piliostigma thonningii
Piptadenia excelsa
Piptadenia macrocarpa
Piptadenia paraguaynensis
Piptadeniastrum africanum
Piscidia piscipula
Pithecellobium adinocephalum
Pithecellobium arboreum
Pithecellobium caraboboense
Pithecellobium cauliflorum
Pithecellobium collinum
Pithecellobium dulce
Pithecellobium flexicaule
Pithecellobium jiringa
Pithecellobium lobatum
Plagiosiphon discifer
Plathymenia reticulata
Platycelyphium cyananthum
Platycyamus regnellii
Platycyamus ulei

Platymiscium dimorphandrum
Platymiscium pinnatum
Platymiscium trinitatis
Platymiscium ulei
Platypodium elegans
Platysepalum vanhouttei
Platysepalum violaceum
Platysepalum violouttei
Podopetalum ormondii
Poecilanthe effusa
Poeppigia procera
Pogocybe entadoides
Polystemonanthus dinklagei
Pongamia pinnata
Prioria copaifera
Prosopis africana
Prosopis alba
Prosopis articulata
Prosopis chilensis
Prosopis cineraria
Prosopis dulcis
Prosopis glandulosa
Prosopis juliflora
Prosopis kuntzeie
Prosopis nigra
Prosopis pallida
Prosopis ruscifolia
Prosopis tamarugo
Prosopis velutina
Pseudosamanea guachapele
Psorodendron spinosum
Pterocarpus angolensis
Pterocarpus blancoi
Pterocarpus echinatus
Pterocarpus indicus
Pterocarpus marsupium
Pterocarpus officinalis
Pterocarpus podocarpus
Pterocarpus rotundifolius
Pterocarpus santaloides
Pterocarpus sericeus
Pterocarpus soyauxii
Pterocarpus stevensonii
Pterocarpus vidalianus
Pterodon emarginatus
Pterogyne nitens
Pynaertiodendron congolanum
Ramorinoa girolae
Recordoxylon amazonicum
Robinia hispida

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Robinia neomexicana
Robinia pseudoacacia
Robinia viscosa
Sabinea florida
Sakoanala madagascariensis
Samanea pedicellaris
Samanea polycephala
Samanea saman
Samanea saminiqua

Sophora tomentosa
Sopropis palmeri
Spirotropis longifolia
Stachyothyrsus staudtii
Stahlia maritima
Steinbachiella leptoclada
Stemonoroleus micranthus
Storkiella vitiensis
Strombocarpa strombulifera

Xanthocercis zambesiaca
Xeroderris stuhlmannii
Xylia evansii
Xylia ghesquierei
Xylia xylocarpa
Yucaratonia brenningii
Zenia insignis
Zenkerella citrina
Zenkerella citrina

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ECONOMICALLY IMPORTANT NITROGEN FIXING TREE SPECIES

ECONOMICALLY IMPORTANT NITROGEN FIXING TREE SPECIES

(J. L. Brewbaker and Brian T. Styles, eds.
Prepared for Bellagio Workshop; Document #2A)

Format:

SPECIES (FAMILY)
1. ORIGIN; HEIGHT, SHAPE
2. USES AND CHARACTERISTICS
3. ADAPTATION (INCL. MIN. RAINFALL)
4. COMMENTS, CHROMOSOME NO.

ACACIA ALBIDA DEL. (MIMOSOIDEAE; LEGUMINOSAE)
1. Africa and Israel, to 20 m; leafless in rainy season
2. Forage (pods, foliage), shade
3. Dry tropics, Sahel (to 300 mm min)
4. Slow growth 2n=26

ACACIA AURICULIFORMIS A. CUNN. EX BENTH. (MIMOSOIDEAE; LEGUMINOSAE)
1. Australia, New Guinea; to 30m, spreading
2. Fuelwood, pulpwood; .68 sp.gr.; 15 m3/ha/yr
3. Wide adapt., acid soils; humid tropics (750 mm. min)
4. Not too tolerant of drought? fire? winds? 2n=26

ACACIA CONFUSA MERR. (MIMOSOIDEAE; LEGUMINOSAE)
1. Philippines, Taiwan; to 14 m, spreading
2. Firewood (high sp. gr.), ornamental
3. Wet subtropics (to 750 mm min), acid soils
4. Slow growth 2n=26

ACACIA FARNESIANA (L.) WILLD. (MIMOSOIDEAE; LEGUMINOSAE)
1. Tropical America; to 10 m, often shrubby
2. Fuelwood; forage, tanning; perfume from flowers; ornamental; black dye used to make ink
3. Dry tropics; wide variety of soils
4. Very thorny; can be weedy 2n=52

ACACIA MANGIUM WILLD. (MIMOSOIDEAE; LEGUMINOSAE)
1. Australia and Papua New Guinea, Indonesia; to 30 m, erect, stately
2. Timber (.65 sp gr), Firewood?, to 30 m3/ha/yr
3. Moist tropics (to 1000 mm min), acid soils?
4. Insects on leaves, genetic variability

ACACIA MEARNSII WILLD. (MIMOSOIDEAE; LEGUMINOSAE)
1. Australia; to 25 m, spreading
2. Fuelwood, charcoal, tannins; dense wood (.75 sp.gr.), to 25 m3/ha/yr
3. Moist sub-tropics, mid elevations; to 800 mm min?
4. Can become weedy 2n=26

ACACIA NILOTICA (L.) WILLD. EX DEL. (MIMOSOIDEAE; LEGUMINOSAE)
1. Africa and India; to 20 m, usually less
2. Firewood, charcoal, fodder (pods, leaves), tannin and gum
3. Dry tropics (but thrives under irrigation)
4. Extremely thorny, variable 2n=52,104

ACACIA SALIGNA (LABILL.) H. WENDL. (MIMOSOIDEAE; LEGUMINOSAE)
1. W. Australia; shrub or small tree to 7 m
2. Fodder; fuel; sand-dune fixation; tannin; recolonization of mining areas; erosion control ornamental
3. Humid to subhumid tropics; 300-1000 mm. rainfall; adapted to both sandy and swampy sites
4. Rapid growth outside native areas; tolerant to drought, salt, winds, and fire; may become weedy

ACACIA SENEGAL (L.) WILLD. (MIMOSOIDEAE; LEGUMINOSAE)
1. Africa, Pakistan, India; to 13 m, often shrubby
2. Firewood, charcoal; to 5 m3/ha/yr, gum arabic, feed (pods, foliage)
3. Dry tropics (to 200 mm min), poor soil, hot
4. Extremely thorny, becomes weedy 2n=26

ACACIA TORTILIS (FORSK.) HAYNE (MIMOSOIDEAE; LEGUMINOSAE)
1. Africa, Sahel, Israel, Arabia; to 15 m, often shrubby;
2. Firewood, dense; fodder (pods, leaves)
3. Dry tropics (to 100 mm min), heat tolerant, alkaline soils
4. Thorny, lateral roots

ALBIZIA FALCATARIA (L.) FOSBERG (MIMOSOIDEAE; LEGUMINOSAE)
1. Indonesia, New Guinea; to 45 m
2. Pulpwood, soft, .33 sp. gr., moldings, boxes, soil improvement
3. Moist tropics (to 1000 mm min), midlands
4. Soft wood, poor fuel

ALBIZIA LEBBEK (L.) BENTH. (MIMOSOIDEAE; LEGUMINOSAE)
1. Tropical Asia and Africa; to 30 m
2. Fuelwood (high value, 5200 kcal/kg), foliage for feed, yields to 5 m3/ha/yr, furniture
3. Wide adaptability, dry and moist tropics (to 600 mm min)
4. Slow growth 2n=26

ALNUS ACUMINATA O. KUNTZE (BETULACEAE)
1. C. America; to 25 m or more
2. Firewood, sp. gr. .5; timber, to 15 m3/ha/yr; shoes
3. Cool tropic highlands to 3000 m, moist (1250 mm min)
4. Not heat or drought tolerant

ALNUS GLUTINOSA (L.) GAERTN. (BETULACEAE)
1. Europe to W. Asia; Asia Minor to N. Africa; to 40 m
2. Energy production (fuel); soil stabilization, e.g. river banks, roadsides, mine wastes; shoes; sp.gr. .52
3. Widely adapted, temperate or subtropical, to 500m
4. Not drought tolerant 2n=28

ALNUS NEPALENSIS D. DON (BETULACEAE)
1. Himalayas; to 30 m
2. Firewood but sp.gr. .35; utility timber and forage
3. Cool tropic highlands to 3000m, mesic (800 mm min?)
4. Some insects, soft wood 2n=28

CALLIANDRA CALOTHYRSUS MEISSN. (MIMOSOIDEAE; LEGUMINOSAE)
1. C. and S. America; to 10 m, shrubby
2. Firewood; forage (high tannin) and green manure; sp. gr. .65
3. Moist tropics (min. 1000mm), cooler (above 500m?); to 40 m3/ha/yr with annual harvest
4. Shrubby (=C. confusa Sprague & Riley) 2n=22

CASUARINA CUNNINGHAMIANA MIQ. (CASUARINACEAE)
1. Australia, to 35 m
2. Firewood, sp. gr. .7; shade tree; river bank stabilization
3. Cool tropics to warm temperate; 500 mm min.
4. Can be weedy (Florida) 2n=18

CASUARINA EQUISETIFOLIA L. (CASUARINACEAE)
1. Australia and Pacific Isl. to India; to 35 m
2. Firewood, charcoal; sp. gr. 1.0, "best in world"; windbreak; timber for postwood
3. Warm tropics, coastal areas; typhoon tolerant, very saline tolerant; very saline tolerant
4. Coppices poorly?

CASUARINA GLAUCA SIEB. EX SPRENG. (CASUARINACEAE)
1. Australia (N.S.Wales to Qld.); to 20 m
2. Firewood, charcoal, fencing, piles for seawater, windbreaks in coastal areas; sp.gr. .98
3. Warm temperate to subtropics, coastal areas; salt-tolerant; heavy clay soils
4. Produces root suckers and can be weedy (e.g. Florida)

CASUARINA JUNGHUNIANA MIQ. (CASUARINACEAE)
1. Indonesia; to 30 m
2. Firewood, charcoal, poles, piling; wood splits easily
3. Tropical lowlands and midlands, forming dense forests; wide pH tolerance, moderate drought tolerance
4. Little studied; male clone (or hybrid) widely used in Thailand

DALBERGIA SISSOO ROXB. (PAPILIONOIDEAE; LEGUMINOSAE)
1. Indian subcontinent; to 30 m
2. Lumber, fuelwood, sp.gr. .68
3. Warm tropics, mesic or arid (to 500 mm min); yields fast for a Dalbergia, slow by other standards
4. Slow growth 2n=20

N.B. / Cajanus cajan

ERYTHRINA BERTOEROANA URBAN (PAPILIONOIDEAE; LEGUMINOSAE)
1. Tropical America; to 10 m; small crown
2. Live fence posts; soft wood which accepts wires and nails well; forage; windbreaks; easily cloned
3. Lowland and submontane moist tropics to 2000 m; usually in wetter areas but needs good drainage
4. Fast growth; resistant to wind 2n=42

ERYTHRINA FUSCA LOUR. (PAPILIONOIDEAE; LEGUMINOSAE)
1. C. & S. America, to 30 m; broad crown
2. Shade for coffee and cacao; live fenceposts; soft wood
3. Lowland moist tropics to 1500 m; often in swamps or on poorly drained clayey soils
4. Fast growth; effective green manure; easily cloned 2n=42

ERYTHRINA POEPPIGIANA (WALPERS) O.F. COOK (PAPILIONOIDEAE; LEGUMINOSAE)
1. S. America to Panama; to 40m
2. Shade for coffee, ornamental; soft wood; paper pulp; forage, mulch
3. Dry to mesic tropics, to highlands
4. Fast growth; coppices and clones easily 2N=42

GLIRICIDIA SEPIUM (JACQ.) WALP. (PAPILIONOIDEAE; LEGUMINOSAE)
1. S. and C. America; small tree to 10 m
2. Firewood, timber, sp. gr. .75, fodder, shade, ornamental; easily propagated by cuttings, living fence, to 8 m3/ha/yr
3. Dry to humid tropics (1000 mm min), also saline areas
4. Toxic bark/seeds/roots; aphids on foliage 2n=20

INGA VERA (L.) BRITTON (PAPILIONOIDEAE; LEGUMINOSAE)
1. Caribbean, C. America; to 20 m
2. Shade for coffee, fuelwood (sp. gr. .75), timber, shade, honey relatively fast growth
3. Humid tropics (1000 mm min?), lowlands
4. Little studied

INTSIA BIJUGA (COLEBR.) O. KUNTZE (CAESALPIINIOIDEAE; LEGUMINOSAE)
1. Southeast Asia, E. Africa, India; to 40 m, buttressed
2. Handsome timber, decking, truck bodies ("ipil" in Philippines), highly resistant to rot; slow growth
3. Moist tropics, prob. 2000 mm min;
4. Genetic variability 2n=24

LEUCAENA DIVERSIFOLIA (SCHLECHT) BENTH. (MIMOSOIDEAE; LEGUMINOSAE)
1. C. America, to 18 m (with shrubby variants)
2. Fuelwood (est. .5 sp. gr.), shade, forage
3. Dry to mesic tropics, prob. 500 mm min, to midlands (1500 m)
4. Little studied, great genetic diversity 2n=52

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LEUCAENA LEUCOCEPHALA (LAM.) DE WIT (MIMOSOIDEAE: LEGUMINOSAE)
1. C. America and Mexico, to 18 m (with shrubby variants)
2. Fuelwood, nurse tree, forage, small timber and pulpwood; sp. gr. .55, some food use (pods, seeds, leaves), energy plantations, yields to 50 m3/ha/yr
3. Dry to mesic tropics, 500 mm min, lowland
4. Widely studied 2n=104

MIMOSA SCABRELLA BENTH. (MIMOSOIDEAE; LEGUMINOSAE)
1. S.E. Brazil & Argentina; to 12 m, thornless
2. Fuelwood, pulpwood, ornamental; shade for coffee; rapid growth?
3. Mid-elevation cool tropics and subtropics (flourishes at 2400 m, Guatemala)
4. Little studied

PARKIA JAVANICA (LAM.) MERRILL (MIMOSOIDEAE; LEGUMINOSAE)
1. Indo-Malaysia, Philippines; now widely pantropical; to 40 m, umbrella crown
2. Timber, ornamental, seeds used in local medicine
3. Humid tropics to 1000 mm; 500-700 m elevation
4. Pest-tolerant; protected in Indonesia (also known as P. roxburghii G. Don.)

PARKIA SPECIOSA MASSK. (MIMOSOIDEAE; LEGUMINOSAE)
1. Thailand, Malaysia; to 15 m, thin crown
2. Food (seeds from large pods)
3. Humid tropics, to 1500 m elevation
4. Seeds often insect infested; slow growth; apparently hybridizes with P. javanica; recalcitrant seed

PARKINSONIA ACULEATA L. (CAESALPINIOIDEAE; LEGUMINOSAE)
1. Americas; to 20 m, spreading
2. Fuelwood; fodder; ornamental; fences; local medicine
3. Widely adapted, to moist tropical and dry areas, also sandy and saline soils
4. Very thorny; weedy in Argentina 2n=28

PITHECELLOBIUM DULCE (ROXB.) BENTH. (MIMOSOIDEAE; LEGUMINOSAE)
1. C. to S. America, to 20 m, irregular and untidy spreading tree
2. Fuelwood (to 5500 kcal/kg), smoky; forage, construction postwood, shade (thorny hedges), food (pods), some tannin and oil (seeds)
3. Very wide adaptability, from dry to humid tropics and to cooler elevations (So. Florida)
4. Thorny (segregating), poor form 2n=26

PONGAMIA PINNATA (L.) PIERRE (PAPILIONOIDEAE; LEGUMINOSAE)
1. Indian subcontinent, Malaysia, China, Tropical Asia; to 8 m
2. Firewood, fodder (leaves), oil (seeds), pest control (leaves), shade tree, medicine
3. Mesic tropics (min. 600mm), saline tolerant; to full height in 5 yrs.
4. Aggressive spreading roots; also known as <u>Derris indica</u> (Lam.) Bennet

PROSOPIS ALBA/CHILENSIS "Complex"
(Includes P. alba Griseb. and P. chilensis (Mol.) Stuntz; also P. flexuosa and P. nigra)
1. Argentina, Paraguay, Chile, S. Peru; to 15 m
2. Firewood, occasional use as timber; fodder (pods); to 12 m3/ha/yr
3. Cool dry subtropics (200 mm min); to 3000 m in Peru
4. Thorny (segregating) 2n=28

PROSOPIS CINERARIA (L.) DRUCE (MIMOSACEAE; LEGUMINOSAE)
1. India, to 9 m, thorny, spreading
2. Firewood, excellent charcoal; fodder, some timber; green manure, yields to 3 m3/ha/yr (under drought stress)
3. Dry hot tropics, to 100 mm min?
4. Thorny (segregating), weedy

PROSOPIS PALLIDA/JULIFLORA "Complex"
(Includes P. pallida (Humb & Bon ex Willd) and P. juliflora (Swartz) DC)
1. C. and No. S. America; to 15 m, aggressive
2. Firewood (.8 sp. gr.), exc. charcoal; fodder (pods), honey, wood, to 5 m3/ha/yr
3. Dry hot tropics, to 200 mm min; deep roots, some var. frost-tolerant
4. Thorny (segregating), often weedy (P. glandulosa and P. velutina are the mesquites of So. USA and elsewhere in tropics, often labelled juliflora in error) 2n=26,52,56

PROSOPIS TAMARUGO F. PHIL. (MIMOSOIDEAE; LEGUMINOSAE)
1. Chile, to 15 m,
2. Firewood, forage (pods, leaves), some use use (high sp. gr.)
3. Dry hot saline tropics, to 10 mm (uses fog drip?); remarkable saline tolerance
4. Slow growth, thorny but segregating?

PTEROCARPUS INDICUS WILLD. (MIMOSACEAE; LEGUMINOSAE)
1. S. E. Asia, Indo-China, Pacific IslandS; to 40 m, broad crown, lofty
2. Choice timber (narra), ornamental, furniture, flooring
3. Moist tropics; relatively fast growth
4. Needs deep soil; some diseases 2n=22

ROBINIA PSEUDOACACIA L. (PAPILIONOIDEAE; LEGUMINOSAE)
1. N.E. America, to 25 m
2. Fuelwood (dense), erosion control, nurse tree, posts, to 20m3/ha/yr; forage
3. Temperate
4. Restricted to highland tropics (little tested) and temperate regions 2n=20,22,24

SAMANEA SAMAN (JACQ.) MERRILL (MIMOSOIDEAE; LEGUMINOSAE)

1. C. & So. America, Mexico; to 40 m, wide spreading
2. Shade, timber and craftwood, food (pod), sp. gr. .52, ornamental
3. Mesic to wet tropics (to 600 mm min)
4. Not good fuelwood, rapid growth. 2n=26

SESBANIA GRANDIFLORA (L.) POIR. (PAPILIONOIDEAE; LEGUMINOSAE)

1. India to SE Asia; to 10m, slender
2. Pulpwood, forage (leaves, pods), food (flower, leaves, young pods), ornamental; sp. gr. .42; to 22 m3/ha/yr, large nodules
3. Moist tropics (1000mm min), onto poor soils
4. Genetic variability, soft wood, borer susceptibility 2n=14,24

NFTA 82-04B

ECONOMICALLY IMPORTANT NITROGEN FIXING TREE SPECIES "B" LIST

(James L. Brewbaker and Brian T. Styles, Eds.
Prepared for Bellagio NFT Workshop, Sept. 1982)

The following species were considered important economically, but of less importance than the annotated "A" list.

The first list includes species known to fix nitrogen, while the second list are not known to fix nitrogen, which may account for their absence from the "A" list.

Acacia aneura
Acacia aulacocarpa
Acacia caven
Acacia holosericea
Acacia karroo
Acacia koa
Acacia melanoxylon
Acacia peuce
Acacia pennata
Acacia salicina
Acacia seyal
Acrocarpus fraxinifolius
Acenanthera pavonina
Albizia procera
Alnus rubra
~~Casuarina~~ cristata
Casuarina grandis
Casuarina obesa
Casuarina oligodon
Casuarina sumatrana
Dalbergia latifolia
Enterolobium cyclocarpum
Erythrina indica
Erythrina orientalis
Haematoxylon brasiletto
Inga edulis
Inga paterna
Lysiloma bahamensis
Mimosa tenuiflora
Pericopsis elata
Prosopis glandulosa (a complex, including P. glandulosa P. torreyana and P. velutina)
Prosopis pubescens
Schizolobium parahyba

N-fixation unknown or uncertain:
Caesalpinia coriaria
Cassia fistula
Cassia grandis
Cassia javanica
Cassia siamea
Cedrelinga catenaeformis
Ceratonia siliqua
Cercidium floridium
Copaifera langsdorfii
Diphysa robinioides
Geoffroea decorticans
Koompassia excelsa
Peltophorum pterocarpum
Pithecellobium jiringa
Sindora javanica
Tamarindus indica

Fodder trees for Nepal hills

Source: Kessler (1981)

Albizzia mollis

Artocarpus lakoocha

Bassia butyracaea

Bauhinia longifolia
B. variegata

Brassiopsis hainla

Castanopsis hystrix
C. indica
C. tribuloides

Erythrina arborescens

Ficus lacor
F. nemoralis
F. glaberrina
F. roxburghii
F. semecordata

Litsea citrate
L. polyantha

Morus alba

Prunus cerrasoides

Quercus incana
Q. lamellosa

Salix spp.

Sarauria nepaulensis

Schima wallichi

Savanna trees of nutritional importance in Nigeria

Source: Okafor (1980)

No.	Species	Family	Parts Edible*							
	1	2	3	4	5	6	7	8	9	10
1.	*Lannea microcarpa*	Anacardiacea			X					
2.	*Pseudospondias microcarpa*				X					
3.	*Sclerocarya birrea*				X					X
4.	*Spondias mombin*				X					
5.	*Annona senegalensis*	Annonaceae			X		X			
6.	*Hexalobus monopetalus*	"			X					
7.	*Balanites aegyptiaca*	Balanitaceae			X				X	X
8.	*Kigelia africana*	Bignoniaceae					X			
9.	*Adansonia digitata*	Bombacaceae	X	X	X	X		X		X
10.	*Bombax costatum*	"			X		X			
11.	*Ceiba pentandra*	"	X	X	X	X				
12.	*Canarium schweinfurthii*	Burseraceae			X					
13.	*Afzelia africana*	Caesalpinaecae				X				
14.	*Barachystegia curycoma*	"				X				
15.	*Daniallia oliveri*	"	X							
16.	*Detarium microcarpum*	"			X	X				
17.	*Dialium guincense*	"			X					X
18.	*Tamarindus indica*	"			X					X
19.	*Crateva adansonii*	Capparidaceae	X		X					
20.	*Parinari curatellifolia*	Chrysobalanaceae			X					
21.	*Diospyros elliotii*	Ebenaceae			X					
22.	*Diospyros mespiliformis*	"			X					
23.	*Antidesma venosum*	Euphobiaceae			X					
24.	*Irvingia smithii*	Irvingiaceae				X				
25.	*Strychnos innocua*	Loganiaceae			X					
26.	*Strychnos spinosa*	"			X					
27.	*Parkia clappertoniana*	Mimosaceae			X	X				X
28.	*Prosopis africana*	"				X				
29.	*Ficus capensis*	Moraceae	X		X					
30.	*Ficus polita*	"			X					
31.	*Moringa oleifera*	Moringaceae	X				X			
32.	*Syzypium guineense* var. *macrocarpum*	Myrtaceae			X					
33.	*Borassus aethiopum*	Palmae			X	X		X	X	X
34.	*Elacis guineensis*	"			X	X			X	X
35.	*Phoenix reclinata*	Palmae			X					X
36.	*Raphia sudanica*	"			X					X
37.	*Pterocarpus santalinoides*	Papilonaceae	X							
38.	*Ziziphus mauritiana*	Phamnaceae			X					
39.	*Ziziphus spina-christi* var. *spina-christi*	"			X					
40.	*Gardenia erubescens*	Rubiaceae			X					
41.	*Nauclea latifolia*	"			X					
42.	*Aphania sanegalensis*	Sapindaceae			X					
43.	*Blighia sapida*	"			X					
44.	*Zanha golungensis*	"			X					
45.	*Butyrospermum paradoxum* subsp. *parkii*	Sapotaceae			X				X	
46.	*Pachystella brevipes*	"			X					
47.	*Sterculia tragacantha*	Sterculiaceae	X		X					
48.	*Grewia bicolor*	Tiliaceae			X					
49.	*Grewia mollis*	"		X	X		X			
50.	*Celtis integrifolia*	Ulmaceae	X		X					
51.	*Vitex doniana*	Verbenaceae	X		X					

*Parts Edible

3: Leaves
4: Bark
5: Fruit
6: Seeds
7: Flowers
8: Roots
9: Oil
10: Local beverage

CAB's Online Services

The database

The CAB ABSTRACTS database is available online through various hosts including Lockheed Dialog, SDC Orbit, European Space Agency's I.R.S. & DIMDI.

It covers 1973 to the present and contains over a million records. 150,000 additional records are added each year.

Subject Coverage

The database covers the world's literature on agriculture and related fields of applied biology and corresponds to CAB's abstract journals which cover the following disciplines:–

ANIMAL BREEDING & GENETICS
ANIMAL HEALTH
ARID LANDS
DAIRY SCIENCE
ECONOMICS & SOCIOLOGY
ENGINEERING
ENTOMOLOGY & NEMATOLOGY
FORESTRY & FOREST PRODUCTS
HELMINTHOLOGY
HORTICULTURE & PLANTATION CROPS
HUMAN & ANIMAL NUTRITION
MEDICAL & VETERINARY
PARASITOLOGY & MYCOLOGY
PASTURES & FIELD CROPS
PLANT BREEDING & GENETICS
PLANT PATHOLOGY
RURAL DEVELOPMENT & SOCIOLOGY
SOILS & FERTIZERS
WEED CONTROL

The equipment

To search CAB ABSTRACTS, you will need a computer terminal to access a host computer via telecommunications system such as TYMNET, TELENET, or EURONET.

The cost

Online searching is a highly cost-effective way of carrying out literature searches. Relevant literature can be found quickly and efficiently and print-outs obtained which save hours of manual effort. Full abstracts containing detailed information, are available online and may substitute for original documents.

The cost of searching CAB is less than £35 per hour computer time, plus a charge for telecommunications and printing. Most searches cost less than £30.

Search-aids

CAB has published a comprehensive search guide "CAB ABSTRACTS Online". This describes the content and format of the database, and searching techniques.

A Word List is also available from CAB. This lists the principal terms occurring in the descriptor field of the CAB ABSTRACTS database. A full Thesaurus is in preparation.

Training

To search online cost-effectively, the user should become fully acquainted with the CAB ABSTRACTS database. To help achieve this, CAB regularly hold one-day online user workshops throughout the world. CAB would also be interested to hear from organisations prepared to host such workshops.

Additional Services

- CAB staff are available to give help and advise on searching techniques and the contents of the database.
- A "Call CAB" service is available to provide help and advice and carry out search requests.
- Copies of over 3,000 retrospective searches already performed are available at low cost.
- CAB can provide copies of most original documents included in the database. These may be ordered by post, or via the hosts online document delivery services.
- Magnetic tapes are available for those wishing to search CAB ABSTRACTS on their own computer.

For additional information contact:–

Training Officer,
Commonwealth Agricultural Bureaux,
Farnham House,
Farnham Royal, Slough, U.K.
Tel: Farnham Common 2281 Telex 847964
Cables COMAG, SLOUGH.

Appendix

Numbers of references located in CAB DATABASE through DIALOG in preparing this document (1972-83 literature)

(A). Multipurpose trees

	Subject words	No. of references
Group 1	Roundwood	789
	Poles	1077
	Canes	830
	Rattans	34
	Lumber	1162
	Timber	7646
	Sawnwood	38
	Sawn	882
	Any one or more	10899
Group 2	Firewood	215
	Charcoal	1221
	Fuelwood	505
	Fuels	857
	Any one or more	2588
Group 3	Fodder	11957
	Nuts	2056
	Fruit	45299
	Seed + uses	358
	Foliage + uses	201
	Any one or more	59109
Group 4	Extractives	737
	Resin	3695
	Medicinal	2892
	Pharmaceutical	1154
	Honey	4721
	Beekeeping	1578
	Silk	591
	Lac	337
	Any one or more	14887
Group 5	Shelterbelts	765
	Shade trees	284
	Windbreaks	513
	Erosion + trees	266
	Catchment + trees	64
	Soil improve	288
	Any one or more	1934

Group 6	Soil conservation + trees	75
Combined[1]	1 plus 2	257
	1 plus 3	393
	1 plus 4	202
	1 plus 6	7
	2 plus 3	110
	2 plus 4	67
	2 plus 6	3
	3 plus 4	661
	3 plus 6	15
	4 plus 6	0
	Any pair or more	1609
	All above groups in FA/FPA	580

i.e. Within the CAB database, in the last 10 years 580 references have been concerned with 2 or more groups of tree uses.

(B). Exotics and Weed trees

Subject words	No. of references	
Exotics	1098	
Introductions	28026	
Non-indigenous	41	
Any one or more	28199	Combined 16 references
Weed and trees	497	

(C). Bibliographies

Subject	No. of references
Bibliograph	4745

[1] The combination of Groups 1, 2, 3 or 4 with 5 were omitted in error during this search

INFO / DOC. ICRAF ...

An interactive, userfriendly agroforestry information request service...

Some services we can provide to YOU

An information request service

The role of the Information and Documentation Programme at ICRAF is to acquire, analyse, interpret and disseminate information about agroforestry.

The Council provides this service not only to it's own staff, but in answer to requests from outside and as a way to promote and support work in agroforestry.

For example

For example, let us say you want information on the selection of candidate trees and crops for intercropping in the lowland humid tropics. Info/Doc ICRAF will refer you to some recent documents on the subject as well as some specific citations that are available at the ICRAF library. Info/Doc. ICRAF will, if possible, discuss your request with senior staff scientists, in this case the Council's Forester and the Agronomist. They will provide some more references, and interpret what they know of the subject.

Computer searches

Computer searches can also be requested on the species in question and referral to scientists or research institutions undertaking this work can also be made.

A first reply will be formulated. It will offer some information and indicate what else the Council is undertaking to provide more information.

Many requests have been received. For example, requests concerning: the economics of agroforestry systems, candidate woody perennials for animal agroforestry, the effect of trees on soil quality and grass productivity, the use of Sesbania grandiflora to reduce waterlogging on irrigation systems for example, and many others.

Commonly, information is sought regarding tree species with potential for agroforestry.

Acquiring the info

For many of these requests, the information is just not readily available, or more likely, what is available is incomplete. To get at it requires some 'digging' and this takes time.

.../

(4)

The result-correspondence between ICRAF and the source of the request.

- Info/Doc. ICRAF can 'plug you into' the following information sources.

At ICRAF:

Information sources

- The Agroforestry collection of the ICRAF library: 3000 reprints specific to agroforestry and about 2000 books, monographs and reports.

  Manual searches can be done using a species or geographic index.

  Access to a local agricultural library which holds most of the broader agricultural literature of interest.

- The ICRAF'Agroforestry Brain Bank' A multidisciplinary team of senior scientists working at ICRAF with extensive and varied experience of tropical land use systems and practices. Advice and interpretation can usually be obtained from this source.

Removed from ICRAF

- the computerized data bases that contain the conventional scientific literature reported in the well known abstract journals - Agricola, CAB, BIOSIS, etc.

  Replies to queries can be received at ICRAF, Nairobi, within a month, sometimes within a week.

- Specialized information centres located worldwide and dealing with land use, tropical agriculture, forestry, livestock production, specialized commodity crops, farming or cropping systems, etc.

  These are consulted via correspondence to undertake manual searches. Information sought from these sources often takes longest to arrive but can be the richest.

  Included under this heading is the vast colonial literature and the information services of some institutes of the Consultative Group on International Agricultural Research.

- AGRIS, the FAO coordinated International Information System for the Agricultural Sciences and Technology. This is a computerized data base listing non conventional literature, much of which originates from developing countries.

Up to 9,000 citations are produced per month by AGRIS.

Information centres dealing with agroforestry. Examples are the Agricultural Information Bank for Asia in the Philippines and CATIE in Turrialba, Costa Rica.

ICRAF correspondents who are practicing agroforestry or who are undertaking research on the subject.

For example, participants at any of several international conferences or workshops on the subject. This is known as the 'invisible college' of agroforestry workers worldwide.

Conditions of use

Users can avail themselves of the agroforestry information service as long as their requests deal with agroforestry. The definition of agroforestry is appended to this document. Agroforestry is not social forestry, nor is it community forestry or village forestry, although it may be included as a component of these land use management systems.

Requests should be addressed to:

Programme Coordinator
Information and Documentation
ICRAF
P.O.Box 30677
Nairobi.
Kenya.

Speed of reply

It is our intention to provide a rapid reply to incoming requests. Specific requests are most readily dealt with. Of course, the rate of reply will depend on the number of incoming requests. Experience has shown that there can be a delay of up to six months (rare), but preliminary information can be sent out within 4 - 6 weeks. It is helpful to include what the information is needed for and if possible, a bibliographic citation.

Once a request is received, it is kept in an 'active' dossier while action is initiated to recover the information needed.

When many requests are received, preference will be given to answer those originating from developing countries.

The Output - What you get!

a specialized list of references prepared at ICRAF. This can take the form of a series of photocopied index cards (see attached) from the ICRAF library collection.

This is quickly reproduced at ICRAF and mailed as a first step in providing the information required. If the citations are numerous, they are sent without copies of the original document The originator of the request identifies the one wanted.

a computerized printout of references for analys by the originator. In some cases, depending on tl request and number of citations retrieved, ICRAF will seek the hard copies directly.

pertinent ICRAF publications

advice or interpretation of information. In some cases, the ICRAF staff scientists are consluted to provide advice. This depends on the availability of the staff.

phtocopied documents. These are provided when requested or when it is thought they will be usef to those requesting the information.

What is in it for ICRAF?

Information exchange is a 2 way street. In exchange for providing information, ICRAF develops contacts with AF researchers and can help to create a community of interest in agroforestry.

Given that ICRAF is a Council to promote agroforestry. The first thing to be done is to link up researchers so they can derive mutual benefit from their own experience and provide impetus to research in agroforestry.

NFTA 82-10

PERIODICALS, BIBLIOGRAPHIES AND GENERAL REFERENCES TO NFT

(James A. Duke and James L. Brewbaker, Eds.
Prepared for Bellagio Workshop, Document #8)

(Foreword: This list is just germinating, and we will appreciate your help. It is intended to be a list of major bibliographies, books and periodicals that deal laregly or wholly with NFT on the high priority list prepared at Bellagio; it is not intended to be a comprehensive list of research publications).

1. PERIODICALS DEALING WITH NFT

Arid Lands Newsletter. Patricia Paylore, Ed. U. Ariz. Tucson, Arizona. (Frequent mention of legumes for biomass, etc.)

~~Beanbag. R.S. Cowan and C.R. Gunn, Eds. Smithsonian Institutic~~ , Washington, D. C. (Taxonomically oriented; includes lists of specialists)

BNF Bulletin. NiFTAL, P. O. Box "O", Paia, Maui, Hawaii 96779. (Published 3 times annually; focussed on biological nitrogen fixation)

Forest Research. CSIRO, P. O. Box 4008, Canberra, ACT 2600, Australia. (Monthly)

ICRAF Newsletter. Internatl. Council for Research in Agroforestry, P. O. Box 30677, Nairobi, Kenya. (Periodical; announcements of publications and meetings)

ISTF News. Frank H. Wadsworth, Ed. International Soc. Tropical Foresters, 5400 Grosvenor Lane, Bethesda, Md. 20814. (Quarterly; news nottes, announcements of publications and meetings)

Leucaena Research Reports. J.L. Brewbaker, Ed. Nitrogen-Fixing Tree Association, P.O. Box 680, Waimanalo, HI, USA (Annual, publ. in July by CAPD, Taiwan).

LISA. 1982. Diversity (Plant Genetic Resources Community) CSU, 302 Aylesworth, Ft. Collins, Colorado 80523, USA

Mimosoid Bulletin. J. Vassal, Ed. Internatl. Group for the Study of Mimosoideae. Lab. Botanique, Univ. P. Sabatier, 39 Allees J. Guesde, 31062 Toulouse Cedex, France (Annual; Research articles and news, lists of scientists)

NFTRR (Nitrogen Fixing Tree Research Reports). J. L. Brewbaker, Ed. Nitrogen-Fixing Tree Association, P.O.Box 680, Waimanalo, HI, 96795, USA. (Annual; publ. in February by TISTR, Pahonyothin Rd., Bangkhen, Bangkok)

The Legume/Rhizobium Symbiosis: A Continuing Bibliography. NiFTAL Project and MIRCEN, P.O. Box O, Paia, HI 96779. (Periodical)

2. MAJOR BIBLIOGRAPHIES AND PUBLICATIONS ON NFT

(NOTE: Numbers after species name refer to "general references" in Section 3 below)

ACACIA ALBIDA DEL. 1,4,5,7,10

Felker, P. 1978. State of the Art: Acacia albida as a complementary intercrop with annual crops. USAID Information Services. USAID, Washington, D.C.

ACACIA AURICULIFORMIS A. CUNN. EX BENTH. 2,3,4,10

National Acad. Sciences (USA). 1983. Mangium and other acacias. Innovations in tropical reforestation IV. National Academy Press, Washington, D.C.

Wiersum, K.F. and A. Ramlan. 1982. Cultivation of Acacia auriculiformis on Java, Indonesia. Inst. Ecology, Padjadjaran Univ., Bandung, Indonesia (unpublished)

ACACIA CONFUSA MERR. 5,10

ACACIA FARNESIANA (L.) WILLD. 4,5,6,8,9,10

ACACIA MANGIUM WILLD. 3,4,10

Davidson, J. 1982. Acacia mangium. Eucalyptus and Forestry Sevices, P.O. 419, Armidale, NSW, Australia. 110 pp.

National Academy of Sciences (USA). 1983. Mangium and other acacias. Innovations in tropical reforestation. IV. National Academy Press, Washington, D.C.

ACACIA MEARNSII WILLD. 2,3,4,5,6,10

Sherry, S. P. 1971. The black wattle (acacia mearnsii de Willd.). Univ. Natal Press, Pietermaritzburg, S. Africa. 402 pp.

ACACIA NILOTICA (L.) WILLD. EX DEL. 1,3,4,5,6,10

Greaves, A., ed. 1982. Acacia nilotica (syn. A. arabica). Annot. Bibliography No. 000, Commonwealth Forestry Inst., So. Parks Rd., Oxford, England.

ACACIA SALIGNA (LABILL.) H. WENDL. 2,3,4,5,7

ACACIA SENEGAL (L.) WILLD. 1,3,4,5,6,10

Ross, J.H. 1968. Acacia senegal (L.) Willd. in Africa, with particular reference to Natal. Bol. Soc. Brot., Ser. 2, 42:207-240.

ACACIA TORTILIS (FORSK.) HAYNE 1,3,4,5,10

Mulhana, K.D. and G. D. Arora. 1980. Acacia tortilis--a promising fast-growing tree for Indian arid zones. Central Arid Zone Res. Inst., Jodhpur, Rajasthan 342003, India

ALBIZIA FALCATARIA (L.) FOSBERG 2,4,5,7,10

ALBIZIA LEBBEK (L.) BENTH. 1,2,3,4,5,7,8,10

ALNUS ACUMINATA O. KUNTZE 3,10

ALNUS GLUTINOSA (L.) GAERTN. 3,10

ALNUS NEPALENSIS D. DON 3,7,10

CALLIANDRA CALOTHYRSUS MEISSN. 3,4,7
National Academy of Sciences (USA). 1983. Calliandra. Innovations in tropical reforestation. V. National Academy Press, Washington, D.C.

CASUARINA CUNNINGHAMIANA MIQ. 3,10
Heathes, H. 1981. An annotated bibliography of casuarinas. Internatl. Working Group on Casuarinas (IUFRO). CSIRO, P. O. 4008, Canberra 2600, Australia.

CASUARINA EQUISETIFOLIA L. 2,3,7,9,10

CASUARINA GLAUCA SIEB. EX SPRENG. 3,10

CASUARINA JUNGHUNIANA MIQ. 3,10

DALBERGIA SISSOO ROXB. 4,5,7,10

ERYTHRINA BERTOEROANA URBAN 5,8,9

ERYTHRINA FUSCA LOUR. 5

ERYTHRINA POEPPIGIANA (WALPERS) O.F. COOK 4,5,8,10
Russo, R. O. 1982. Resultados preliminares de biomasa de la poda de Erythrina poeppigiana en Turrialba, Costa Rica. CATIE, Turrialba, Cost Rica. 10 pp. (unpublished)

GLIRICIDIA SEPIUM (JACQ.) WALP. 3,4,5,7,8,9,10

INGA VERA (L.) BRITTON 3,5

INTSIA BIJUGA (COLEBR.) O. KUNTZE 4,5

LEUCAENA DIVERSIFOLIA (SCHLECHT) BENTH. 10

LEUCAENA LEUCOCEPHALA (LAM.) DE WIT 1,2,3,4,5,6,9,10
Brewbaker, J. L. and E. M. Hutton. 1979. Leucaena--Versatile tropical tree legume. In New Agricultural Crops, G. A. Ritchie, Ed. Amer. Assn. Adv. Science. Publ., Westview Press, Boulder, Colorado. pp. 207-259.
National Academy of Sciences. 1977. Leucaena; Promising Forage and Tree Crop for the Tropics. Natl. Acad. Sciences, Washington, D.C. 115 pp.
Oakes, A. J. 1982. Bibliography on Leucaena. Germplasm Resources Center, USDA, Beltsville. Md. 171pp

MIMOSA SCABRELLA BENTH. 3,4

PARKIA JAVANICA (LAM.) MERRILL 7
Hopkins, M. 1983. Monograph of Parkia species. Doctoral Thesis, Oxford Univ., Oxford, England

PARKIA SPECIOSA MASSK. 5

PARKINSONIA ACULEATA L. 3,5,7,8,10

PITHECELLOBIUM DULCE (ROXB.) BENTH. 3,4,5,7,9,10

PONGAMIA PINNATA (L.) PIERRE 1,3,5,7,10

PROSOPIS ALBA/CHILENSIS "Complex" 1,3,4,10
(Includes P. alba Griseb. and P. chilensis (Mol.) Stuntz; also P. flexuosa and P. nigra)

PROSOPIS CINERARIA (L.) DRUCE 3
Mann, H. S. and S. K. Saxena, eds. 1980. Khejri (prosopis cineraria) in the Indian desert; its role in agroforestry. CAZRI, Jodhpur 342003, Rahasthan, India

PROSOPIS PALLIDA/JULIFLORA "Complex" 1,2,3,4,5,7,8,9,1(
(Includes P. pallida (Humb & Bon ex Willd) and P. juliflora (Swartz) DC)
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PROSOPIS TAMARUGO F. PHIL. 1,2,3,4,5,10
Habit, M. A., T. D. Contreras and R. H. Gonzalez. 1981. Prosopis tamarugo: Fodder tree for arid zones. FAO Plant Production and Protection Paper 25. FAO, Rome, italy. 110 pp.

PTEROCARPUS INDICUS WILLD. 4,10

ROBINIA PSEUDOACACIA L. 2,4,5,7,10

SAMANEA SAMAN (JACQ.) MERRILL 2,4,9,10

SESBANIA GRANDIFLORA (L.) POIR. 4,7,8,9,10
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8. Garciz Barrige, H. 1974. Flora Medicinal de Colombia. Botanica Medica Imprenta Nacional. Vol 1. 561 pp. Bogota, Colombia.

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Possibly to add later:

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Periodicals, bibliographies and general references relating to multipurpose trees

(additional to those for nitrogen fixing trees shown in Appendix 11a)

A. Bibliographies, reviews, general references

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BALICK, M.J., ANDERSON, A.B. and FRE TAS DE SILVA, M. (1982). Palm taxonomy in Brazilian Amazonia: the state of systematic collections in regional herbaria. Brittonia 34 (4), 463-77.

BOLAND, D.J. and TURNBULL, J.W. (1981). Selection of Australian trees other than eucalypts for trials as fuelwood species in developing countries. Aust. For. 44 (4), 235-46.

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B. Periodicals

Acta Amazonica (Brasilia, Brazil)
Agro-Forestry (Turrialba, Costa Rica)
Agroforestry Systems (The Hague, Netherlands)
Annals of Arid Zone (Jodhpur, India)
Australian Forest Research (Canberra, Australia)
Biotropica (Washington DC, USA)
Bois et Forets des Tropiques (Paris, France)
Brazil Florestal (Brasilia, Brazil)
Brittonia (New York, USA)
Commonwealth Forestry Review (Oxford, England)
East African Agriculture and Forestry Journal (Nairobi, Kenya
Economic Botany (New York, USA)
Experimental Agriculture
Indian Forester (Dehra Dun, India)
International Tree crops Journal (Berkhamstead, England)
Kew Bulletin (London, England)
La - Yaaren (Ilanoth, Israel)
Malaysian Forester (Kuala Lumpur, Malaysia)
Nigerian Journal of Forestry (Ibadan, Nigeria)
Pakistan Journal of Forestry (Peshawar, Pakistan)
Principes (Kansas, USA)
Sudan Silva (Khartoum, Sudan)
South African Forestry Journal (Pretoria, South Africa)
Sri Lanka Forester (Colombo, Sri Lanka)
Sylva Africana (Nairobi, Kenya)
Sylvatrop (Laguna, Philippines)
Tropical Forestry Papers (Oxford, England)
Tropical Science (London, England)
Turrialba (Turrialba, Costa Rica)
Unasylva (Rome, Italy)

Abstracts

Applied Botany Abstracts (Lucknow, India)
Arid Lands Abstracts (Farnham Royal, England)(Terminated)
Ecological Abstracts (Norwich, England)
Ecology Abstracts (London, England)
Forest Products Abstracts (Farnham Royal, England)
Forestry Abstracts (Farnham Royal, England)
Herbage Abstracts (Farnham Royal, England)
Horticultural Abstracts (Farnham Royal, England)
Plant Breeding Abstracts (Farnham Royal, England)
Weed Abstracts (Farnham Royal, England)

Recommendations of Fourth Session of FAO Panel of Experts on Forest Gene Resources (FAO, 1977)

A. General

1. To International Organizations

(1) On the assumption that the funds available for seed procurement under FAO's Regular Programme in 1978/79 would be the same as in 1976/77, i.e. US$ 45 000, the Panel recommended that it should be distributed as follows:

(a) US$ 10 000 to the Instituto Nacional de Investigaciones Forestales (INIF) in Mexico, for further exploration and collection of Mexican conifers and hardwoods.

(b) US$ 3 000 to the Forest Research Institute of Nigeria, for further exploration and collection of tropical hardwoods in West Africa.

(c) US$ 3 000 to the Centre Technique Forestier Tropical, for further exploration and collection of tropical hardwoods in West Africa.

(d) US$ 15 000 to the Division of Forest Research, C.S.I.R.O. in Canberra, for further exploration and collection of the genus Eucalyptus and other genera in Australia, and for cooperative exploration and collection expeditions with countries in the East Indies.

(e) US$ 5 000 to the Department of Forests, Papua New Guinea for further exploration and collection of species of Eucalyptus, Araucaria, Toona and Flindersia.

(f) US$ 1 000 to the United States Forest Tree Seed Centre at Macon, for supply of seed to developing countries.

(g) US$ 8 000 for contingencies, to other institutes as required.

(2) The Panel noted with gratification the proposals of FAO's Forestry Department that the Regular Programme funds for Forest Genetic Resources in 1978/79 be substantially increased, as compared with 1976/77. It recommended that, in distributing such additional funds, FAO should give consideration to supporting the following:

(a) Exploration/collection of Central American conifers and hardwoods by the Commonwealth Forestry Institute, Oxford.

(b) Additional exploration and collection of West African hardwoods by Forest Research Institute of Nigeria and Centre Technique Forestier Tropical.

(c) Collection of Mediterranean conifers coordinated by Istituto Sperimentale per la Selvicoltura, Florence.

(d) Additional exploration/collection of Australian species by Division of Forest Research, C.S.I.R.O., Canberra.

(e) Additional exploration/collection of Papua New Guinea species by Department of Forests, Papua New Guinea.

(f) Exploration/collection of Gmelina and other hardwoods, and of Himalayan conifers, by the Indian Forest Service and the Danish/FAO Forest Tree Seed Centre.

(g) Additional collections by the U.S. Forest Tree Seed Centre, Macon, for supply to developing countries.

(h) International surveys and assessments of provenance trials of Eucalyptus and other genera.

(i) Training activites in all aspects of the exploration, collection, evaluation, conservation and utilization of forest genetic resources.

(3) The Panel stressed the need for it to maintain its responsibilities for the central direction and coordination of the Global Programme on Forest Genetic Resources. Advice on specialised aspects, e.g. data storage and retrieval, long-term seed storage, could be provided by IUFRO Working Parties or ad hoc panels, but would not replace the global coordinating function, which only the Panel could fulfil.

(4) The Panel emphasised the value of the publication "Forest Genetic Resources Information" and recommended that FAO continue to publish it periodically.

(5) The Panel welcomed the proposed change of title of one post in FAO's Forestry Department from Forestry Officer (Afforestation) to Forestry Officer (Genetic Resources and Tree Improvement), which reflects the importance which Forest Genetic Resources has increasingly assumed in the Department's Regular Programme over the past decade. At the same time it recognised that the increasing commitment for central coordination of the Global Programme, which results from the financial support of UNEP and possibly from future support from IBPGR, would need additional coordinating staff, which might be financed from Trust Funds.

(6) The Panel warmly welcomed the new project on Conservation of Forest Genetic Resources (1108-75-05), which is being financially supported by UNEP, and noted the progress made. It stressed the importance of conservation of natural ecosystems in situ, as the most suitable method for the majority of species, but recognised its long-term nature. Operations for in situ conservation which could be completed in a two year project were confined to ecological survey, demarcation of boundaries etc. For this reason, the Panel noted that the project's operational progress in in situ conservation had been slower than in ex situ conservation . It recommended that attempts to identify worthwhile operations for in situ conservation should be continued for six months. At the end of that period, any funds unspent under in situ conservation could be transferred to establishment of ex situ conservation stands, for which there is a considerable demand,or to training activities. The funds of the current project should, if possible, be allocated in sufficient quantity to cover the full establishment period. The Panel recommended that UNEP give favourable consideration to the continuation of conservation operations by financing a follow-up project when the current project ends.

(7) The Panel recommended that close liaison be maintained with Unesco (MAB 8 programme) and IUCN in all activities concerned with in situ conservation. In situ conservation of forest genetic resources can frequently be combined with nature conservation in general, but the special needs and problems of genetic conservation should not be overlooked.

(8) The Panel noted that the IBPGR at its Third Session (February 1976) had, in addition to food trees, identified the exploration and conservation of the genetic resources of a few species important for agriculture, in connection either with the fuel requirements of farming populations or the stabilization of marginal environments, as projects in which it should be authorized to give limited financial support. The Panel welcomed the interest of the IBPGR in species valuable for agricultural communities and noted the list of candidate species in the secretariat note "Species for Improvement of Agricultural Environment and Rural Living" (FO: FGR/4/6). Of these, Eucalyptus camaldulensis and E. tereticornis were already included in the UNEP project, while E. microtheca and several species of Acacia and Prosopis should be given high priority.

(9) The Panel emphasised the importance, and the present inadequacy, of training facilities in the comparatively new field of Forest Genetic Resources. It recommended that training should be expanded. It should be adapted to local needs and could include short practical courses in the field, as well as longer and more formal academic courses at universities.

(10) The Panel recommended the intensification of international cooperation in tree breeding programmes for individual species of wide importance, e.g. Pinus caribaea in the tropics, Pseudotsuga in N. America and Europe. Where appropriate, this should include national seed orchards producing seed for international use. An essential part of this work would be the compilation of an international register of seed orchards, following the example of EEC, showing the quantities of seed expected to become available to other countrie

2. To Governments

(1) The Panel expressed its warm appreciation of the excellent work of the Danish/FAO Forest Tree Seed Centre in Humlebaek, Denmark, and noted that the present financing period of the Seed Centre is due to expire in approximately two years. In view of the essential role of the Seed Centre in the series of FAO/DANIDA Training Courses on Tree Improvement, Genetic Resources, Seed Handling and Afforestation, in coordination and advice to regional seed and tree improvement centres, e.g. in India and Thailand, and in evaluation and conservation activities, the Panel recommended that the Danish Government give consideration to the continuation and, if possible, the strengthening of the Seed Centre at Humlebaek.

(2) The Panel noted that a proposal had recently been put forward by FAO that the Danish International Development Agency (DANIDA) should consider including the establishment of international ex situ provenance conservation stands in its programme. The Panel endorsed this proposal for an important addition to the valuable programme in international forest genetic resources already being carried out with DANIDA support and suggested that the Danish/FAO Forest Tree Seed Centre would be the best institute to coordinate the new programme, which would be a logical extension of its existing activities.

(3) The Panel expressed its warm appreciation of the excellent work of the Commonwealth Forestry Institute at Oxford, through its Unit of Tropical Silviculture, which included such varied activities as the exploration and collection of Central American pines and hardwoods, studies of the genus Agathis and the production of the series of Tropical Forestry Papers. The Panel expressed the hope that the U.K. Government would continue to support this important work.

(4) The Panel expressed its warm appreciation of the excellent work of the Seed Section of the Division of Forest Research, C.S.I.R.O. Canberra and noted the wide range of species and provenances collected since its last session in 1974. It expressed particular satisfaction that substantial new collections of the Petford and Katherine provenances of Eucalyptus camaldulensis and the Mt. Garnet provenance of Eucalyptus tereticornis had been made for conservation purposes with the assistance of UNEP funds. It recommended that the Division of Forest Research continue these operations, which are of great value to many developing countries, and that, in determining the species to be collected in the future, priority be given to those of value for agricultural communities.

(5) The Panel expressed its warm appreciation of the excellent work of the Instituto Nacional de Investigaciones Forestales in Mexico, in the further exploration and collection of Pinus oocarpa provenances in the 1976/77 season, and recommended that seed for international trials of both the INIF and CFI Oxford collections be distributed as soon as possible. It expressed the hope that these operations be continued and expanded to cover additional genera, e.g. Pseudotsuga, Populus.

(6) The Panel expressed its warm appreciation of the excellent work of the Indian Forest Service in the exploration and collection of a number of provenances of Gmelina arborea in India, in collaboration with the Danish/FAO Forest Tree Seed Centre. In view of the potential importance of this species for many tropical countries, the Panel recommended that this work be continued and extended to other countries.

(7) The Panel expressed its warm appreciation of the excellent work of the Forest Research Institute of Nigeria and the Centre Technique Forestier Tropical, in the exploration and collection of tropical hardwoods in West Africa, and of the work done by CTFT in

collection of eucalypt seed in Australia and the East Indies. It recommended that this work be continued and, if possible, expanded.

(8) The Panel expressed its warm appreciation of the excellent services provided by the U.S. Forest Tree Seed Centre at Macon and recommended that these be continued and expanded.

(9) The Panel recognised the paramount role of national staff in the management and assessment of species and provenance trials, in order to derive information of maximum value for local purposes. At the same time, it recognised the value, for comparing results between countries, of assessments carried out to a common international standard. It recommended that institutes responsible for the coordination of international trials should be prepared, on request, to assist cooperating countries in assessment and documentation of the trials, and should provide the necessary funds for the travel involved.

B. Technical and Operational

(1) The Panel reiterated its previous recommendation that research should be intensified, particularly in the tropics, on flowering and reproductive systems, in addition to seed handling. While welcoming the publication "Tropical Trees, Variation, Breeding and Conservation", the Panel noted that basic research on reproductive biology of most tropical hardwoods is still lacking.

(2) The Panel welcomed the publication of the Report of the IBPGR Working Group on Engineering, Design and Cost Aspects of long-term Seed Storage Facilities. It recommended that panel members should seek the comments of forest seed experts in their respective countries on the extent to which the prescriptions for long-term storage of agricultural seeds are applicable to forest seeds. If the requirements are similar, at least in the case of "orthodox seeds", the Panel recommended a survey to ascertain which forest seed centres could provide the recommended facilities.

(3) The Panel reiterated its previous recommendation that information on equipment for seed collection be summarised and published as soon as possible. It noted the current survey of seed equipment being carried out by Dr. Bonner for the IUFRO Working Party on Seed Problems, which is expected to include equipment for seed collection. If additional, more detailed, information is required, the Panel expressed the hope that the FAO/DANIDA Forest Tree Seed Centre would undertake the work. It recommended that the publication should include information on safety regulations.

NATIONAL RESEARCH COUNCIL
OFFICE OF INTERNATIONAL AFFAIRS
2101 Constitution Avenue Washington, D.C. 20418

BOARD ON SCIENCE AND TECHNOLOGY
FOR INTERNATIONAL DEVELOPMENT

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FAST-GROWING, NITROGEN-FIXING TREES

GRANTS APPROVED

through December 1982

NO./TITLE	INSTITUTION/COUNTRY	PRINCIPAL INVESTIGATOR	PERIOD
FGT-CL-1-83-13 Evaluation and Testing of Fast-Growing, Nitrogen-Fixing Tree Species for Semi-Arid Regions	Instituto de Investigaciones Tecnologicas (INTEC) Chile	E. Maria Elena Torres	11/30/82-11/30/85
FGT-KE-1-82-19 Technical/Scientific Back-up	International Council for Research in Agroforestry (ICRAF), Kenya	Peter A. Huxley	3/9/82-3/8/83
FGT-KE-3-83-17 Selection and Testing of FGNFTs for Use in Farm Woodlots and Agroforestry Combinations	Department of Forestry University of Nairobi, Kenya	Frederick Owino	11/23/82-11/22/86
FGT-MX-2-83-12 Native FGNFTs in Upland and Lowland Sites as a Source of Fodder, Fuelwood and Soil Enrichment	Instituto Nacional de Investigaciones Sobre Recursos Bioticos (INIREB), Mexico	Enrique Pardo Tejeda	3 years
FGT-PH-1-83-11 Nitrogen Fixation and Multiple Uses of *Albizzia falcataria*, *Gliricidia sepium*, and *Sesbania grandiflora*	Visayas State College of Agriculture (ViSCA), Philippines	Rudolfo G. Escalada	3 years

FGT-TH-1-82-20 Field Trials and Testing of Selected Species of Fast-Growing, Nitrogen-Fixing Trees	Thailand Institute of Scientific and Technological Research (TISTR), Thailand	Narong Chomchalow	2/11/82-2/10/85

GRANTS IN PROCESS*

Determination of Best Species, Provenances Rhizobia, Mycorrhiza in the Congolese Savannahs	Centre Technique Forestier Tropical (CTFT), People's Republic of the Congo	Daniel Diangana	4 years
Fast-Growing, Nitrogen Fixing Trees in Agro-forestry: Effect on Crop Yields and Soil Properties	Bunda College of Agriculture, Malawi	O.T. Edje	4 years
Soil Factors which Limit Biological Nitrogen Fixation in *Leucaena leucocephala* in Panamanian Soils	University of Panama, Panama	Blanca C. de Hernandez	3 years

GRANTS TENTATIVELY APPROVED*

Nitrogen Fixation Potential of Some Woody Chilean Plant Species	Pontificia Universidad Catolica de Chile, Chile	Orlando Balboa	3 years
An Inventory of the Genus *Acacia* in Sudan: Spatial Extent, Utilization, and Germ Plasm Characteristics	University of Gezira, Sudan	Mahdi Beshir	2 years

Titles shown are subject to modification as grant documents are prepared.

Research units of IUFRO that are or could be concerned with multipurpose trees

Division 1. Forest environment and silviculture

S1.01-06	Tropical and subtropical forest ecosystems
S1.05-02	Afforestation problems in arid and sub-arid regions
S1.05-06	Multiple-use silviculture
S1.07.06	Silviculture of mangrove forests
S1.07-07	Agroforestry
S1.07-08	Silviculture of mangrove forests
S1.07-09	Wood production in the neotropics via plantations
S1.07-10	Tropical land rehabilitation by afforestation
S1.07-11	Tropical nursery and plantation techniques
P1.09-00	Integrated research in biomass for energy
P1.11-00	Mediterranean shrub ecosystems
P1.12.00	*Casuarina*

Division 2. Forest plants and forest protection

S2.02-01	Dendrology
S2.02-02	Conservation of gene resources
S2.02-03	Species monographs
S2.02-08	Tropical species provenances (excluding eucalypts)
S2.02-09	Eucalypt provenances
S2.03-01	Breeding tropical species
S2.03-03	Seed orchards
S2.03-04	World directory of geneticists and tree breeders
S2.03-10	Breeding *Eucalyptus*

S2.06-13	Phytosanitary regulations and quarantines
P2.02-04	Nitrogen fixing trees
P2.04-00	Seed problems

Division 5. Forest products

P5.01-00	Properties and utilization of tropical woods
P5.03-00	Energy and chemicals from forest biomass
P5.04-00	Production and utilization of bamboo and related species

N.B. Further details and addresses of offices in these research units can be obtained from the IUFRO Secretariat, Schonbrunn, Tirolergarten, A-1131, Vienna, Austria.

Position Announcement

The International Union of Forestry Research Organizations (IUFRO) is seeking a senior level forester for a position as Special Coordinator, to increase IUFRO program activities in support of forestry research in developing countries. This is a new position, established on a trial basis for two years and beginning approximately July 1, 1983. Primary duties during the first year will be (1) to organize up to three workshops in developing countries that will identify urgent research needs and develop action plans to meet these needs, (2) to disseminate information on forestry research problems and activities in developing countries by preparing articles for IUFRO News and other publications, and (3) subject to further negotiation with donors, to administer travel funds to increase participation of researchers from developing countries in international scientific meetings.

Qualifications required

1. A university degree in forestry, preferably at the doctoral level.

2. Experience in the conduct, management, and administration of forestry research.

3. Appreciation of the forestry conditions and the customs and needs of people in developing regions.

4. A working knowledge of the principles and procedures of IUFRO, FAO, and other international forestry organizations.

5. Experience in dealing with high-level government officials, university and other research institute directors, and officers of international organizations in administering multilateral and bilateral donor funded projects in a developing country environment.

6. Capability to work independently without close supervision or direction.

7. Fluency in English, including the demonstrated ability to write polished letters and reports. The ability to speak and write in Spanish, French, and/or German is desirable.

8. The physical stamina to carry out extensive and extended travel to a wide variety of locations throughout the world.

Applications

Applicants should submit a letter describing how they meet the above qualifications, a curriculum vitae, and the names (with address and telephone number) of two references having specific knowledge of their qualifications for this position.

Two copies of the application should be sent, one each to:

Professor Dr. Dusan Mlinsek
IUFRO President
Biotechnical Faculty
Krekov trg 1
61000 Ljubljana
Yugoslavia

Dr. Robert E. Buckman
Vice President, IUFRO
USDA Forest Service
P.O. Box 2417
Washington, D.C. 20013
USA

Applications must be received by March 31, 1983.

NOTE: The successful applicant will be expected to attend the 1983 meeting of the IUFRO Executive Board in Manaus, Brazil, July 17-29.

Extract from J.B.W. Kenrick's M.Sc. thesis on Acacia breeding system, School of Botany, University of Melbourne

Source: Miss J.B.W. Kenrick

There are indications that at least some species of Acacia are self-incompatible. Keighery (cited in Hopper and Maslin, 1978) found that a number of species do not self-pollinate; Hocking (1970) and Janzen (1974) noted that when the swollen-thorn acacias were grown in glasshouses they did not set seed; and Moffett and Nixon (1974) concluded from their own work and that of their predecessors at the Wattle Research Institute that there was probably some self-incompatibility in A. mearnsii and A. decurrens. Both A. mearnsii and A. decurrens do set some seed by self-pollination (Philp and Sherry, 1946; Moffett, 1956) and A. baileyana sets seed by self-pollination (Newman, 1934). Zapata and Arroyo (1978) found self incompatibility in A. macracartha.

The mechanism of self-incompatibility is not known. The spatial and temporal separation of anther and stigma surface would be insufficient to prevent pollination because there are almost always other inflorescences on the same plant at various stages of development.

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Seed certification, provenance nomenclature and genetic history in forestry

By N. Jones[1]) and J. Burley[2])

(Received March / revised April 1973)

Introduction

The establishment of forest plantations throughout the world demands annually increasing amounts of seed. Seeds are often transferred between countries, or between areas within countries, accompanied by inadequate information about their source and history. Many countries have established seed zone systems for their indigenous species and various schemes of seed certification have been or are being designed in which better and essential information on seed is provided both nationally and in relation to international trade.

Most existing schemes relate to European and North American countries; the purpose of the present paper is to bring them to the attention of other countries, particularly those tropical and subtropical countries that are currently establishing large industrial plantations of both exotic and indigenous species. The development of local certification schemes based on an international system is recommended. There are, however, limitations in the existing systems for tree breeding programmes which are noted and some amendments suggested.

Seed certification

Certification is defined in English usage as the authoritative attestation of facts or statements and it usually implies documentation by a formal written certificate. Seed certification is an official statement that a seed lot conforms to certain standards which may include specific identity, origin, genetic characters and seed purity. These include the 'genetic' and 'somatic' values described by Rohmeder (1960). As used by plant breeders, after many years of development, seed certification implies genetic improvement and it aims to facilitate the provision of high quality seed from superior crop plants with similar genetic identity and purity. In this case, strictly, the term *certified* should be reserved to describe seed of improved (and uniform genetic) quality; it should not be used to identify seed origin. Complete genetic uniformity and predictability are generally obtained only after several generations of selective breeding and in forestry they have been rarely obtained or required. For forestry, therefore, seed certification systems have developed largely to provide labels and records that give officially authenticated details of identity and origin; a summary of early European work was given by Commonwealth Forestry Bureau (1941). However, as tree breeding progresses and particularly as improved seeds are exchanged between countries, it will become increasingly important to know more of their genetic history and quality.

According to Banks (1968) forestry has been slow to follow agriculture's lead in seed certification for three main reasons: — (i) the lack of appreciation of the importance of seed origin, (ii) seed certification is based on breeding, and tree breeding is slower than agricultural breeding, and (iii) the volume of forest tree seed traded is small. Also tree seed is commonly collected by unsupervised and unskilled labour. However, as tree breeding programmes become productive, seed certification is becoming more urgent, particularly in tropical regions with their fast growth, early flowering and short commercial and breeding rotations.

A detailed review of progress towards seed certification in 30 countries was provided by Matthews (1964). There were at that time 12 comprehensive national certification schemes; with the exception of Japan and U.S.A. these were all for European countries. Since then Canada has progressed towards the development of a national scheme which is currently applicable in Alberta, British Columbia, and parts of Northwest Territory and the Yukon (Wang and Szikla, 1969; Anon., 1971, 1973; Piesch and Phelps, 1971). (Source-identified seeds with a value approaching a quarter of a million Canadian dollars are now exported annually from Canada under this scheme.) In Australia the principles of seed certification have been discussed (e. g. Banks, 1968, 1970) but there are no state or national systems operating. The State Forest Services have usually maintained records of the origin of seed lots on a voluntary basis (Turnbull, 1973; pers. comm.[2]).

Matthews (1964) outlined the principles of a national seed certification scheme and a good example of the details of such a scheme was given by Schoenike (1969) for the state of South Carolina, U.S.A. Minimum standards for certification, particularly for the provenance and progeny testing necessary, have been described by the Georgia Crop Improvement Association (1959), Wakeley *et al.* (1960), Barber (1964), Schoenike (1969) and Stern (1969).

Despite the cooperation of foresters, seed collectors, seed dealers and local or national legislators, it is obviously difficult do develop national schemes that are acceptable to all those concerned with tree seed. (See, for example, the earlier controversy in the United States recorded in Society of American Foresters Seed Certification Subcommittee, 1961, 1963 a, 1963 b; Western Forest Tree Seed Committee, 1961; Cech, Barber and Zobel, 1962).

Clearly it is important, even though difficult, to create internationally acceptable systems of seed certification. As more countries become involved in seed exchange, plantation work and tree improvement, such a system can be considered essential. In fact an international scheme does now exist. This is the scheme which sets minimum standards for the control of forest reproductive material moving in international trade, prepared by the Organization for Economic Cooperation and Development (O.E.C.D., 1971; see also Barner in F.A.O., 1971). First accepted in 1967 after several years' preparatory work and meetings, this latest version is still subject to discussion and amendment. O.E.C.D. covers 23 countries, 17 of which are interested in the scheme while 11 have already named their designated authorities for the issue of certificates and for making the necessary checks.

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The Organization for Economic Cooperation and Development, in its scheme discussed above, defined the following:

Provenance – *The area on which any stand of trees is growing. The stand may be indigenous or non-indigenous.* (At its meeting in 1972 the O.E.C.D. proposed a slight amendment: *The place in which any stand of trees is growing. The stand may be indigenous or non-indigenous.*[9])

Origin – *For an indigenous stand of trees the origin is the place in which the trees are growing; for a non-indigenous stand the origin is the place from which the seed or plants were originally introduced.*

Which ever definition of provenance is used, it is desirable to compare different seed lots in designed experiments called provenance tests. Indeed the *'certified'* category in the O.E.C.D. scheme requires proof of superiority to be shown by provenance or progeny tests. Currently proposed amendments for the O.E.C.D. scheme may include one or other of the following definitions:

Progeny.

Offspring of a particular mating, or of a particular mate, or of a particular individual in the case of apomictic reproduction (Rieger, Michaelis and Green, 1968).

Progeny test.

Evaluation of parents by comparing the performance of their offspring. Accuracy is usually gained because several to many offspring per parent are evaluated under more controlled conditions than exist for the parent (Snyder, 1972)

Progeny test.

Evaluation of parents by the performance of their sexual progeny. Includes 1-parent progeny test, in which only the female parent is known, and 2-parent progeny test, in which both the seed and pollen parents are known (Wright, 1962).

Limitations of existing definitions

All the definitions of provenance quoted above have limitations. The object of any definition is to provide as many people as possible with as much unequivocal information as possible about the object described. With careful and combined use of one or more of the above definitions, the geographic history of a seed lot could be described, *i. e.* where the seed itself was collected and where the seed that produced its parent trees had originated, and so on.

Consider, for example, the provenance nomenclature applicable to a sample of seed of *Pinus patula* collected in Kenyan plantations; these plantations were raised from seed collected in South African plantations and these were themselves raised from seed collected in natural stands in Los Reyes, Hidalgo, Mexico. The source, origin or provenance could variously and reasonably be named Kenya, or Kenya ex Mexico, or Kenya ex South Africa ex Mexico, or Mexico (Los Reyes, Hidalgo). In practice all available information should be sought and given, particularly in international transfers of seeds.

However, none of these possible names would give any indication of the history of natural and artificial selection to which the natural stand and subsequent plantations had been subjected, and which could influence the genetic constitution of the seed sample. (Additionally, and quite correctly, none of these names gives any indication of the pattern of natural variability in a species.) None of the classificatory and nomenclatural systems discussed above can impart all the information that is desirable about the antecedents of a given seed lot; they relate only to the geographical history not to genetic history.

All genetically based tree improvement programmes essentially follow classical plant breeding procedures. The value of the end product is recognised and cultural techniques are developed to produce an acceptable yield. Certain highly productive or better adapted populations are identified and intensive breeding is based on these. The genetic variability is high in early populations; as the amount of parental stock is decreased by selective breeding, the genetic variability will be reduced which in turn reduces the genetic gains possible by further selection.

To maximise genetic gains it is essential to know the genetic composition of the initial population used for breeding. In the next section we consider some of the possible alternative histories of natural and artificial selection that could have a bearing on the planning of programmes of selection and breeding. It is not suggested that a formal system of nomenclature or classification be developed for these; rather we would wish only to emphasise the need to obtain as much relevant information as possible on each seed lot.

Genetic history

A sample of reproductive material may comprise fruits, seeds, pollen, scions for vegetative propagation, or tissue for aseptic culture, but the following discussion will be restricted to seeds because these form the major component of commercial forest reproduction, particularly seeds of naturally outcrossing species.

A sample of seed from one population of parent trees may be collected from one, a few, or many parents. The amount of genetic variability represented generally increases with increasing number of parents particularly if they were randomly selected to represent the population. However, genetic variability may be reduced even with larger numbers of parents if the parents were located close together in a natural stand, or if they occur in a plantation which itself was derived from a small number of parents, or if they were selected to meet special criteria. In the latter case, their phenotypes are similar and there is an increased chance that their genotypes will be similar; in the other two cases there is a greater chance of common descent (coancestry).

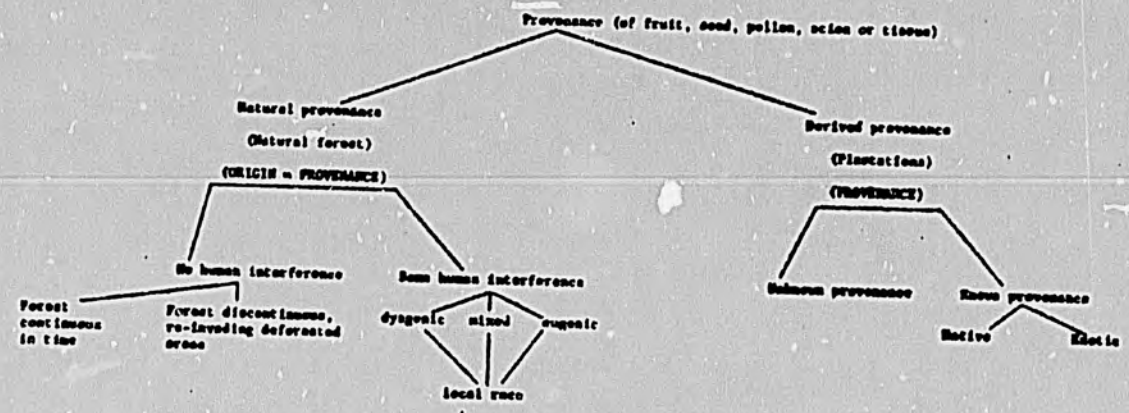
There are three important consequences of reduced genetic variability in a seed sample. Firstly, in the commercial plantation there is a risk of increased susceptibility to damage by pathogens and climate factors, and to a change in marketability of produce; this risk, common to all types of monoculture, increases as genetic variability decreases, although it may be offset to some extent by increased predictability of performance and ease of management. Secondly, the amount of additive genetic variance available for future use by selection in the plantations is decreased, reducing the further gains possible through breeding. Thirdly, the risk of inbreeding depression in a breeding programme increases with increasing degree of relationship between selected individuals.

The number of parents represented, and their degree of relationship are thus important considerations when a crop is raised from seed. Seed may be obtained in bulk commercial collections or as small research lots; the latter may

[9] Personal communication, H. Barner 4th July, 1972.

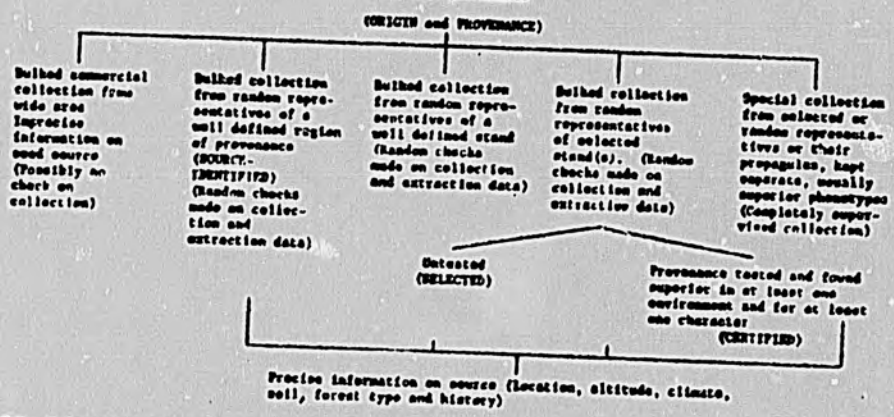
Table 1. A stylised classification of genetic history

A. Classification into natural and derived provenances



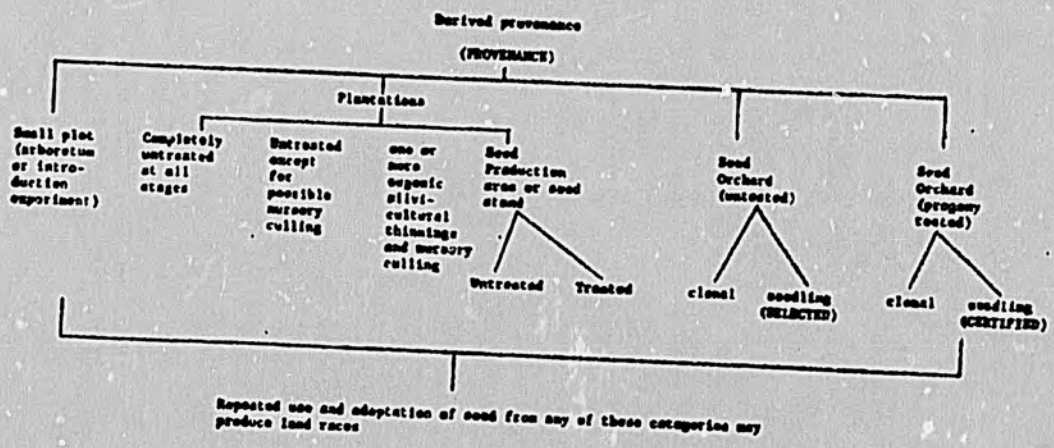
N.B. The entire system or any level of it could be repeated for percentages of 1 parent tree, 2-10 parent trees, or more than 10 parent trees; similarly by year of collection. Equivalent terms from the O.E.C.D. system are given in capital letters in brackets.

B. Sub-classification of natural provenance



N.B. Information, value and uniformity increase from left to right.

C. Sub-classification of derived provenance



N.B. Information, value and uniformity increase from left to right.

Appendix 18

Responses to questionnaire

A list of some 150 species will be distributed at the meeting.

MULTIPURPOSE PALM GERMPLASM

A Supporting Document Prepared for
A Workshop to Discuss International
Cooperation with Regard to Multipurpose
Tree Germplasm

By

Dennis V. Johnson

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INTRODUCTION

The purpose of this supporting document is to assess the state-of-science of germplasm resources of palms which have multiple utility and possess potential for incorporation into agroforestry systems, and to address four problem areas of practical concern to the future development of palm germplasm. The report draws to a considerable degree upon professional experience with useful palms, supplemented with the gathering of current general information on germplasm resources, and a brief trip to interview scientists at the New York Botanical Garden, Bronx, New York and the U.S. Department of Agriculture Germplasm Resources Laboratory, Beltsville, Maryland. Undertaken at very short notice, this report should be considered as a first approximation on the subject of palm germplasm.

Two major sections make up the body of this report. Section One provides a determination of those palms considered to have multipurpose qualities, a classification of the designated palms into three groups on the basis of their current level of domestication, and a discussion of some of their distinctive botanical characteristics as far as agroforestry is concerned. The major sources of palm germplasm, ranging from natural areas of occurrence to tissue culture, are also discussed.

In Section Two, practical problems related to germplasm sources are addressed. These include the acquisition and distribution of germplasm which is adequately documented, the identification of suitable seed-stands and access thereto, the potential for improvement of germplasm based upon previous experiences with palms, and finally certain of the legal actions required to facilitate the distribution of and trade in germplasm materials.

In the text, both common and scientific names are given upon the first reference to a palm; thereafter, for the sake of brevity, only the common name is employed.

MULTIPURPOSE PALMS AND GERMPLASM SOURCES

At least 2,700 species of palms, representing more than 200 genera, are known to science. The palm family (Palmae) ranks second only to the grass family (Graminae) in terms of importance to mankind. Despite their usefulness, palms have received less study than any other large plant group. This oversight can be attributed to the limitations placed on agronomic research by a lack of trained personnel and funds in the countries where the palms occur; and because palms are mostly native to the tropics, they are inconvenient for study by botanists at research centers in the middle latitudes. Thus when dealing with the palm family one must not attribute to it a more advanced state of knowledge than is the actual case.

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Determination and Classification of Multipurpose Palms[1]

Determining which of the many palms should be considered to be multipurpose in character is not easy, especially with regard to the lesser-known palms, because of an inadequate amount of ethnobotanical evidence. Therefore the following attempt must be considered to be interim in nature. In this report, the growth of palms for ornamental purposes is not taken into account to satisfy the multipurpose requirement.

A total of 50 multipurpose palms have been selected for inclusion in this study. To facilitate discussion, and to better understand their current status and agroforestry potential, the palms are classified into three groups on the basis of their level of plant domestication.

Table I lists the four improved, cultivated palms which have been the object of botanical and agronomic research such that cultivars are named and progress made in crop improvement. They are among the major tropical crops. Incipient agroforestry systems are already being practised with these palms, and more advances can be expected as strategies for improving the productivity of the palms are allied with complementary cropping and grazing systems. Although commonly not included among agroforestry species, the date palm (Phoenix dactylifera) is included because of its potential for tropical desert grazing systems. These palms are all multipurpose in character, although their lesser products are not yet valorized. Having been brought to the status of full domestication, they may serve as working models for designing development programs for other palms.

Listed in Table II are 19 palms which may be described as being in a state of incipient domestication. All are multipurpose plants, and they embrace the full range of tropical habitats. Most of the products are consumed locally and thus far there does not appear to have been much effort to increase their productivity or quality. Two notable exceptions are the peach palm (Bactris gasipaes), which is the object of an active program of research and development for fruit, palm heart production, and reforestation; and the sago palm (Metroxylon sagu) under investigation as a more industrialized source of starch. Both palms are nearly ready to be elevated into Group I. In general, these unimproved cultivated or managed palms have not been evaluated with regard to their status of multiple cropping or agroforestry.

The 27 palms included in Table III are either semi-wild or wild: the distinction is often difficult to make in settled areas. These palms have yet to be brought under cultivation for their products, although their occurrence and distribution in some cases may have been indirectly affected by agricultural or forestry activities. Given the scant amount of information available about these palms, further investigations are required to evaluate their potential. Despite their underdeveloped status, the murumuru (Astrocaryum murumuru), piassava (Attalea funifera), and raffia (Raphia spp.) palms support export fiber industries, and rattans (Daemonorops spp.) furnish commercial quantities of cane. A number of the palms show promise as reforestation plants, such as the mazari palm (Nannorohops ritchiana) in mountainous terrain, the sealing wax palm (Cyrtostachys lakka) in tropical swamps, and the thatch palms (Thrinax spp.) in dry, limestone areas.

Distinctive Palm Characteristics

Palms possess several distinctive botanical characteristics which should be taken into account when considering them for incorporation into agroforestry development schemes. Taxonomically, palms are placed in the subclass Monocotyledoneae - those plants producing a single seed leaf. Considering that palms normally are unbranched (with the exception of the doum palm (Hyphaene spp.), this means that each plant has only a single growing tip. Physical damage to or parasitic attack upon the growing tip can seriously injure or kill the palm; therefore they are more vulnerable than dicots. It is this tender, pale terminal bud which is edible in nearly all palms and is the commercial source of hearts of palm. An agricultural disadvantage of a single growing tip is that palms cannot be pruned to maintain a low stature as is the practice among a number of other tree crops. Fruit or leaf harvest of tall, mature trees is therefore difficult in major palms, such as the date, coconut (Cocos nucifera), and oil palm (Elaeis guineensis), and in a number of minor ones.

An advantage of these monocots is that, owing to their single, unbranched trunk and tight compact crown of leaves, they cast less shade than dicots. Their stature also permits a greater planting density than is feasible with spreading dicots. By allowing more light to penetrate through the vegetation canopy, palms afford more opportunities for understory growth of annual and perennial crops. Because palms do not require branch pruning the labor requirements for aftercare generally are less than for dicotyledonous tree crops, especially during the early years of growth. Palms do, however, require the removal of dead leaves.

Among those palms where leaves are harvested for fiber or wax, such as the palmyra (Borassus flabellifer) and carnauba wax palm (Copernicia prunifera), leaf cutting must be done carefully to avoid damage to the growing tip. Furthermore, excessive leaf removal is deleterious since it may weaken the natural resistance of the tree to environmental stress, and make it more susceptible to parasitic insects and diseases, and stunt its growth.

Palms are less vulnerable to fire damage than conifers and dicotyledons because the bascular tissues are organized into separate bundles and scattered through the trunk, and they have no bark since cells of the procambial strands mature into xylem and phloem. Therefore superficial scorching of the trunk of an adult tree is not serious. Adhering leaf bases, such as found on the oil palm, provide further insulation to the trunk. Young palms, however, are susceptible to fire damage, which is often fatal. Fire is an important concern in agricultural systems which include palms and periodic burning to control weeds.

Flowering is another palm characteristic to be considered. Palms exhibit more instances of diocism than woody dicots; several important species, such as the palmyra and date palms, bear male and female flowers on different plants. In cultivating dioecious palms for fruit, it is essential that an adequate number of male palms be present to assure a high rate of fruit set. Dioecism may be exploited to advantage for plant improvement by restricting pollen sources. Female trees may be pollinated by hand from superior male plants to guarantee high fruit

quality. This is a common procedure in commercial date growing.

Certain of the cultivated palms are terminal flowering. This hapaxanthic made of life, rare in woody perennials, is a disadvantage because those species must be replaced more frequently. The sago palm, for example, begins to flower at 10-15 years of age and then dies. Paradoxically, it is this very characteristic which gives the palm its major economic value, for the tree accumulates large quantities of starch in the trunk for the terminal flowering. This accumulated starch may be extracted from the interior of the trunk providing the tree is felled before the onset of flowering.

In association with flowering, some palms produce sufficient quantities of sweet sap to make it worthwhile to tap the inflorescences. The sap can be fermented and drunk as palm wine, or it can be heated and reduced to palm sugar. Tapping of the trunk is also possible in some species, but it eventually leads to the death of the tree.

Germplasm Sources

As far as I have been able to determine, the subject of palm germplasm *per se* has never before been addressed. For convenience, the discussion of germplasm will also loosely follow the tripartite classification system used above. Although ornamental use was excluded as a criterion in fulfilling the multipurpose definition; plant societies, seed dealers, and nurseries become quite relevant as germplasm sources when dealing with multipurpose palms which are also grown as ornamentals.

Before beginning to discuss germplasm sources, it is useful to consider palm propagation in general. This subject has been treated by Kiem (1958) and a number of others in the nursery trade. Palm propagation methods are more limited than is the case with dicots because vegetative propagation via grafting, budding, layering, the rooting of stems, etc., cannot be utilized. The only currently operational method of asexual propagation of palms is the separation of basal suckers with roots and the division of clumps. Unfortunately, a relatively limited number of palms have these growth habits. As far as the multipurpose species are concerned, the following can be propagated asexually:

Group I	Group II	Group III
Phoenix dactylifer	*Bactris gasipaes*	*Copernicia* spp. (some)
	Eugeissona utilis	*Cyrtostachys lakka*
	Euterpe oleracea	*Daemonorops* spp. (come)
	Metroxylon sagu	*Licuala* spp.
	Nypa fruticans	*Nannorhops ritchiana*
	Salacca zalacca	*Oncosperma* spp.
		Pinanga spp.
		Raphia spp.

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This group of palms can be grown from seed as well, but they generally would not be under commercial operations because it requires a year or more to grow from seed a plant the size of a basal sucker. For the remainder of the multipurpose palms, propagation by seed is the only practical means currently available.

Palm fruits vary from genus to genus, but there are four common characteristics which can be noted. They are relatively large, generally contain a single large seed, do not dehisce when ripe, and are not dormant when mature. The viability of palm seed is a subject about which much remains to be learned. Deleon (1958) estimated that palm seed viability ranged from 2 weeks to 3 months, depending upon the environment of the palm and the thickness of the endocarp. The Palm Society Seed Bank operates under the assumption that seeds retain viability for up to 3 months. Detailed studies have been conducted on some of the major cultivated palms

Coconuts store for up to 4 months in cool, dry, ventilated shelters (Purseglove, 1972); oil palm seeds packed in covered drums at ambient temperature retain a high level of viability for up to 12 months (Hartley, 1977); and date palm seeds kept in closed containers without refrigeration proved to be highly viable for up to 6 years (Nixon, 1964). The general practice, however, is not to store palm seed at all but to use it for propagation immediately after being harvested.

Natural Areas.

For most of the palms under consideration, natural areas represent major sources of germplasm. This is particularly true of Group III palms, and to a slightly lesser degree of those in Group II. Three of the latter--peach palm, sugar palm (*Arenga pinnata*), and talipot palm (*Corypha umbraculifera*)-- are unknown in the wild, but do have wild relatives which can furnish germplasm for breeding programs. None of the palms in Group I is found wild, although the status of the oil palm is not quite clear. One other species of that palm, the American oil palm (*Elaeis oleifera*) in Group II, is found wild as are congenetic species of the areca palm (*Areca catechu*), and of the date palm. One of the latter is the wild date palm (*Phoenix sylvestris*) in Group II. The coconut stands by itself as a monotypic palm without any closely related wild relatives.

The geographical distribution of these multipurpose palms is known approximately from floras, species lists of vegetation formations, hervaria records, and general sources. Some maps of palm distribution at the generic level, and for all of the palm subfamilies, can be found in Moore (1973a). However, the current situation is still somewhat uncertain because many taxonomic questions remain to be answered. Even the date palm genus *Phoenix* is not fully understood, in part because of natural hybrids among the species. Of the palms in Groups II and III, only a few genera have been monographed. The rattan genera *Calamus* and *Daemonorops* were recently studied by Dransfied (1979); the genus *Copernicia* by Glassman (1961, 1963); *Pritchardia* by Beccari and Rock (1921); the West African species of Raphia by Russell (1964); and the genus *Thrinax* by Read (1975). Investigations in progress by Michael J. Balick of the New York Botanical Garden should clear up the taxonomic confusion in the *Jessenia*, *Oenocarpus* and

Orbignya genera. General knowledge of all palm genera will be greatly enhanced upon completion of Genera Palmarum, begun by the late Harold E. Moore, Jr. and scheduled for publication in 1984 through the joint efforts of Natalie W. Uhl of Cornell University, Ithaca, New York and John Dransfied of the Royal Botanic Gardens at Kew, England.

Inextricably linked to reliance upon natural areas as sources of palm germplasm is the identification and appropriate protection of an adequate number of tropical ecosystems (NAS, 1978). Failure to do so has already threatened the survival of some palms. Moore (1979) details several palms as being endangered, among them all species of Ceroxylon, and one of the royal palms (Roystonea elata).

Selected Stands.

This germplasm source represents a refinement of the information about natural areas and is applicable when greater scientific knowledge about a particular palm is available, or can be inferred from the location of commercial extraction activities. In either case a selected stand generally represents the core, or a core, area of a palm within its geographic range. As such, the concept of a selected stand applies to managed, semi-wild, and wild palms of Groups II and III. As either the densest concentration of a particular palm, or a plant population which has proved empirically to be above average in yield of its useful products, a selected stand is a gene pool possessing high potential. Those palms in Group II which have been brought under a rudimentary form of cultivation probably represent selected germplasm from the wild, used as planting material because of direct evidence of high productivity. Core areas also convey information about the optimal environmental parameters of a palm, of great utility in determining where cultivation should be promoted. This often strong link between distribution and environment is exemplified by the moriche palm (Mauritia flexuosa) which is a reliable ecological indicator of tropical rainforest swamps (Moore, 1973b).

The quantity and quality of information available on selected stands of the palms in Groups II and III, ranges from adequate and good, to almost nonexistant and poor. An example of the former is the carnauba wax palm in Group II. As a result of studies by Dahlgren and Glassman (1961) and Johnson (1972a) the major areas of dense stands are known to be on the river floodplains of semi-arid northeastern Brazil, and have been mapped. In some of these areas, the palms have been brought to a predomestication level through management and multiple land use, including livestock grazing.

The licuala palms (Licuala spp.) of Group III may serve as an example of inadequate information. According to Whitmore (1973) there are 25 accepted species in the Malay Peninsula alone. The species distributions overlap, the site requirements of individual species are imperfectly known, and the ethnobotanical data are not clearly related to particular species. To accurately identify selected stands would require a considerable amount of botanical and ethnological study.

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Seed Orchards

As used here, this designation is taken to mean the intentional cultivation of palms in order to provide planting material to subsistence or commercial farmers for replacement of old or establishment of new palm groves. Planting material refers to both seeds (called seednuts in coconut) and basal suckers. Seed orchards *per se* exist for only a few of the more commercially developed palms.

Planting material for the palms in Group I is derived to some extent from seed orchards. This is in the form of seed for the areca, coconut, and oil palm; and suckers for the date palm. To an undetermined extent, the peach palm of Group II is propagated by means of seed or suckers from organized orchards. The only other palm fitting into this category is the sago, propagated to a limited degree from what might be loosely termed orchards. As for the remainder of the multipurpose palms, their individual valorization as sources of raw materials has apparently not yet reached the stage where public or private seed orchards are justifiable or economically attractive.

Botanic Gardens

The natural beauty of palms and their popularity among gardening enthusiasts has done a great deal to assure a good representation of palms in public and private gardens. Because of their almost exlusively tropical origins, this representation is limited to garden in subtropical or tropical locations. A number of palm species do well as house plants if their requirements for temperature, moisture, and light are satisfied. The two most notable indoor palm collections are found in the massive glass houses of the Kew Gardens and the New York Botanical Garden.

Fundamental to the use of botanic gardens as sources of germplasm is accurate and up-to-date information on the palms in their collections. This appears simple to obtain, but is in fact difficult. Many botanic gardens were established and maintained more as parks than as centers of plant science research. If the plants are labelled, the identification may be incorrect or not reflect the currently accepted binomials. The latter of course can be remedied by referring to synonym listings. Being a specialized plant group that requires an expert to make accurate identifications, palms are often poorly known in a collection. Botanical gardens publish plant catalogues or species lists, but they suffer from being based on uncertain data and are rarely updated on a regular basis.

Bearing in mind all of the above caveats, some published data on palms in botanic gardens are available. McCurrach (1960) in his Palms of the World includes an appendix with data on palms growing in eight major botanic gardens around the world. A list of living palm collections was also published in The American Horticultural Magazine (1961), and identified 30 important collections; however, no enumeration of taxa was provided. More recently, Basu (1978) published a list of palms in the Indian Botanic Garden near Calcutta, and the Fairchild Tropical Garden (1979) issued a new plant catalogue.

To gain a tentative and approximate idea of where living specimens of the multipurpose palms can be found in botanic gardens, the above sources were used to compile Table IV. As indicated, all but two species are found in the garden included. However, because the Bogor Botanic Gardens listing provides only genera, inclusion of specimens of Eugeissona utilis (Group II) and Borassus aethiopicum (Group III) is uncertain. Since most of the censuses were taken in the 1950s, and both the Fairchild Tropical Garden and the Indian Botanic Garden have long been in existence, it is safe to assume that if the specimens are still in the collections they are mature and bearing seed.

An alternative to obtaining palm seed is to turn to commercial nurserymen for live plants. In the United States, there is a fairly well developed commerce of selling palm seedlings to private growers. In 1981, as an aid to those growers, the San Juan Tropicals Company, San Juan Bautista, California, specializing in palms and bromeliads, established a new service. For a fee, interested parties may subscribe to a quarterly computer-assisted listing of all species of palm trees for sale in the United States. The service is designed for both buyers and sellers of palms.

Seeds, Pollen, and Tissue Culture

Grouped together, these three represent the remaining germplasm resources to be introduced and discussed in general terms. Seeds in this context are distinguished from those directly acquired from natural areas, selected stands, seed orchards, and botanic gardens, by the fact that indirect sources are used.

Of prime importance in this regard is the Seed Bank maintained by the Palm Society. Created in 1957, just one year after the founding of the Society, the Seed Bank is run by volunteers within the organization and provides a means for members to obtain fresh palm seed from various parts of the world. These seeds are planted in private gardens, or may be provided for civic improvement projects in public parks.

The Seed Bank functions in a simple and efficient manner. A roster of members willing to provide seed has been developed, and includes sources within the United States, along with Puerto Rico and the Virgin Islands. Active foreign sources are in Australia, Barbados, Brazil, Canary Islands, Colombia, Costa Rica, Fiji, Mexico, Nevis, New Caledonia, New Guinea, New Zealand, Philippines, Solomon Islands, South Africa, and Thailand. This coverage affords an opportunity to obtain an impressive variety of seed. The standard Seed Bank list is reproduced in Table V. A copy of this listing is distributed to all society members; if they are interested in obtaining seed, they so indicate the species on the form and return it to the Seed Bank. When a shipment of seed is received, small batches are immediately dispatched to participating members. The operation maintains itself by charging members a fee to cover the cost of seed shipment to the Bank and their distribution. Air mail is used for all shipments.

The seed available through the Seed Bank originates from private collections, botanic gardens, and from wild plants; it goes back to private collectors and to botanic gardens. Of the 50 multipurpose palms, 25 are a part of this exchange system. Operated for years from Southern Florida, the Seed Bank was shifted to Southern California in 1979 because of the lethal yellowing disease attacking Florida palms.

Although it provides the greatest variety of fresh palm seed, the Seed Bank is not the only source. Commercial dealers handle some palm seed, typically specializing in the more popular species. These dealers include Peter Dow in Gisborne, New Zealand; Ronald Hurov in Chula Vista, California; and DeArmand Hull, in Miami, Florida. Reportedly, seed obtained from commercial dealers is less viable than that from the Seed Bank. This may be because commercial dealers attempt to store seed and are not able to ship it as soon as it becomes available. Occasionally, advertisements by United States and foreign dealers are placed in Principes, the journal of the Palm Society, for the sale or exchange of palm seed. Scientific names are generally given in the adverstisements.

Palm pollen must be considered among the germplasm resources because of its role in artificial fertilization of commercially-grown date palms and its utilization in breeding programs of major palms. For the latter purpose, pollen of the coconut, date, and oil palms has been exchanged between research stations in different parts of the world and has contributed to plant improvement successes.

Research on the general characteristics of palm pollen by Parthasarathy (1970) and Sowunmi (1972) and on pollen storage by Read (1979) has advanced the knowledge of this resource. In 1979 the Palm Society, in cooperation with the Fairchild Tropical Garden, established an informal pollen exchange program.

Tissue culture as a means of propagation is an exciting new frontier and holds great promise for improving the productivity of cultivated palms, especially those that cannot be vegetatively reproduced via basal suckers. This is not the place to attempt a detailed review of the substantial amount of research on tissue culture. The current state-of-science can quickly be summarized from the work of Fisher and Tsai (1979), Corley (1980), and Tisserat (1981).

Tissue culture methods are now being employed on a trial basis to produce planting material for oil palms in Malaysia; this represents the farthest advancement of date for any palm. Plants have been successfully produced from cultures of the date palm, and tissue cultures made from the coconut. In Costa Rica, the research being conducted on the peach palm includes tissue culture. Corley believes that, given the level of success achieved with the oil palm, tissue culture can be adopted on a commercial scale to vegetatively propagate the more economically useful palms.

Two related research activities should be referred to here before completing this section. Experiments conducted at the U.S Department of Agriculture, Fruit and Vegetable Chemistry Laboratory, Pasadena, California, have proved that cryogenic storage of date palm callus, seed, embryos, and pollen is a success (Tisserat, pers. comm.). These results could be highly significant for the future storage of various forms of palm germplasm if the techniques can be extended to other palms.

An alternative method of vegetative propagation of the coconut palm is being studied in Indonesia and has thus far resulted in the successful air-layering of bulbil-shoots, their separation from the parent plant, and planting as clones (Davis, Sudasrip, and Azis, 1981). These bulbil-clones have produced bulbil-shoots, but not normal flower bunches. Further research is being conducted to try to reverse the clones to bear fruit. Since other economicall important palms produce bulbils (areca, sugar palm, palmyra, oil palm, and species of Phoenix), this line of investigation also holds promise for multipurpose palm propagation.

PROBLEMS OF GERMPLASM DEVELOPMENT

The foregoing general description of palm germplasm sets the stage for consideration of problem areas of germplasm development. Because palms are almost exclusively tropical in origin, nearly all activities related to the development of germplasm resources involve developing countries. Many of these nations do not yet have an accurate assessment of their renewable natural resources and therefore can be expected to act with care and caution where those resources are concerned. Another common characteristic of these countries is an attitude toward resource utilization which is often antithetical to the conservationist view of the more developed temperate countries. This too must be taken into account when proposing to protect tropical ecosystems.

Given 50 multipurpose palms and more than a dozen countries of origin, it will be exceedingly difficult to formulate procedures which can be applied consistently to all palm germplasm development. It is much more realistic to draft technical guidelines to assure the achievement of desired results, and modify them to fit the circumstances of the country involved.

Acquisition and Distribution of Documented Germplasm

Crucial to the acquisition and distribution of palm germplasm is a determination of where, geographically, the major development effort is to take place. Origins of the multipurpose palms are included in Tables I, II and III. Re-examination of them from that standpoint reveals that Tropical America and South or Southeast Asia are two major geographic centers; respectively, they account for 25 and 18 species. A few comments about the exceptions are appropriate. The oil palm, although native to West Africa, has seen its greatest commercial development in Southeast Asia; the date and doum palms can be adequately dealt with by the Palm and Date Research Center in Baghdad; Calamus rattans have a distribution which includes Southeast Asia; the African fan palm (Borassus aethiopicum) can easily be grown in Asia; the Fiji fan palms (Pritchardia spp.) could be grown in mainland Tropical America; and finally the West African raffia palms in Tropical America where one species occurs.

At the national level, Brazil could most practically function as a Tropical American palm germplasm development center, and either Malaysia or Indonesia as an Asian center. Establishment of a program linked to existing agricultural or forestry research stations in Brazil

and Malaysia would greatly facilitate collection of germplasm from native wild and selected stands. Moreover, as indicated in Table IV, the botanical gardens in Rio de Janeiro, Brazil and Singapore are major sources of multipurpose palm seed.

Acquisition of germplasm along with accurate documentation of its geographic origin, site conditions, and parent plant characteristics can only be accomplished through specific collecting expeditions to native areas of occurrence. Often, because of the high cost of mounting expeditions, attempts are made to secure seed indirectly through local technicians or scientists. This procedure is generally not very successful due to a lack of expertise in palm identification, and because local individuals cannot take time away from their regular duties to make extended trips, even if funds for that purpose are furnished. Therefore seed collected in this manner originates from the nearest accessible location and is not representative of the full range of phenotypic characteristics.

The expense of acquiring documented germplasm can be reduced by sending a single palm expert to lead an expedition made up of local technicians and scientists from a cooperating agency. In addition to producing the desired results, local individuals benefit from training in the identification, collection techniques, and location of major natural stands of economic palms.

This procedure has been used successfully by the New York Botanical Garden's study of babassu in Brazil, which includes all species of Orbignya. This is a joint United States-Brazil program consisting of the Garden and five Brazilian agencies. The objective is to obtain representative germplasm by intensively collecting from a small number of plant populations over a wide geographic range. Seed selection combined randomness and representation of the greatest possible variation. Botanical voucher specimens of Orbignya spp. were made at the time of seed collection and deposited in herbaria in Brazil and the United States. A comprehensive format for botanical collection of palms used for the program is reproduced in Appendix I. It is included because in almost every case the acquisition of germplasm should be combined with the collection of botanical specimens to help resolve the taxonomic questions which are so prevalent.

Distribution of documented germplasm poses fewer difficulties than collections. Prompt shipment of fresh palm seed to the site of planting will increase the rate of germination and lessen the chance of seed infection by fungi. Air freight should be used if land shipment requires more than a few days or if international boundaries must be crossed. Measures seeking to control the transmission of pathogens in seed shipments will be discussed later.

To continue with the example of babassu in Brazil, seed collected within the country was shipped to the State Institute of Babassu in Bacabal, Maranhao and added to the active germplasm bank. This recently-founded, 100-ha research station, one of the cooperating agencies, is devoted exclusively to babassu; it is ideally located in a core area of the palm's distribution. In 1982 the New York Botanical Garden sent out another expedition, this time to Bolivia, and collected other species of Orbignya. No problems were encountered in shipment of the seed to Brazil, where it has been added to the germplasm bank

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at Bacabal. This lends at least some support to the argument for establishment of regional centers which group together countries more accustomed to dealing with each other.

The Palm Society Seed Bank has already been mentioned as a seed source. The Seed Bank requests that volunteer supplies complete a collection data sheet to be furnished with the seed; the information is then passed on to those botanical gardens receiving seed. Unfortunately, full collection data are infrequently provided and, furthermore, there is a very real possibility of misidentification of parent palms. Thus the Seed Bank represents only a supplementary germplasm source, not one which could be relied upon for a systematic research effort. According to Ernest Chew, who heads the Seed Bank, no difficulties have been experienced in receipt of palm seed from the 16 foreign areas listed previously, providing that U.S. Department of Agriculture import tags (furnished by the Seed Bank) are used and the seed is clean. Similarly, the dissemination of seed to foreign countries presents no obstacles; the Seed Bank relies upon recipients to furnish any special packing instructions or forms to accompany the seed.

For reasons already discussed, botanical gardens are only moderately satisfactory as sources of documented germplasm. Typically, the information on the origin of the palms in the gardens is very generalized unless the seeds were obtained as part of an organized botanical expedition, in which case collection data should be available.

The degree to which botanical gardens succeed, under known conditions of soil and climate, in growing different palm species can be a useful indications of the palm's tolerance to different environments, and may reveal if certain growth habits are genotypic or phenotypic. An excellent example of the latter is the carnauba wax palm. It was widely believed in Brazil that carnauba palms produced heavy leaf wax in direct response to the semi-arid climate of its native habitat, and that if grown in other, more humid environments, no wax would be produced. E.D. Kitzke's research (cited in Johnson, 1972b) on carnauba palms growing at the U.S. Plant Introduction Garden, Coconut Grove, Florida, conclusively proved that a heavy coat of leaf wax is a genotypic trait, and not a physiological response to climate.

Selecting and Securing Suitable Seedstands

The identification of suitable seedstands and the securing of seeds therefrom must be approached on a palm-by-palm basis; it is most feasible with Group II multipurpose palms. Two types of problems can be anticipated: one, sufficient information to identify the desired stands; and, two, the logistics of obtaining the seed. If stands can be identified, there may also be inadequate information on the flowering and fruiting seasons, which can and do vary somewhat over the maximum geographic range. More than one collecting trip may therefore be needed. According to Mardy Darian, an avid and experienced palm explorer and private collector, the success of a return collecting trip can be improved by tagging desirable trees, clearing away competing vegetation, and adding time-release plant food to the soil around the tree. This has been shown to induce flowering and fruiting.

Some of the logistical problems of obtaining seeds have already been referred to. In addition to securing the cooperation of a local host

agency, it is also generally necessary to obtain a plant collection permit for an expedition, and possibly obtain advance permission to collect on private land. Group II palms, especially, are more likely to be found on private property, whereas Group III palms may occur on unoccupied public lands where a collecting permit should suffice.

International political considerations may be a factor in gaining access to seedstands. As an example, let us assume that it were decided to develop the yarey palms (Copernicia spp.) for incorporation into tropical grazing systems. These palms are almost exclusively native to the island of Cuba. Since the revolution in 1959, it has been very difficult for foreign scientists to conduct field research in Cuba and there are recent reports of long delays in the export of plant materials. Given such difficulties, an alternative source of germplasm should be sought. Fortunately, in this case, there exists, a collection of Cuban Copernicias near Fortaleza, Brazil, established as part of a commercial wax palm breeding project. The Raposa palm plantation contains over 1,300 specimens, representing 12 of the 24 Cuban taxa, and is fully documented (Johnson, 1971, 1981). It would serve as an acceptable substitute germplasm source. However, this is an exceptional circumstance and it should not be assumed that alternative sources exist for all of the multipurpose palms.

The scientific and logistical problems associated with obtaining palm germplasm will vary according to the multipurpose palms chosen for study, their countries of origin, and which locations are designated for active germplasm banks. All of these factors should be taken into account in future planning.

Improving Germplasm

As a group, palms represent some notable successes in plant breeding. However, of the 50 multipurpose palms, only the areca, coconut, date and oil palms (Group I); and the peach palm, American oil palm, and perhaps the sago (Group II), have thus far benefited from systematic programs of applied research. Although only 7 palms have been the object of improvement programs, in the aggregate they reveal enough about palms in general to assess the potential for improving the productivity and quality of products from other palms.

The oil palm represents the most successful example of palm development to date. In the early 20th century, commercial plantations were established in Zaire and in Southeast Asia and Crop improvement was undertaken in both areas. Focussed initially on mass selection and controlled pollination, research on the tenera cultivar led to the discovery at mid-century that it was a natural hybrid. This opened the way to improvement of the parent types and an increase in yield of palm oil to such an extent that the oil palm became the world's highest yielding oil crop per unit area and a tropical development success story (Johnson, 1980).

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Current oil palm breeding programs are able to draw upon genetic resources including the Nigerian Institute for Oil Palm Research (NIFOR), the Institut National pour l'Etude Agronomique du Congo Belge (INEAC) in Zaire, the Institut de Recherches pour les Huiles et Oleagineaux (IRHO) in Ivory Coast, and the Malaysian Agricultural Research and Development Institute (MARDI) (Hardon et al., 1976). Hybrids made between the African and American oil palms show promising results, with disease resistance for cultivation in South America Among other desirable characteristics (Hartley, 1977; Tam et al., 1977). Improvement of the oil palm is facilitated by the fact that the tree reaches sexual maturity at about 2 years of age. Another major increase in oil palm productivity is expected in the 1980s as breeders release new cultivars, and tissue culture is adopted as an operational means of propagation.

It is not possible here to discuss in any detail the other improved palms, but a few selected references can be provided. Bavappa (1969) and Velappan and Paulose (1974) detail some of the research on the areca palm in India. The status of the coconut can be found in Child (1964), Manthriratna(1974, 1978), Rosenquist (1976), Harries (1979), and Thampan (1981). Contemporary information on the date palm is provided by Carpenter and Ream (1976), Carpenter (1979, 1981), and Mohammed (1981). Improvements in the peach palm are summarized by Clement and Mora U., 1982); and of the sago palm by Tan (1977), Ruddle et al., 1978), and Stanton and Flach (1980).

A word of caution should be added regarding the potential for breeding improvement of multipurpose palms. All types of breeding programs are costly undertakings; in the case of tree crops, results are prolonged because of the length of time required to reach sexual maturity. Palms in Group I all begin their earliest flowering at 2-4 years of age, whereas the period for the peach palm is 5 years, and the sago palm is 10 years. Indications are (and the available data are far from complete) that many of the other multipurpose species have an even later sexual maturity: fishtail palm (Caryota urens): 15 years; palmyra palm: 20 years; and the talipot palm: 30 years.

Abandonment in the 1960s of a breeding program to develop the carnauba wax palm into a higher producing palm with the aid of other Copernicia species at the Raposa plantation in Brazil was due, in part, to the fact that the carnauba requires at least 14 years to reach sexual maturity. The other crucial factor was the marked substitution of polymer waxes for vegetable waxes in the same decade (Johnson, 1972b).

Necessary Legal Actions Concerning Germplasm Distribution and Trade

International exchange of germplasm--seed, pollen, live plants, plant tissue-poses a set of legal and administrative impediments to palm development. Solutions are made complicated by the involvement of many different nations, and because no international body of laws exists to regulate this type of trade. Palm germplasm appears to fall between seed legislation, normally applicable to annual food and other major crops on the one hand, and plant quarantine requirements designed to prevent the inadvertent introduction of harmful plant pathogens into a country, on the other.

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An excellent review of world seed programs is presented by Douglas (1980); unfortunately, only passing reference is made to types of germplasm other than grain seed. Despite the major role of germplasm exchange in the development of the oil palm, the subject has not been given much specific attention. Turner (1981), in his recent book on oil palm diseases, discusses quarantine requirements to prevent the spread of major oil palm diseases, many of which also affect other palms. He recommends that detailed research be conducted on seed and pollen borne microorganisms so that more effective control measures can be legislated and adopted. Turner mentions the transfer of germplasm by the tissue culture method as the best solution for the future.

It is not possible to cite the import and export regulations of one of the countries most likely to be involved in the development of multipurpose palm germplasm. However, because developed countries often serve as models for legislation of this nature, the legal and administrative procedures in force in the United States may serve as an example.

Responsibility for regulating the export and import of germplasm rests with the U.S. Department of Agriculture, Plant Quarantine Center, Beltsville, Maryland. The designation "plant material" is used to cover all types of germplasm. Appendix II summarizes the procedures for exporting plant material from the United States, and notes that bilateral agreements exist between the United States and seven foreign countries to facilitate inspection and shipment. Import regulations are outlined in Appendix III. Some of the food crops requiring special import permits are given. The United States has no restrictions on either the import or export of plant material from the palm family.

There exists the possibility that some country may impose restrictions on the free exchange of palm germplasm. This might occur if it were believed that a palm's development elsewhere would deprive the country of that opportunity. Such restrictions could be carried out under the guise of plant quarantine regulations or by delays in shipment of seed or other plant material to the extent that viability would be lost. To avoid such circumstances, palm germplasm development must be accomplished with the full cooperation and knowledge of the individual countries involved.

CONCLUSION

On the basis of germplasm resources, prospects are quite encouraging for the development of multipurpose palm species and their integration into agroforestry systems in the tropics. Rather than restate the evidence to support that statement, let me offer some recommendations on how this may be achieved.

The 50 palms included in this supporting document need to be reduced in number so that the most promising species can be studied in greater

detail. Those palms selected for further investigation should best serve two general purposes: one, lead to the development of the palms with the greatest potential for furnishing commercial raw materials to generate income for local inhabitants and provide new or increased exports for developing countries; two, provide a sufficient array of candidate palms to fill the broad ecological niches in the tropics. Each palm should provide some useful, but not necessarily highly commercialized, products, and function as a plant species, along with other compatible trees, to rehabilitate degraded environments and to stabilize those subject to erosion and degradation.

Although some of the palms may be eliminated from the list on the basis of further study of published information and refinement of the roles the palms will play, final determination will require field work in the two centers suggested: Tropical America (Brazil) and South-East Asia (Malaysia).

Note

1. This and the following section on palm characteristics are based on a manuscript entitled "Multipurpose palms in agroforestry: a classification and assessment," submitted for publication to The International Tree Crops Journal on November 15, 1982.

TABLES AND APPENDICES

TABLE 1: IMPROVED, CULTIVATED PALMS

Scientific and Common Names	Origin and Native Habitat	Products
Areca catechu L. areca or betel palm	S,SE Asia: inferred tropical rainforest, to 900m; unknown wild	Seed as masticatory; edible heart; leaves for thatch; leaf sheaths for hats, containers, trunk for wood; seed in veterinary medicine
Cocos nucifera L. coconut palm	SE Asia: inferred tropical rainforest, esp. coastal sites, to 300 m; unknown wild	edible oil, fruit, drink heart; leaves for thatch, weaving; trunk for wood; many misc. products.
Elaeis guineensis Jacq. oil palm or African oil palm	W Africa: tropical rainforest, forest, esp. open, wet sites to 800 m; semi-wild only	edible and industrial oil; sap for wine; edible heart; leaves for thatch, weaving; petioles for fencing, construction
Phoenix dactylifera L. date palm	Middle East: subtropical semi-desert to desert; unknown wild	edible fruit; sap for wine; leaves for thatch, weaving; trunck for wood; many misc. products

TABLE II: UNIMPROVED CULTIVATED OR MANAGED PALMS

Scientific and Common Names	Origin and Native Habitat	Products
Arenga pinnata (Wurmb.) Merr. Sugar or gomuti palm	S,SE Asia: inferred tropical rainforest into dry forest, to 1,200 m; unknown wild	sap for sugar, wine, starch from trunk; fiber from leaf sheath; edible heart
Bactris gasipaes HBK peach palm, pejibaye, pupunha	C,S America: inferred tropical rainforest, to 1,200 m; unknown wild	edible fruit, heart; trunk for wood
Borassus flabellifer L. Palmyra palm	S Asia: tropical dry forest into savanna, to 750 m	sap for sugar, wine; fiber from leaf stalk; edible fruit; leaves for thatch, weaving; trunk for wood; many misc. products
Calamus spp. rattan	Old World: tropical rainforest to 1,000 m	rattan canes; edible fruit some spp; fruit for medicinal use
Caryota urens L. Fishtail or toddy palm	S,SE Asia: tropical rainforest, esp. secondary forest, to 1,500 m	sap for wine, sugar; starch from trunk; fiber from leaf sheath; edible heart
Copernicia prunifera (Mill.) Moore carnauba wax palm	S America: tropical dry forest into savanna, esp. floodplains	wax from leaves; leaves for weaving; trunk for wood
Corypha umbraculifera L. talipot palm	S,SE Asia: inferred tropical rainforest, to 600 m; unknown wild	sap for sugar, wine; starch from trunk; leaves for matting, paper
Elaeis oleifera (HBK) Cortes American oil palm, corozo	S, C America: tropical rainforest lowlands	edible and industrial oil
Eugeissona utilis Becc. bertam palm	SE Asia: tropical rainforest, esp. disturbed sites, to 1,000 m	starch from trunk; edible fruit; leaves for thatch
Euterpe edulis Mart. palmito branco or jucara	S America: tropical rainforest into subtropics, to 1,000 m	edible heart; cellulose
Euterpe oleracea Mart. Acai or palmito da Amazonia	S America: tropical rainforest, sites subject to flooding	edible heart, fruit

TABLE II (cont'd)

Scientific and Common Names	Origin and Native Habitat	Products
Hyphaene thetaica (L)Mart doum or dum palm	Africa: semidesert to desert, to 600 m	edible fruit, heart; sap for wine; fruit for medicinal use; leaves for weaving
Metroxylon sagu Rottb. Sago palm	SE Asia: tropical rainforest swamps	starch from trunk; leaves for thatch
Nypa fruticans Wurmb. nipa palm	SE Asia: tropical rainforest, banks of brackis tidal rivers	edible fruit; sap for sugar; leaves for thatch, weaving
Orbignya speciosa Barb. Rodg. babassu or babacu palm	S America: tropical rain forest, upland sites	edible and industrial oil; leaves for thatch
Phoenix sylvestris (L.) Roxb. Wild date palm, silver date palm	India: tropical rainforest to 1,500 m	edible fruit; sap for wine, sugar; leaves for weaving
Roystonea spp. royal palm, Cuban royal palm, cabbage palm	Carib. C,S America: tropical rainforest into drier forest and savanna	fruit for livestock; edible heart; starch from trunk; leaves for thatch, weaving; trunk for wood
Salacca zalacca (Gaertn.) Voss Salak palm	SE Asia: tropical rainforest, in dense shade, t 300 m	edible fruit; leaves for thatch, mats
Syagrus coronata (Mart.) Becc. ouricuri or licuri palm	S America: tropical dry forest to savanna	edible and industrial oil; wax from leaves

TABLE III: SEMI-WILD OR WILD PALMS

Scientific and Common Names	Origin and Native Habitat	Products or Potential Use
Acrocomia sclerocarpa Mart. macauba, macaja, coco de catorro	S America: tropical dry savanna to tropical rainforest	edible and industrial oil; edible fruit, heart; leaves for thatch
Astrocaryum jauari Mart. jauari, awarra	S America: tropical rainforest sites subject to flooding	edible and industrial oil; leaves for thatch
Astrocaryum murumuru Mart. murumuru	S America: tropical rainforest, sites subject to flooding	edible and industrial oil; fruit for livestock; leaves for thatch
Astrocaryum vulgare Mart. tucuma	S America: tropical rainforest, upland sites	edible and industrial oil; edible fruit, heart; fiber from rachis; leaves for thatch
Attalea funifera Mart. piassava or piacava, Bahia piassava	S America: tropical rainforest, coastoal sites	leaf base fiber; leaves for thatch
Borassus aethiopicum Mart. African fan palm	Africa: tropical wet savanna	edible immature fruit; sap for wine; leaves for thatch, weaving
Ceroxylon alpinum Bonpl. ex DC. South American wax palm	S America: tropical mountains	wax from trunk; mountain reforestation
Copernicia spp. yarey palms	Carib: tropical dry savanna	fruit for livestock; leaves for weaving; trunk for pillars; compatible with grazing systems
Crytostachys lakka Becc. sealing wax palm	SE Asia: tropical rainforest swamps	wood for pillars, flooring; swamp stabilization
Daemonorops spp. rattan	SE Asia: tropical rainforest	rattan canes; some spp. edible fruit; fruit scales in medicine
Jessenia spp. seje, pataua, milpesos, sacumana	S America: tropical rainforest, upland sites	edible and industrial oil; fruit juice as beverage; leaves for weaving

TABLE III (Cont'd)

Scientific and Common Names	Origin and Native Habitat	Products or Potential Use
Leopoldinia piassaba Wall. Para piassava, piacava	S America: tropical rainforest, sites subject to flooding	edible fruit; leaf base for fiber; leaves for thatch
Licuala spp. Licuala	SE Asia: tropical rainforest undergrowth	edible heart; walking sticks from trunk; leaves for weaving; some spp ecological indicators
Livistona spp. serdang	SE Asia: tropical rain forest, coastal and mountain sites	edible fruit, heart; fruit for livestock; leaves for fans; trunk for wood
Phytelephas macrocarpa Ruiz & Pav. ivory nut palm, tagua	S America: tropical rainforest, esp. sites subject to flooding, to 1,500 m	edible immature fruit; vegetable ivory
Pinanga spp. pinang	SE Asia: tropical dry forest, mountains to 1,200 m; some spp in sites subject to flooding	edible heart; leaves for weaving; trunk for walking sticks, wood; erosion control
Pritchardia spp. Fiji fan palm	Polynesia: tropical mountain slopes, wet to dry	edible immature seed; leaves for thatch, weaving; erosion control
Raphia spp. raffia palms, African piassava	W Africa: tropical rainforest, swamps, sites subject to flooding	edible fruit, oil; sap for wine, leaves for fiber, thatch, weaving; petiole, leaf rachis for building material
Sabal spp. palmetto	N,S America: tropical and subtropical, wet to dry	edible fruit, heart; leaves for thatch, weaving, brush fiber; reforestation
Scheelea spp. corozo, coroba	S America: tropical rainforest, riverbanks, savanna	edible and industrial oil; leaves for thatch; [illegible] wood, fuel
Thrinax spp. thatch palms	Carib: tropical and subtropical dry forest	leaves for thatch, weaving; reforestation
Manicaria saccifera Gaert. temiche palm, guagara	S America: tropical rainforest, swampy sites	edible fruit; starch from trunk; leaves for thatch; spathe for cloth

TABLE III (Cont'd)

Scientific and Common Names	Origin and Native Habitat	Products or Potential Us
Mauritia flexuosa L. Moriche, buriti, muriti, aguaje	S America: tropical rain-forest, sites subject to flooding	edible and industrial oil; edible fruit, heart; starch from trunk; leaf fiber for rope; petiole for cork; trunk for wood; indicator plant of tropical rain-forest swamp
Maximiliana martiana Karst. inaja	S America: tropical rain-forest, dry, sandy, uplar sites	edible fruit, heart, oil; leaves for thatch, weaving
Nannerhops ritchiana Griff. Mazari palm	S Asia: subtropical mountains to 1,500 m	edible fruit, heart, young inflorescence; leaves for thatch, weaving; leaves, petioles, trunk for fuel; erosion control mountain slopes
Oenocarpus spp. bacaba	S America: tropical rain-forest second growth, upland sites	edible and industrial oil; edible fruit; trunk for wood; potential fiber source
Oncosperma spp. nibong or nibung	SE Asia: tropical rain-forest, mountain slopes to 1,500 m	edible heart; trunk for wood resistant to salt water

TABLE IV: MULTIPURPOSE PALMS IN BOTANIC GARDENS

The following abbreviations are used:

BGA	Botanic Garden of Adelaide, Australia (1958)
BGS	Botanic Gardens, Singapore (1939)
BOG	Bogor Botanic Garden, Bogor, Indonesia (1957)
CGF	U.S. Plant Introduction Garden, Coconut Grove, Florida (1956)
FTG	Fairchild Tropical Garden, Miami, Florida (1979)
HBG	Huntington Botanical Garden, San Marino, California (1951)
HOP	Hope Botanical Garden, Kingston, Jamaica (1954)
IBG	Indian Botanic Garden, Calcutta, India (1978)
JBB	Jardim Botanico, Rio de Janero, Brazil (1958)

Notes: § Dates indicate when the censuses were completed

* Data for Bogor is available only at the generic level

Group I

Areca catechu	BGA, BGS, BOG§ CGF, FTG, HOP, IBG, JBB
Cocos nucifera	BGS, BOG, CGF, FTG, IBG
Elaeis guineensis	BGA, EGS, BOG, CGF, FTG, HOP, IBG, JBB
Phoenix dactylifera	BGA, BOG, CGF, FTG, HBG, JBB

Group II

Arenga pinnata	BGA, BGS, BOG, CGF, FTG, IBG, JBB
Bactris gasipaes	BGS, BOG, CGF, FTG, IBG, JBB
Borassus flabellifer	BOG, CGF, FTG, IBG, JBB
Calamus spp	BGS, BOG, FTG, IBG, JBB
Caryota urens	BGA, BOG, CGF, FTG, IBG, JBB
Copernicia prunifera	CGF, FTG, HOP, JBB
Corypha umbraculifera	BOG, CGF, FTG, HOP, IBG, JBB
Elaeis oleifera	CGF, FTG, JBB
Eugeissona utilis	BOG
Euterpe edulis	BOG, HOP
Euterpe oleracea	BGS, BOG, JBB
Hyphaene thetaica	BOG, FTG, IBG
Metroxylon sagu	BGS, BOG
Nypa fruticans	BGS, BOG, CGF, FTG
Orbignya speciosa	BOG, CGF, FTG, JBB
Phoenix sylvestris	BGS, BOG, CGF, FTG, HBG, IBG, JBB
Roystonea spp.	BGA, BGS, BOG, CGF, FTG, HOP, IBG, JBB
Salacca zalacca	BGS, BOG, FTG, IBG, JBB
Syagrus coronata	BOG, CGF, FTG, JBB

Group III

Acrocomia sclerocarpa	CGF, JBB
Astrocaryum jauari	BOG, JBB
Astrocaryum murumuru	BOG, CGF, JBB
Astrocaryum vulgare	BGS, BOG, HOP
Attalea funifera	BOG, JBB

TABLE IV (Cont'd)

Group III (Cont'd)

Borassus aethiopicum	BOG
Ceroxylon alpinum	(none)
Copernicia spp.	CGF, FTG, JBB
Cyrtostachys lakka	BGS, BOG, FTG
Daemonorops spp.	BGA, BGS, BOG, CGF, IBG, JBB
Jessenia spp.	(none)
Leopoldinia piassaba	JBB
Licuala spp.	BGS, BOG, CGF, FTG, HOP, IBG, JBB
Livistona spp.	BGA, BGS, BOG, CGF, FTG, HBG, HOP, IBG, JBB
Manicaria saccifera	JBB
Mauritia flexuosa	CGF, FTG, JBB
Maximiliana martiana	BOG, JBB
Nannorphops ritchiana	CGF, FTG
Oenocarpus spp.	BOG, JBB
Oncosperma spp.	BGS, BOG, FTG, HOP, JBB
Phytelephas macrocarpa	BOG, FTG, JBB
Pinanga spp.	BGS, BOG, CGF, FTG, HOP, JBB
Pritchardia spp.	BPG, FTG, HOP, IBG, JBB
Raphia spp.	BGA, BGS, BOG, CGF, FTG
Sabal spp.	BGA, BGS, BOG, CGF, FTG, HBG, HOP, IBG, JBB
Scheelea spp.	BGS, BOG, CGF, FTG, IBG, JBB
Thrinax spp.	BGS, BOG, CGF, FTG, HOP, IBG, JBB

TABLE V (Cont'd)

01580 *Clinosperma bracteale*
01590 *Clinostigma ponpensis*
01612 *Coccothrinax argentea*
01611 *Coccothrinax orinita*
01613 *Coccothrinax dussiana*
01610 *Coccothrinax fragrans*
01614 *Coccothrinax miraguama*
01615 *Coccothrinax readii*
01630 *Cocos nucifera*
01650 *Copernicia alba*
01651 *Copernicia baileyana*
01680 *Corypha elata*
01690 *Cryosophila argentea*
01720 *Cyphosperma balansae*
01732 *Cyrtostachys compsoclada*
01731 *Cyrtostachys glauca*
01730 *Cyrtostachys lakka*
01733 *Cyrtostachys ledermeniana*
01745 *Daemonorops collarifera*
01744 *Daemonorops didymophylla*
01742 *Daemonorops formicaria*
01741 *Daemonorops loherianus*
01740 *Daemonorops mollis*
01743 *Daemonorops periacantha*
01890 *Deckenia nobilis*
01902 *Desmoncus prunifera*
01900 *Desmoncus tobagonis*
02010 *Dictyosperma album*
02020 *Drymophloeus beguinii*
02070 *Elaeis guineensis*
02110 *Eugeissona insignis*
02121 *Euterpe edulis*
02120 *Euterpe globosa*
02124 *Euterpe macrospadix*
02122 *Euterpe oleracea*
02123 *Euterpe purpurea*
02140 *Gastrococos crispa*
02160 *Geonoma interrupta*
02161 *Geonoma palustris*
02164 *Geonoma pinnatifrons*
02162 *Geonoma schottiana*
02270 *Gronophyllum ramsayi*
02350 *Heterospathe elata*
02353 *Heterospathe philippinensis*
02351 *Heterospathe sibuyanensis*
02354 *Heterospathe woodfordiana*
02352 *Heterospathe negrosensis*
02391 *Howea bellmoreana*
02390 *Howea forsterana*
03250 *Orania appendiculata*
03251 *Orania palindan*
03340 *Pelagodoxa minor*
03360 *Phoenicophorium borsigianum*
03374 *Phoenix canariensis*
03372 *Phoenix loureirii*
03371 *Phoenix lowrunti*
03375 *Phoenix reclinata*
03373 *Phoenix roebelenii*
02411 *Hyophorbe verschaffeltii*
02520 *Iriartea exorrhiza*
02580 *Jubaea chilensis*
02581 *Jubaea spectabilis*
02610 *Korthalsia laciniosa*
02650 *Laccospadix australasica*
02660 *Latania loddigesii*
02661 *Latania verschaffeltii*
02714 *Licuala elegans*
02715 *Licuala furcata*
02711 *Licuala grandis*
02713 *Licuala muelleri*
02710 *Licuala spinosa*
02716 *Licuala valida*
02821 *Linospadix minor*
02820 *Linospadix monostachys*
02847 *Livistona australis*
02848 *Livistona chinensis*
02855 *Livistona chinensis var. subglobosa*
02851 *Livistona decipiens*
02844 *Livistona drudei*
02845 *Livistona eastonii*
02842 *Livistona humilis*
02852 *Livistona merrillii*
02840 *Livistona muelleri*
02849 *Livistona rigida*
02853 *Livistona robinsoniana*
02846 *Livistona rotundifolia*
02841 *Livistona rotundifolia var. luzonensis*
02843 *Livistona saribus*
02854 *Livistona speciosa*
02960 *Mauritia vinifera*
03031 *Microcoelum insigne*
03030 *Microcoelum martianum (weddellianum)*
03032 *Microcoelum weddellianum*
03080 *Nengella pinangoides*
03100 *Neodypsis decaryii*
03121 *Neonicholsonia watsonii*
03160 *Neoveitchia storckii*
03170 *Nephrosperma vanhouttteanum*
03180 *Normandya normandyi*
03190 *Nypa fruticans*
03201 *Oenocarpus panamanus*
03231 *Oncosperma filamentosa*
03230 *Oncosperma tigillarium*
03240 *Opsiandra maya*
03942 *Roystonea elata*
03941 *Roystonea oleracea*
03940 *Roystonea regia*
03956 *Sabal blackburnia*
03952 *Sabal causiarum*
03954 *Sabal etonia*
03959 *Sabal glabra*
03958 *Sabal mauritiformis*
03957 *Sabal mexicana*

TABLE V: THE PALM SOCIETY SEED BANK SPECIES DISTRIBUTION LISTING

00020	*Acoelorrhaphe wrightii*
00030	*Acrocomia aculeata*
00034	*Acrocomia antioquiensis*
00032	*Acrocomia intumescens*
00033	*Acronomia mexicana*
00031	*Acrocomia mokayayba*
00080	*Aiphanes caryotifolia*
00081	*Aiphanes erosa*
00121	*Allagoptera arenaria*
00120	*Allagoptera campestris*
00171	*Archontophoenix alexandrae*
00175	*Archontophoenix alexandrae var. (Mt. Lewis)*
00170	*Archontophoenix alexandrae var. beatricae*
00173	*Archotophoenix cunninghamiana*
00185	*Areca catechu*
00186	*Areca guppyana*
00182	*Areca hutchinsoniana*
00181	*Areca ipot*
00188	*Areca langloisiana*
00189	*Areca minuta*
00180	*Areca triandra*
00183	*Areca vestiara*
00184	*Areca whitefordii var. luzonensis*
00230	*Arecastrum romanzoffianum*
00243	*Arenga australis*
00245	*Arenga caudata*
00240	*Arenga engleri*
00244	*Arenga mindorensis*
00241	*Arenga pinnata*
00242	*Arenga tremula*
00246	*Arenga westerhoutii*
00260	*Arikuryroba schizophylla*
00270	*Asterogyne martiana*
00281	*Astrocaryum mexicana*
00280	*Astrocaryum tucuman*
00332	*Attalea allenii*
00333	*Attalea geraensis*
00331	*Attalea humilis*
00330	*Attalea lunifera*
00363	*Bactris gasipaes*
00360	*Bactris maraja*
00610	*Balaka longirostris*
00611	*Bâlaka seemanii*
00630	*Barbosa pseudococos*
00652	*Basselinia eriostachys*
00650	*Basselinia pancheri*
01520	*Chambeyronia macrocarpa*
01540	*Chrysalidocarpus lutescens*
01542	*Chrysalidocarpus madagascariensis*
01541	*Chrysalidocarpus madagascariensis var. lucubensis*
00690	*Bismarckia nobilis*
00720	*Brahea brandegeii*
00722	*Brahea edulis*
00771	*Butia capitata*
00774	*Butia eriospatha*
00770	*Butia yatay var. paraguayensis*
00780	*Calamus australis*
00795	*Calamus caesius*
00795	*Calamus dimorphocanthus*
00790	*Calamus eriocanthus*
00784	*Calamus filispadix*
00789	*Calamus lambirensis*
00796	*Calamus microcarpus*
00783	*Calamus mindorensis*
00787	*Calamus ornatus*
00791	*Calamus paspalanthus*
00781	*Calamus radicalis*
00782	*Calamus revesianus*
00793	*Calamus ruvidus*
00788	*Calamus sophonocathus*
00786	*Calamus usitatus var. palawanensis*
01190	*Calyptrocalyx spicatus*
01231	*Calyptrogyne serapiquinsee*
01260	*Carpentaria acuminata*
01280	*Caryota aequatoralis*
01281	*Caryota cummingii*
01283	*Caryota mitis*
01282	*Caryota ochlandra*
01284	*Caryota rumphiana var. philippinensis*
01285	*Caryota urens*
01330	*Ceroxylon guidenense*
01369	*Chamaedorea brachyclada*
01350	*Chamaedorea cataractarum*
01367	*Chamaedorea concolor*
01352	*Chamaedorea costaricana*
01359	*Chamaedorea ernesti-augusti*
01368	*Chamaedorea erumpens*
01366	*Chamaedorea geonomaeformis*
01365	*Chamaedorea glaucifolia*
01360	*Chamaedorea microspadix*
01355	*Chamaedorea oblongata*
01351	*Chamaedorea radicalis*
01362	*Chamaedorea seifrizii*
01358	*Chamaedorea tepelijote*
01500	*Chamaerops humilis*
02403	*Hydriastele beccarianum*
02402	*Hydriastele douglasiana*
02403	*Hydriastele microspadix*
02400	*Hydriastele wendlandiana*
02410	*Hyophorbe lagenocaulis*

TABLE V (Cont'd)

03376 *Phoenix sylvestris*
03410 *Physokentia insolita*
03477 *Pinanga barnesii*
03466 *Pinanga copelandii*
03482 *Pinanga crassipes*
03481 *Pinanga densiflora*
03478 *Pinanga dicksonii*
03474 *Pinanga elmerii*
03461 *Pinanga geonomaeformis*
03460 *Pinanga insignis*
03472 *Pinanga isabelensis*
03479 *Pinanga kuhlii*
03434 *Pinanga limosa*
03462 *Pinanga maculata*
03485 *Pinanga malaiana*
03473 *Pinanga merrillii*
03480 *Pinanga modesta*
03476 *Pinanga philippinensis*
03483 *Pinanga polymorpha*
03475 *Pinanga salicifolia*
03600 *Plectocomiopsis mira*
03620 *Polyandrococos caudescens*
03640 *Prestoea longipetiolata*
03683 *Pritchardia affinis*
03685 *Pritachardia beccariana*
03681 *Pritchardia beccariana var. giffardiana*
03682 *Pritchardia hillebrandii*
03680 *Pritchardia pacifica*
03686 *Pritchardia samoense*
03684 *Pritchardia thurstonii*
03730 *Pseudophoenix sargentii*
05000 *Ptychoraphis intermedia*
03750 *Ptychosperma elegans*
03751 *Ptychosperma macarthurii*
03753 *Ptychosperma microcarpum*
03754 *Ptychosperma nicolai*
03840 *Reinhardtia gracilis var. rostrata*
03841 *Reinhartia simplex*
03842 *Reinhartia simplex*

03850 *Rhaptdophyllum hystrix*
03891 *Rhopalostylis baueri*
03890 *Rhopalostylis sapida*

03950 *Sabal minor*
03955 *Sabal palmetto*
03951 *Sabal texana*
04000 *Scheelea phalerata*
04050 *Schippia concolor*
04071 *Serenoa repens*
04070 *Serenoa repens (blue and green form)*
04072 *Serenoa repens (silver form)*
04100 *Socratea durissima*
04135 *Syagrus comosa*
04133 *Syagrus coronata*
04136 *Syagrus flexuosa*
04139 *Syagrus macrocarpa*
04138 *Syagrus oleracea*
04130 *Syagrus picrophylla*
04137 *Syagrus pseudococos*
04131 *Syagrus romanzoffianum*
04134 *Syagrus sancona*
04132 *Syagrus schizophylla*
04170 *Synechanthus warscewiozianus*

04192 *Thrinax microcarpa*
04193 *Thrinax morrisii*
04190 *Thrinax parviflora*
04191 *Thrinax radiata*
00203 *Trachycarpus caespitosis*
04200 *Trachycarpus fortunei*
04201 *Trachycarpus martianus*
04202 *Trachycarpus wagnerianus*
04210 *Trithrinax acanthacoma*
04211 *Trithrinax brasiliensis*
04220 *Veillonia alba*
04233 *Veitchia joannis*
04230 *Veitchia merrillii*
04231 *Veitchia sessilifolia*
04232 *Veitchia winin*
04250 *Verschaffeltia splendida*
04281 *Washingtonia filifera*
04280 *Washingtonia robusta*
04311 *Wettinia fascicularis*
04312 *Wettinia hirsuta*
04313 *Wettinia quinaria*

APPENDIX I: FORMAT FOR BOTANICAL COLLECTION OF PALMS

The best overall strategy for collecting palms is to attempt to capture a "picture" of the specimen which is as complete and biologically accurate as possible. Palms are often bulky organisms and for practical purposes only portions of diagnostic materials such as leaves and reproductive structures should be collected. Lack of material must be compensated by considerable quantitative and qualitative data (including photographs) obtained in the field. In general, as dimensions of the palm increase, greater amounts of field data are required.

Prior to collecting, the entire specimen should be photographed to illustrate distinctive characteristics. Large palms require felling to obtain the best material. One should note the length and diameter of the stem, and whether it is solitary or caespitose. Either a complete section (in the case of small palms) or a quartered section of the stem provides useful information on morphological characters, such as the presence and arrangement of prominent internodes, spines, adventitious roots and persistent sheaths. In the case of heavily armed stems (e.g., Astrocaryum), a separate collection of spines should be made and described (i.e. color, size, hardness and position on stem. Presence, dimension and color of above-ground advertitious roots is also recorded.

Leaves should be counted and the lengths of their component parts (i.e. sheath, petiole and rachis) measured. The number, color and texture of pinnae (or segments) should be noted. The best-preserved leaf is then chosen for pressing. A large leaf must be cut into sections. If the leaf is pinnate, this is accomplished by separating sections consisting of the apex, middle and base of the rachis; to reduce bulk, the pinnae can be removed from one side by clipping just above the point of insertion, and the remainder folded in accordian fashion. If the leaf is palmate or costapalmate, most of the segments should be removed and the remainder folded. A section of the petiole and sheath, with indumentum and spines (if present), should also be included. In the case of smaller palms, the entire leaf can often be collected. Qualitative and quantitative notes should still be made, although usually in less detail than in larger, more fragmentary specimens. Photographs of the entire leaf, with a person or rule for scale, allow the specialist to note such details as pinnae arrangement and angle of their insertion into the rachis.

As juvenile palms rarely possess leaves identical to those of adult stage, collection of seedlings provides useful information of leaf development and growth.

Due to their large dimensions, many palm inflorescences also require special collecting procedures. The complete inflorescence, including accompanying bract(s) and prophyll, should be photographed and described in detail. The description should include the inflorescence's position on the stem in relation to the leaves (i.e. infra-, inter- or supra-foliar), qualitative data (e.g., color and texture of rachillae), and quantitative data (e.g., length of peduncle and rachis, length and number of secondary axes, etc.). In the case of bulky inflorescences, only

APPENDIX I (Cont'd)

representative portions of all axes need be collected; the rest may be removed by clipping. Such inflorescences are often impossible to fit into a press, in which case they should be tagged and stored separately until drying. Lengthy sections may require coiling before being dried in order to fit on an herbarium sheet or in a specimen box. Fruits and flowers (including staminate and pistillate, if separate) should also be collected. Color and odor of flowers are noted and, if possible, floral visitors collected and stored separately. As the size, shape and color of fruits may change upon drying, quantitative data, photographs and spirit collections of fruits are recommended. Inflorescence bracts should be photographed and, if large, cut down to size for pressing or direct drying. As is the case with other organs, the color of inflorescence and bract indumentum can change upon preservation and should be recorded.

Finally, field notes or habitat, population density, local names and uses make the specimen of multidisciplinary value.

APPENDIX II: SENDING PLANT MATERIAL TO A FOREIGN COUNTRY

All plant materials sent to a foreign country should be inspected and have a phytosanitary certificate issued. While inspectors from the Animal and Plant Health Inspection Service (APHIS) are located throughout the U.S., most experimental shipments (very small quantities) are routed through the USDA Plant Germplasm Quarantine Center located in Beltsville, Maryland. Personnel from both APHIS and the ARS Plant Introduction Office are located at this center. Inspection, treatment, and issuance of a phytosanitary certificate is handled by APHIS. Shipment and record keeping is handled by ARS.

To issue a phytosanitary certificate, the plant material must be physically present and the shipment must be in full compliance with the regulations of the importing country. Compliance is determined by APHIS and any required fumigation or teatments can usually be provided at the quarantine center. Unless a problem in completing the shipment arises, e.g., the need for an import permit, most material is forwarded by air mail within one week of its receipt at the quarantine center.

Agreements have been made with some countries, e.g., Australia, India, Israel, New Zealand, People's Republic of China, South Africa and USSR, that shipments are always sent through designated Plant Introduction or Quarantine Offices. Shipments from the Plant Germplasm Quarantine Center are automatically routed through these offices as required.

Shipments may be made through intermediary parties, by diplomatic pouch or returned for hand carrying. However, regardless of the mode of transportation, the complete address of the final destination of the material is required to issue a phytosanitary certificate.

While all correspondence regarding shipments is handled by the Plant Introduction Office, all plant material must go through the Plant Germplasm Quarantine Center. The offices are separated by several miles and both addresses should be noted:

Dr. George A. White
Plant Introduction Officer
Building 001, Room 322
BARC-West
Beltsville, MD 20705
(301) 344-3328

Plant Germplasm Quarantine Center
Building 320, BARC-East
Beltsville, Maryland 20705
Att: H.R. Hanes
(301) 344-2048

When sending plant material to be forwarded to a foreign country, the following procedures should be followed:

1. Address the plant material directly to the Plant Germplasm Quarantine Center.

2. Enclose with the shipment, two copies of a listing of the material provided and some identification of the shipment (a reference to a request letter, by date, from the Plant Introduction Office; a copy of your transmittal letter or form; a copy of the original request from the foreign scientist). There may be a considerable delay in forwarding if a shipment cannot be associated with pertinent correspondence or if additional correspondence is required.

3. Import permits or special shipping instructions provided by the requestor should accompany the plant material.

4. A copy of the list of material and a copy of the transmittal or request letter should also be sent to the Plant Introduction Office. Any required correspondence is handled by the Plant Introduction Office and not the quarantine center.

As quarantine regulations become increasingly strict, more and more shipments require import permits. Since it may take several weeks or months to obtain a permit, this should be considered in sending any perishable items or meeting planting dates.

Sources of additional information are given below:

1. Import regulations of a certain country for a given crop:

   USDA, APHIS, PPQ
   Plant Germplasm Quarantine Center
   Building 320, BARC-East
   Beltsville, Maryland 20705
   (301) 344-3141

2. Status of a given shipment:

   USDA, ARS
   Plant Germplasm Quarantine Center
   Building 320, BARC-East
   Beltsville, Maryland 20705
   att: H.R. Hanes
   (301) 344-2048

3. Names and addresses of APHIS inspectors in other locations in the U.S.:

   Export Certification
   USDA, APHIS, PPQ
   Federal Building, Room 637
   Hyattsville, MD 20782
   (301) 436-8537

Inquiries of any nature may be directed to the Plant Introduction Office. Specific responses may be expedited, however, by direct contact with the above sources.

December 21, 1981
Prepared by Sharon Kenworthy
Plant Introduction Offic

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APPENDIX III: IMPORTING PLANT MATERIAL INTO THE U.S. FROM A FOREIGN COUNTRY

All plant material entering the United States must be inspected by the Animal and Plant Health Inspection Service (APHIS). For most experimental samples, inspection is done at the Plant Germplasm Quarantine Center. Beltsville, Maryland. Personnel from both APHIS and the ARS Plant Introduction Office are located at the center.

The Plant Introduction Office coordinates the introduction and exchange of all crops with all countries. Requests for any material should be addressed to:

Dr. George A. White
Plant Introduction Officer
Germplasm Resources Laboratory
Building 001, Room 322
USDA Agricultural Research Center
Beltsville, Maryland 20705 USA
(301) 344-3328

Requests should be as specific as possible indicating the specific cultivars or lines of interest, a literature citation, suggested source, research objectives, whether the material is for propagation or analysis, or any other known information. The more specific a request can be, the higher the success rate in obtaining the desired material.

When the source is known, requests may be made direct. It is very important, however, that the supplier be given very specifc shipping instructions. The following address only should appear on the outside of the package:

USDA Plant Germplasm Quarantine Center
Building 320, BARC-East
Beltsville, Maryland 20705
attn: H.R. Hanes

On the inside of the package, the material should be completely identified. The complete name and address of the sender and the intended recipient should also be given. Copies of the request letter should be sent both to the Plant Introduction Office and the Plant Germplasm Quarantine Center. While all plant material is handled at the quarantine center, all correspondence, documentation, and special arrangements are handled by the Plant Introduction Office. The Offices are separated by several miles and both must be alerted to any pending shipments.

Note that the quarantine center is geared for very small experimental quantities. Prior arrangements must be made for large shipments. International mail or diplomatic pouch are recommended. There may be a considerable delay in receiving air freight shipments. In addition, all shipments must be prepaid to Beltsville.

Mailing labels are available from the Plant Introduction Office to expediate the shipment of the plant material. The address of the Plant Germplasm Quarantine Center will suffice if labels are not available.

APPENDIX III (Cont'd)

While all plant materials may be received at the Plant Germplasm Quarantine Center without an import permit, permits must be in order before the material can be released. In the case of quarantine-prohibited budwood, a mailing label with the appropriate permit number is preferred. Rootstock for such materials must also be available. Advance notice of shipments of all perishable materials is extremely important.

Import regulations vary considerably both by crop and country involved. Many crops are prohibited and require an import permit to receive the material. Some crops are prohibited only from certain countries. In general, the following crops require an import permit: wheat, corn, sorghum, millets, rice, cotton, potatoes, many fruits and several vegetatively propagated materials. Qualified individuals may obtain permits to receive some prohibited crops after inspection. Others can be imported only through USDA and grown under quarantine conditions before release.

Import permits, as well as information on the import regulations of a given crop from a certain country, may be requested from:

Permit Unit
USDA, APHIS, PPQ
Federal Building, Room 638
Hyattsville, Maryland 20782
(301) 436-8248

Hand-carried materials are subject to the same import restrictions. Unless prior arrangements are made, restricted hand-carried plant materials must be turned over to the inspector at the port of entry. They should be packaged as if for mailing with the quarantine center as the only address on the outside. The sender, a complete listing of the contents, and intended recipient should be completely identified inside the package.

Questions regarding any aspect of the above procedures may be directed to the Plant Introduction Office.

Prepared February 1982
Sharon Kenworthy, Geneticist
Plant Introduction Office

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TREE SEED SUPPLY - A CRITICAL FACTOR FOR THE SUCCESS OF AGROFORESTRY PROJECTS

A Supporting Document Prepared for
A Workshop to Discuss International
Cooperation with Regard to Multipurpose Tree
Germplasm

By

J.W. Turnbull

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Tree Seed Supply — A Critical Factor for the Success of Agroforestry Projects

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Summary

The paper emphasises the need for agroforestry project planners to consider seed supply during feasibility studies and to initiate seed procurement 1–2 years in advance of the nursery phase if seed is required from other than local sources. Failure to allow adequate time for seed procurement can place the success of a planting program at considerable risk. The user can afford to pay a high price for good quality seed as the cost is very low in relation to overall project costs and economic and social consequences of using poor seed can be major and longterm. It is recommended that dependence on external seed supplies be reduced or eliminated at the earliest possible opportunity by the establishment of local seed production areas.

Introduction

In the past 25 years there has been an acceleration of tree planting in tropical and subtropical regions to meet a variety of objectives but principally to provide raw material for products such as paper and wood-based boards. Eucalypts and pines planted as exotics have dominated these plantations. Initially use was made of a limited range of exotic species drawn from introduction trials which were frequently of an *ad hoc* nature. Generalisations from inadequate basic data resulted in the use of species on sites to which they were not fully adapted and where they often failed or grew poorly (FAO 1980). This prompted the establishment of valid introduction trials on representative sites, comprehensive provenance trials and the selection of optimum seed sources. FAO produced a 'global action programme' to make seed available and this was implemented through national institutions such as Australia's CSIRO Division of Forest Research (eucalypts) and the United Kingdom's Commonwealth Forestry Institute (tropical pines) (Palmberg 1980*a*). The limited funds available were directed principally to species providing industrial wood and only minor progress was made in exploring the genetic potential of multi-purpose tree species.

Industrial wood plantations of the 1960s and early 1970s assumed great importance and overshadowed the role trees can play in association with agriculture. In this paper agroforestry implies that trees are combined in space and/or in time with either farm crops, or domestic animals or both. The object is to optimise production per unit area and to maintain the principle of sustained yield (Combe and Budowski 1979). Rural communities in India, Southeast Asia and elsewhere have integrated forestry and agricultural practices for centuries but the Peoples' Republic of China was one of the first countries to recognise officially the complementary nature of planting trees and growing food. Chinese agroforestry systems include the 'four-around' plantings of villages, farms, roads and waterways (FAO 1978), and community shelterbelts (Zhu 1981) that have had an immense social impact and contributed greatly to improved rural living

standards. In the 1970 s there was an increasing recognition in other developing countries of the role forests and trees can play to increase agricultural productivity, improve human welfare, alleviate energy problems and conserve the environment. According to an appraisal by the World Bank and FAO (1981) the main thrust of forestry in the next decade will be afforestation or reafforestation with fast growing trees, with special emphasis on fuelwood and planting multi-purpose trees around homesteads, along boundaries, in village woodlots and in upland watersheds.

It is recognised that the situation in agroforestry now almost exactly parallels that of industrial forestry 25 years ago (FAO 1980). There are problems in the choice of species and provenances. Agroforestry managers have often to choose from a bewildering array of almost unknown species. Remarkable success has been achieved with exotic species such as *Prosopis chilensis/juliflora* in several countries, *Leucaena leucocephala* in the Philippines, *Calliandra calothyrsus* in Indonesia and *Casuarina equisetifolia* in India and China, but with few exceptions lack of provenance investigations mean that seed for additional plantations can be specified only at the species level. Few multi-purpose tree species suitable for agroforestry have been explored sufficiently well to enable the efficient use of their gene resources. Early action to correct this has been recommended (FAO 1977) and some preliminary work instituted (e.g. FAO 1980).

Donor agencies and national governments have begun to make major financial inputs into social forestry programs but there is little evidence that they are treating the question of seed supply seriously. To implement a tree planting project in an orderly way requires agreement and commitment in several key areas, one of which is the procurement of seed and the development of nurseries 1–2 years in advance of the proposed planting date (Evans 1982). Many factors determine the choice of species to plant but when the choice is made there remains the critical factor of seed procurement. If seed of the optimum species from the best seed source is unavailable then the project result will be suboptimum or in the extreme case it may fail completely.

In a summary of the findings of a global survey on plantations of tropical lowland conifers it was stated 'Presently large amounts of unselected seed from wild stands, often of poor quality and/or unsuitable provenances, are used in plantation programs in the tropics. Selection and further breeding is based on populations of inadequate size and unknown genetic composition' (Palmberg 1980). Aid programs financed by developed countries frequently ignore considerations of seed choice and supply. Greathouse (1982) has reported that seed was specifically mentioned in the implementation documents of only three out of 55 tree planting projects supported by US AID between 1978 and 1982. Failure to plan ahead to secure the best seed in the amounts required to meet the planting timetable suggests a lack of appreciation of the profound influence the seed used can have on the outcome of a planting project. The lack of attention to seed sources and the supply of tree seed in forestry projects is remarkable and disappointing when one considers the widespread use of improved varieties in agriculture and the many tree improvement programs in progress.

This paper draws heavily on Australian experience and is written with the intention of increasing the awareness amongst planners and managers that currently a bottleneck exists between the stages of species' choice and planting. The bottleneck is the timely procurement of good quality tree seed with inherent characteristics to meet the stated objectives of agroforestry projects.

Importance of seed quality

The question of what seed to buy can be resolved by considering the merits of using high quality seed. Seed quality is a broad term which embraces seedlot characteristics such as genetic constitution, germination percentage, vigour and purity.

Genetic quality: The genetic constitution of seed can have a major effect on tree growth and yield. It is influenced by factors such as geographic origin (provenance), whether seed was collected from an indigenous stand or otherwise, the number of trees from which the seed was taken, and the degree of selection and breeding of the parent trees. Provenance trials have demonstrated conclusively that large gains in productivity can be made simply by identifying and using the seed source most adapted to the planting locality. The magnitude of provenance differences is indicated by data for *E. camaldulensis* in Nigeria where after 5 years the best provenance in a trial had a mean annual increment of 17.3 m^3 ha^{-1} and the poorest 5.1 m^3 ha^{-1} (FAO 1979). Similar data exist elsewhere, for example in the Congo and Brazil where the yield of eucalypts has been increased by up to 80% by selection of the best seed sources (Chaperon 1978, Brune and Zobel 1981).

In addition to improved yields due to selection of the optimum provenance, growth per generation of 10% for most tree species and 15–25% for some other species can be expected from tree breeding programs (Carlisle and Teich 1978). For pines in southeastern USA increases in yields of 2.5–4.0% were sufficient to pay for the cost of improved seed (Davis 1967). Added to the direct returns from higher yields are other non-quantifiable benefits, such as hardiness, and resistance to pests and diseases, which may be conferred by selected seed.

Data on genetic variation are still scarce for many multi-purpose tree species and research to identify optimum seed sources is an urgent matter. In this situation the purchaser may have to resort to informed guesses to select the source of the seed or should use several seed sources to spread the risk of failure. Occasionally the purchaser can have some aspects of the genetic quality of a seedlot certified by a scheme such as the OECD Scheme for Forest Reproductive Material moving in International Trade (OECD 1974). More often reliance must be placed on the honesty of the seed supplier and the user should seek whatever assurances he can regarding genetic quality. Buying from a supplier with a good reputation rather than the one who offers the lowest quotation is a sound policy.

It has long been understood that different tree species have different site requirements, growth rates and economic potentials but the extent of genetic variability within species has been less well appreciated. Agriculturalists are used to planting highly-bred seed with little variation and administrators frequently have no conception of the magnitude of intraspecific variation and regard seed of a species as a fixed, invariable commodity. Professional foresters have no excuse for ignoring the comprehensive literature on the subject.

Evidence is overwhelming that substantial economic gains can accrue simply by using seed of the best provenance and that further gains are possible from selection and breeding. Under these circumstances failure to purchase seed of the best genetic quality available for a project is indefensible.

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Physical and physiological quality: A nurseryman has to know how much seed of a particular seedlot must be sown to produce a predetermined number of plantable seedlings. Determination of the amount of seed required depends on germination percentage, number of seeds per kg and the estimated level of recovery of seedlings of that species in the nursery. Of these factors, the only one controlled directly by the nurseryman is the level of seedling recovery. This varies between species and between nurseries but is commonly about 70% for conifers and 25–30% for eucalypts. Knowledge of the quality of seed to be used in a tree nursery is therefore essential.

Seed purchased without adequate test data leads to sowing without carefully calculated sowing rates, a practice regarded as 'archaic and wasteful' by Tinus and McDonald (1979). Information on the percentage of seed germinating normally in a seedlot is particularly important if direct sowing into containers is planned. A low percentage will result in empty pots and direct sowing in containers is not recommended unless the germination is at least 50%, and preferably over 70%. The requirement for seed with a reliable high germination percentage is the principal factor influencing the introduction of direct seeding into containers with a precision seeder compared to the more costly broadcast sowing and pricking out (Denison 1979). The other critical parameter for the nurseryman is the number of seeds per unit weight so that numbers of viable seeds per kg can be calculated. Tables showing the average number of seeds per kg for many species are available but the actual number can vary widely between seedlots depending on the time of collection and the geographic origin of the species. *Eucalyptus cloeziana* seeds collected in the moist coastal forests of Queensland average 100 000–400 000 viable seeds/kg whereas seeds from the dry inland woodlands are much larger and seedlots contain only about 35 000–65 000 seeds/kg. Seed tests on over 400 seedlots of *E. camaldulensis* show the number of viable seeds per kg to be 670 000±465 000 (mean ± one standard deviation) (Boland *et al.* 1980). This level of within-species variation is common for other species and genera (Schopmeyer 1974).

A review of Australian and international tree seed suppliers showed that the majority offer inadequate seed test data. Germination percentage figures are sometimes quoted but these are of little relevance unless the number of seeds per unit weight of the seedlot is also provided. Some suppliers quote an average number of seeds or viable seeds per kg for an individual species but few offer to provide actual seed counts and germination data. Other suppliers, such as the Forestry Commission of New South Wales, Australia, will test seedlots at an additional cost to the purchaser and payment of this small extra charge is very worthwhile when the quantity of seed purchased is substantial. For eucalypts and other Australian species the CSIRO Tree Seed Centre provides individual seedlot figures for the number of viable seeds per unit weight based on standard laboratory tests so that after adjustment for nursery recovery rate the amount of seed required to produce a given number of plantable seedlings can be estimated accurately.

Purchasers should insist that reliable and relevant seed test data, preferably of an international standard such as ISTA certification, be available prior to purchase. They should be prepared to pay for the information as the additional cost can be amply recouped by savings in the amount of seed purchased and improved nursery practices. If data cannot be provided the order should be placed elsewhere. Carter (1979) stated 'the inability of some suppliers to furnish relevant seed data is disgraceful, in view of the rising cost of seed and, as prices rise, may force a user to pay more and more for unquantified seed without nursery performance guarantees because the necessary data are not available or are withheld for dubious reasons'. Carter suggested that both suppliers and users would be protected if seed transactions based on

a fixed rate per kg were discontinued and sales based on an index to quantify the potential nursery yield of a given seedlot. A similar practical proposal is that the unit of a seedlot sale should be '1000 normal germinants' (Hodgson 1981). With this figure available the nurseryman would only have to take his nursery recovery factor into account when calculating his seed requirements.

Reliable seed testing procedures and availability of the results prior to the sale will lead to less wastage of seed, more realistic prices and greater nursery efficiency. However the subsequent performance of the seedlings will remain largely determined by the genetic quality of the seed.

Cost of tree seed

Advertised prices for tree seed vary greatly between species and there can also be major price differences between seedlots of the same species. Routine seed collections of *Eucalyptus tereticornis* are available in India for $6* per kg whereas the frost-hardy Tasmanian eucalypt, *E. gunnii*, which is planted as an ornamental garden tree in Europe can be priced as high as $900 per kg. Many factors determine seed prices, most are related to collection and processing costs but supply and demand factors can result in artificially high or low prices. The cheapest seed is usually collected from plantations during logging operations in regions where labour costs are low. The large quantity of *E. grandis* seed exported from Africa is collected in this way and is much cheaper than *E. grandis* seed collected by highly paid labour from the natural forests in Australia. Special provenance collections are often more than double the price of routine seed collections as they may involve specialist staff travelling long distances and collecting from standing trees. The situation is complex and can be illustrated by reference to the price of *Eucalyptus camaldulensis* seed from different suppliers and sources (Table 1).

When demand for seed exceeds supply the price is forced up. Problems in supply arise when substantial quantities of seed of newly recognised species or particular superior seed sources are required and the only source is the natural stand in the country of origin. This has occurred in Honduras where the Siguatepeque seed bank, operated by the Corporacion Hondurena de Desarollo Forestal (COHDEFOR), reports that the demand for seed of *P. caribaea* and *P. oocarpa* exceeds the supply and there has been a consequent price increase (Zerbe *et al.* 1980). There are similar examples of demand exceeding supply for several Australian tree species including *E. dunnii* (a fast growing species with an extremely restricted area of natural occurrence) and *E. camaldulensis* of Petford origin (one of the most productive and adaptable seed sources but the remoteness of the natural stand resulted in insufficient initial seed collections being made). *Acacia mangium* has recently been identified as a promising species for planting on poor sites dominated by Imperata grass in the humid tropics but seed is not yet available in large quantities due to the remoteness of the natural stands and the current difficulties of seed collection and extraction. The price of *A. mangium* seed from natural forests increased from $100 to $330 per kg between 1979 and 1983 when demand exceeded supply. Some arid zone acacias present difficulties due to irregular seed crops and in some species there is extensive destruction of the seed by insects. Similar supply problems are likely to occur at least initially for other multi-purpose tree species identified in trials. In the longer term, the higher prices usually have the effect of improving the availability of seed as it becomes a more attractive commercial proposition and warrants greater efforts to improve the supply.

* All currency figures in this paper are in American dollars.

The cost of seed of multi-purpose trees which have already been widely planted, such as many eucalypt species, *Casuarina equisetifolia* and some *Acacia* species, will remain fairly stable as there are abundant supplies. However, less widely planted species and newly identified species of value in agroforestry projects will have relatively high prices. Researchers testing new species of multi-purpose tree species must be prepared to pay high prices for small quantities of seed collected from natural forests and supplied with full documentation.

Table 1. The price of *Eucalyptus camaldulensis* seed from different suppliers and sources

Supplier and origin	Price/kg (US$)
Australian commercial seed companies and State forest services	
(a) routine collections from natural forests mainly in temperate regions	$50–110
(b) special provenance collections in natural forests, usually from standing trees, higher prices are for collections in the more remote tropical regions	$145–300
Australian CSIRO Tree Seed Centre	
Seed of research quality from identified provenances with detailed collection information available and germination test data provided. Higher prices are for tropical provenances in remote localities	$300–500
Government forest services outside Australia	
Seed collected from felled trees in exotic plantations. Origin in Australia usually not known. Price given is for routine collections in Tanzania	$20
International private seed companies	
Origin of seed not advertised but higher prices if from natural stands. Most seed from exotic plantations	$45–70

Cost of seed in relation to project costs

There is a prevailing policy within many Government organisations and private companies in both developed and developing countries that tree seed should be purchased from the cheapest source. Considerations of seed quality clearly show that this can be false economy. The problem may lie with the project manager who has an insufficient appreciation of the value of using an optimum seed source and who therefore writes an inadequate specification, or with the purchasing officer who considers seed an invariable commodity and so buys the cheapest available, or it may be that unrealistic estimates have been made of seed costs when planning the project, or simply that the country's foreign currency regulations limit the amount that can be spent on importing seed. Whatever the reason it is instructive to relate the cost of seed purchase to the total cost of a planting project and consider the implications.

The cost of seed in a plantation project is extremely small in relation to other costs. For *Eucalyptus* and *Pinus* species the cost is usually less than 1% of direct plantation costs and even less when related to the overall costs of a project. One kg of *E. camaldulensis* seed, of average viability and nursery recovery, yields sufficient seedlings to plant 65 ha (2 × 2 m spacing) or 150 ha (3 × 3 m spacing). The cost for seed per ha is $4.60 for close spacing and $2.00 for the wider spacing if a superior, source-identified Australian seedlot costing $300 per kg is used. Most eucalypt plantations cost $300–600 per ha to establish and maintain to year 3, excluding the cost of land (FAO 1979) so that the seed cost will rarely exceed 1.5% of the direct establishment costs. Greathouse (1982) has provided costings for a US AID project in

Panama using seed of *Pinus caribaea* and *Tectona grandis*. The purchase price of the pine seed was $150 per kg and the teak seed $110 (imported). For the pine the seed cost was only 0.9% of the reforestation cost and 0.4% of the total project cost. For the large-seeded teak comparable costs were 3.9% of the reforestation cost and 1.7% of the total project cost.

These examples show that seed costs are negligible compared to establishment and overall project costs. On the other hand if seedlings from a superior seed source grow faster there may be significant savings in establishment costs, such as weeding, the rotation may be shortened and the yield increased. In agroforestry projects increased yields per unit area can result in more land being used to produce agricultural products. The argument for using optimum seed sources extends beyond economics. If villagers or farmers are given seedlings which fail or grow poorly due to poor seed quality lasting harm can be done. The people lose confidence in the foresters, extension officers and others who have sought to convince them of the value of trees. They may then reject the concept of tree growing in association with agriculture and return to the exploitive gathering of wood from natural forests with long-term deleterious results.

In agroforestry projects, as in short rotation industrial plantations, it is highly probable that the following tree crop will be raised from seed from the original introduction or will be a coppice crop whose performance will depend directly on the genetic quality of original stock. Any genetic deficiencies in the initial seedlot will then be perpetuated in the subsequent rotations. This reinforces the argument that savings in the purchase price of tree seed at the expense of genetic quality can have major and long term negative consequences.

The demand for tree seed

An acceleration in the planting of both industrial and non-industrial forests during the remainder of the 20th century is forecast. In the tropics an annual planting rate of 1 300 000 ha of industrial plantations and 520 000 ha of non-industrial (fuelwood, domestic products, protection) forests between 1981–85 is predicted (Lanly 1982). The need for an additional 50 million ha of non-industrial plantations, chiefly for fuelwood, has been emphasised by Palmberg (1981*b*); China will plant 1–2 million ha annually to meet established targets for industrial and domestic wood (Turnbull 1982) and continuation of the annual plantation rate of over 400 000 ha in Brazil (Simoes 1980) seems likely.

For industrial plantations, *Pinus caribaea* planting is expected to be 90 000 ha by the mid-1980's (Palmberg 1980) and require 11 tonnes of seed (Bell 1979). Current annual planting programs in Brazil consume close to 16 tonnes of eucalypt seed and globally more than 25 tonnes could be used. Most of the seed for industrial plantations will come from existing planted forests in the countries requiring the seed or could be imported from countries that have a surplus of seed from plantations, for example *Pinus caribaea* (Fiji) and *Eucalyptus grandis* (South Africa, Zimbabwe). Large quantities of seed will be required for non-industrial plantings, but as the choice of species remains uncertain it is difficult to predict the amounts required of a particular species.

In recent years there has been greater interest in testing multi-purpose tree species or species with particular attributes which make them attractive for agroforestry. The amount of seed required for this research is relatively small but there is a vast array of potentially useful species which require screening. The National Academy of Sciences lists about 700 species out of over 1200 nominated as potentially important fuelwood sources in developing countries (NAS 1980).

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Most of these species have received little attention previously, so that there are no established source of seed supply and often the flowering and seeding habits of the species are little known.

Australia has many trees with characteristics which indicate they could make excellent multi-purpose trees when grown in association with agriculture. The acacias and casuarinas are nitrogen-fixing species that can tolerate infertile sites and produce a range of wood products, firewood, tannins, honey etc. The number of Australian species in the three genera, *Acacia*, *Casuarina* and *Eucalyptus* exceeds 1300 and there are other species in genera such as *Melaleuca* and *Grevillea* (Boland and Turnbull 1982). It can be readily appreciated that there will be considerable difficulty in meeting demands for seed of many of these species in the short term despite relatively well-organised seed collection activity in Australia. It is necessary for agencies which promote the planting of multi-purpose tree species through publications and the sponsorship of meetings to have an equal commitment to support seed collection activities to satisfy the demand they generate.

Seed Supply

Importing tree seed can be a frustrating exercise, for example the experience of Malaysia importing seed for pine plantations has been 'that overseas seed supply is costly, irregular, often inadequate in quantity and unpredictable in quality. The quarantine and administrative delays substantially reduce the viability of the seeds on arrival at the nurseries' (Sheikh Ali Abod 1982). To minimise some of these problems it is necessary to have long-range planning so that seed procurement procedures can begin well in advance of the proposed sowing date. This is especially important when the seed is to obtained from external sources.

Commercial seed collectors or seed centres can often arrange to make special seed collections for a project if given at least 12 months advance notice of the requirement. Long term planning of seed procurement permits greater flexibility in the choice of a reliable and economical source of supply. Too frequently project managers and researchers have given the matter of seed supply inadequate consideration: they expect their requirements to be available from existing stocks, and often have to be satisfied with insufficient quantities of seed. An example of sensible forward planning occurred in a recent proposed Australia-India bilateral aid project when the Australian Development Assistance Bureau let a contract for the supply of tree seed for research two years in advance of the expected start of the nursery program. This gave time for special collections to be organised to obtain a comprehensive range of species and provenances which were tested for quality and held in storage until required.

The supply of seed poses problems for both the user and the collector. Chang (1981) has described the problems encountered in attempting to assemble seed of a range of fast growing tropical tree species for research in Central America. A circular letter explaining the research project and requesting assistance with seed supply was sent to forestry authorities in 54 countries. In this way up to 20 requests were made for seed of a single species. The response to the letter was poor: 60% of addressees did not reply; 10% indicated they could not assist; 10% could supply seeds only in the following collecting season; 20% sent seeds to the project but 30% of these lots failed to germinate. Obtaining seed in this manner takes time and patience, and depends very much on the goodwill of the donor. For projects requiring many species from different sources the procurement time can easily extend to two or more years.

The experience of the CSIRO Tree Seed Centre is that a bank of seed of a quality suitable for research is not assembled easily or cheaply, facts not always appreciated by researchers making seed collections by mail. The natural occurrences of species are often remote from the collector's base and in unpopulated areas where it is difficult to obtain preliminary information about seed crops or to arrange collections by local residents. Seeding habits are unknown for some species and may be greatly influenced by a variable climate. Seeds are often attacked by insects or eaten by birds before collection or may be dispersed from the tree as soon as they reach maturity. For some species seed collection teams must travel thousands of kilometres over difficult terrain, they cost thousands of dollars to support in the field and may collect only small quantities of low quality seed. A current attempt to assemble such a collection of *Acacia aneura* provenances from the arid zones of Australia has been frustrated by the very erratic seeding of this species in different parts of its extensive natural range. Collections of *A. aneura* have already extended over four years and will cost an estimated $30 000 in operating costs by the time they are completed. Other tree seed centres have comparable problems and their inability to satisfy in full requests for large numbers of species and provenances is in no way a failure to appreciate the merits of the requests. Those collecting seeds by mail must be conscious of these difficulties and not place their expectations unrealistically high.

Seed buyers should be aware that many tree species exhibit periodicity in their seed crops with heavy crops often being several years apart. For such species it is in the buyer's interest to purchase seed during a good seed year and arrange to store it under suitable conditions to cover intervening years of poor supply. The seeds of most tree species can be stored without difficulty for more than one year with minimal storage facilities.

Seed Suppliers

Many forestry and agroforestry projects use exotic trees for which there is no local source of supply and arrangements have to be made to import seeds. The source of supply chosen depends to a large extent on the quantity of seed required, the use to which it will be put and the funds available. Large quantities of seed of individual species for use in routine plantings are usually obtained from commercial seed suppliers whereas small quantities of seed for purposes such as research are best obtained from more specialised agencies.

Commercial seed companies mainly stock seed of better-known species with a proven demand so that they can rarely supply seeds for agroforestry research. In addition there is strong evidence that commercial seed collectors and their agents do not pay adequate attention to identification, intraspecific variation and documentation of collection site details which are so important for research material. This situation is not helped by the lack of formal tree seed certification schemes in most tropical countries. The requests for research seed are therefore usually directed towards government forest services or national tree seed centres which serve as a focal point for activities related to forest genetic resources.

Government forest services have frequently difficulty justifying allocation of their limited resources to provide a seed service for foreign governments and companies but the establishment of tree seed centres has assisted greatly the procurement of seeds for international research purposes. Such bodies have been set up in recent years in countries such as Chile, Colombia, Guatemala, Honduras, India and Iran (Palmberg 1981*a*), and regional seed centres are operating in Costa Rica (Latin American Seed Bank) and Thailand (ASEAN Forest Tree Seed Centre). Most of the national seed centres are relatively small and have limited funds. Some are partially

supported by bilateral or international donor agencies but the number of seed centres and the level of financial support from governments and donor agencies will have to rise substantially if the ever-growing demands for seed of multi-purpose tree species are to be satisfied.

Commercial seed suppliers: The tree seed trade is made up of large or small private companies and government agencies. Most of these organisations prefer to deal in bulk seed so that some require the purchase of a minimum quantity or have a minimum value for each order. The commercial suppliers can usually specify the origin of the seed they supply although the reliability and detail of this information often depends on whether the supplier is also the collector or mere the broker. In transactions with dealers the purchaser needs to protect himself by ensuring that he gives an accurate specification for the seed required and confirming that the dealer is in a position to meet the specification before the purchase agreement is concluded. Specifications will vary according to needs but should cover aspects such as whether the seed is to come from natural stands or plantations, the provenance or region of provenance and the degree of selection of parent trees required, the amount of seed origin detail to accompany the seed, and the provision of a germination test certificate or similar guarantee of seed viability. When buying *Eucalyptus* or *Acacia* seeds from Australian suppliers it should not be assumed that the seed will have been collected from natural stands in Australia as seed from exotic plantations is now common in the tree seed trade. The necessity to nominate the provenance required for species with high genetic variability cannot be over-stressed. For example, when purchasing seed of *Eucalyptus camaldulensis* for use in a tropical environment a tropical seed source from northern Australia must be specified otherwise a cheaper and much less productive temperate seed source is likely to be supplied. The majority of seed dealers do not have their own seed testing facilities but many can arrange for test certificates to be issued by official seed testing stations of the International Seed Testing Association.

It is highly probable that the failure of seed purchasers to insist on good quality seed with adequate documentation has resulted in the lack of attention to these aspects by many tree seed dealers. Dealers who have maintained good quality stocks of seed at marginally higher prices than their competitors have often failed to make sales due to the purchaser buying the cheapest seed available. Action in Europe to restrict imports of uncertified seed from western USA and Canada was one of the main reasons for the acceptance of seed certification schemes in those countries.

A world-wide listing of tree seed suppliers is not available but private companies which deal primarily in tree and shrub seeds exist in a number of countries. A selection of these is listed in Appendix 1. The most comprehensive source of information on tree seed availability is the 'Forest Tree Seed Directory' (FAO 1975) prepared on the basis of a 1973 survey. The directory does not list individual suppliers but for each country gives the name and address of a National Seed Coordinating Centre (NSCC) which can provide more detailed information on local suppliers. Species are listed in the directory together with the countries that indicated they were potential seed suppliers. Although this publication is a very useful starting point in finding a seed supplier its value is limited by the information now being ten years old. Some addresses are out of date and many species of interest to agroforestry projects are not listed. The NSCC in some countries publishes a list of local seed suppliers, examples are 'Seed and Planting Stock Dealers' (USDA 1979) and 'Australian Suppliers of Tree Seed' (CSIRO 1983). The Nitrogen Fixing Tree Association has prepared a resource document listing suppliers of trees that fix

nitrogen. Many of these species are used in agroforestry projects and the list should assist in seed procurement.

Research seed suppliers: Research projects require small quantities of seed of guaranteed authenticity accompanied by accurate details of locality of collection, environmental conditions at the collection site and genetic history. Seed of this quality is best sought from specialised agencies such as designated tree seed centres, universities, research institutes and research sections of national forest services. Addresses of appropriate research workers or institutions can be obtained by reference to the 'IUFRO World Directory of Forest Geneticists and Tree Breeders' (Nienstaedt 1978), from publications such as the FAO Forest Genetic Resources information, or in lists of research contacts which appear in relevant books published by the U.S. National Academy of Sciences.

Small amounts of seed for research can often be obtained free of charge on an exchange basis. When investigators are forced to collect seeds by mail they may feel that they cannot impose too many restrictions on the supplier, but they may obtain far more than expected if they:

a) explain the purpose for which the seed is required, describe the environment of the proposed planting site if appropriate and offer feedback of results;

b) list any special requirements e.g. particular provenances or if the seed is to be kept separately from individual mother trees etc., and provide data sheets showing the kind of information and details needed;

c) state the minimum amount of seed or seedlings needed and give the latest date by which the seed must arrive allowing for delays in quarantine and customs;

d) offer to pay a reasonable price for the seed or to cover the costs of handling and postage if seed is provided free of charge;

e) provide import permits and the exact address to which the seeds are to be consigned;

f) acknowledge promptly any seed and/or assistance received;

g)advise the potential supplier of similar approaches to other individuals or agencies and to seek his advice on alternative suppliers if he cannot assist. This takes little time but can often prevent frustrating duplication of effort on the part of the suppliers.

Some tree seed centres have agreements with donor aid agencies to cover the cost of providing seeds in limited quantities to developing countries for *bona fide* projects. The CSIRO Tree Seed Centre can send Australian tree seeds free of charge to countries of Oceania, southeast Asia, the Indian subcontinent and some African nations under an agreement with the Australian Development Assistance Bureau. Where such arrangements are not in operation it is usually necessary for tree seed centres to make a reasonable charge for the supply of seed for research. The charge is usually related to the cost involved in collecting the seed but is frequently considerably less than the real cost of collection.

Seed collection missions

The collection of seed by mail is often very unsatisfactory, especially when the seed is to be used in research projects. Seeds collected by seed centres or research institutes cannot always satisfy the specifications for a particular project or series of projects. Under these circumstances a special expedition to collect the seeds may be justified.

Seed collections are expensive, need detailed planning and full cooperation with an individual or institution in the proposed collecting area. The cost of travel, equipment and maintenance of a team from overseas undertaking comprehensive seed collections in Australia for a year could be close to $100 000. A recent short term collection of *Acacia mangium* from remote areas of northern Australia by an overseas private company was estimated to have cost over $1000 for every kg of seed collected. The costs should be weighed against the many potential benefits of this type of operation. The researcher can collect sufficient seed to satisfy fully the objectives of the project, ensure correct sampling procedures are followed, and make sure full documentation of site conditions, ecology and tree descriptions is obtained. In addition he gains valuable insights into the ecology of the species, often observes other species of value to his project, and makes contacts for any follow up collections or cooperative research.

In Australia the systematic collection of tree seed for research is an immense task in its demands on the time of skilled staff, as well as financial resources. For this reason overseas foresters have been encouraged to visit Australia to collect their own seeds and it is the policy of the CSIRO Tree Seed Centre to assist these collections (Turnbull and Doran 1980). In return for local assistance it is usual for the collector to donate a sample of all his seedlots to the seed centre for distribution elsewhere. An example of such cooperation is the year-long seed collection mission of the Centre Technique Forestier Tropical (France) in 1973 to collect tree and shrub seeds from tropical Australia for use in research programs in Africa, South America and elsewhere. This mission obtained more than 1500 different seedlots of a wide range of species some which have given excellent results and have formed the basis for seed production areas and new planting programs. A similar project by the Zimbabwe government began in 1982 and there are prospects for a Brazilian seed collection mission in 1983. Private companies have also recognised the value of collecting their own seeds and in recent years Australian eucalypts and acacias have been sampled by teams from Brazil, Sweden and the United States.

Outside Australia, the collection of northwestern American conifer seed by IUFRO in cooperation with the United States and Canadian Forest Services, Danish collections of *Tectona grandis* and *Gmelina arborea* in Asia, and collections of *Pinus radiata* and *P. muricata* by Australia with international support are examples of cooperative seed collections which have been highly beneficial to researchers. Very few developing countries have the resources to undertake seed collection outside their own borders but assistance of such projects by international or bilateral aid organisations can be a very effective use of international aid funds. The collection of tree seeds in Australia in 1982–83 by the Zimbabwe forest service using Australian funds indicates that some aid agencies are becoming aware of the value of this activity.

Local seed production

Numerous problems arise in attempting to sustain a regular planting program based on imported seed and the obvious solution is to develop local seed production areas at the earliest possible opportunity. The most important gains from the management of seed production areas of exotic

species are that a regular and reliable supply of seed of known quality can be secured and the user has some influence over production costs. In addition, the opportunity for subsequent genetic improvement can follow a well-planned program for self-sufficiency in local seed (Eldridge 1978). These are very good reasons for a developing country to aim to be self-sufficient in tree seed supplies of the principal species planted. Until local seed production areas start to produce seed any imported seed should be obtained from the best available sources, not the cheapest sources.

An example of the successful development of local seed production areas comes from Brazil where Champion Papel e Celulosa S.A. planted *Eucalyptus grandis* (Coffs Harbour provenance) in 1969. This company's 100 ha of seed stands yield annually over 1000 kg of seed. The seeds are much sought after as they are demonstrably superior to alternative commercial seed sources in Brazil (Boland *et al.* 1980). International action by FAO and UNEP has resulted in establishment of 'conservation/selection' stands of important individual provenances of *E. camaldulensis* and *E. tereticornis* each 10 ha in area (Palmberg 1981*b*). These stands will form valuable seed production areas in the countries where they are established and could serve as models for other species.

The procurement of seed in 'semi-bulk' quantities for the establishment of seed production areas or pilot plantations (up to 500 ha) is sometimes problematical. Recognising this some seed centres now aim to make available larger quantities of seed of provenances already identified as of high potential for planting and with a wider genetic base than that needed for species elimination trials or provenance research.

Conclusions

The demand for seed of woody species for agroforestry is expected to rise as many projected programs are implemented. Project planners must consider seed supply during feasibility studies and if seed is required from other than local sources seed procurement should be initiated at least 1–2 years in advance of the nursery phase. Failure to allow adequate time for seed procurement can place the success of a planting program at considerable risk. The purchaser should seek seed of the best possible genetic quality and insist on adequate information on germination and seed origin from the supplier before buying. High quality seed may be expensive but the user can afford to pay a high price for it as the cost of seed in relation to overall project costs is very low and the consequences of using poor seed can be major and long term.

International donor agencies and governments must recognise that seed supply is crucial to the success of the tree planting projects they support. Contributions to further the activities of tree seed centres and sponsorship of special seed collection expeditions are legitimate and productive uses of their funds.

Dependence by users on external seed supplies ought to be reduced or eliminated at the earliest possible opportunity by the establishment of local seed production areas. Self-sufficiency in seed supply helps stabilise planting programs and in developing countries can save valuable foreign exchange.

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Appendix 1

Addresses of Suppliers of Seed for Agroforestry Projects

The following organisations will sell or exchange seeds of species used commonly in agroforestry projects in the tropics. Genera handled by each organisation are listed after the address. It is recognised that this list does not include all potential suppliers or all the genera each organisation can supply.

(a) Government-based suppliers

ASIA AND AUSTRALIA

Tree Seed Centre
CSIRO Division of Forest Research
P O Box 4008
CANBERRA 2600, AUSTRALIA
[*Acacia, Casuarina, Eucalyptus, Melaleuca*]

The Arboretum
Chinese Academy of Forestry
Wan Shou Shan
BEIJING, 100091
PEOPLES REPUBLIC OF CHINA
[*Acacia, Gmelina, Paulownia, Pinus, Populus, Ulmus*]

Forest Research Institute
P O New Forest
DEHRA DUN, U.P.
INDIA
[*Acacia, Albizia, Alnus, Cassia, Dalbergia, Gmelina, Pinus, Prosopis, Sesbania, Trema*]

Perum Perhutani
Forest State Corporation
Jalen Jendral Gatut Subrota
P O Box 111
JAKARTA
INDONESIA
[*Calliandra, Leucaena*]

National Seed Coordinating Centre
c/- Forest Research Institute
1 Matsunosato
Kukizaki-mura
Inashiki-gun, Ibaragi-ken
JAPAN
[*Alnus, Paulownia, Pinus, Prunus*]

Forest Research Institute
KEPONG, Selangor
MALAYSIA
[*Anthocephalus, Cassia, Casuarina*]

Forest Research Institute
PESHAWAR, N.W.F.P.
PAKISTAN
[*Acacia, Pinus, Prosopis, Sesbania*]

Office of Forests
P O Box 5055
BOROKO
PAPUA NEW GUINEA
[*Acacia, Araucaria, Casuarina, Eucalyptus*]

Forest Research Institute
College, LAGUNA 3720
PHILIPPINES
[*Casuarina, Derris, Gliricidia, Pinus, Syzygium, Trema*]

Royal Forest Department
Bangkhen
BANGKOK 9
THAILAND
[*Gmelina, Pinus, Tectona*]

AFRICA

Forest Department
P O Box 74
KIKUYU
KENYA
[*Acacia, Albizia, Bauhinia, Erythrina, Eucalyptus, Grevillea, Pinus*]

Forest Research Institute of Malawi
P O Box 270
ZOMBA
MALAWI
[*Colophospermum, Gmelina, Maesopsis, Pinus*]

Federal Department of Forest Research
P.M.B. 5054
IBADAN
NIGERIA
[*Acacia, Acrocarpus, Azadirachta, Gmelina, Maesopsis, Terminalia*]

Forestry Research Institute
P O Box 727
PRETORIA 0001
SOUTH AFRICA
[*Acacia, Eucalyptus*]

Service des Eaux, Forets et Chasses
Parc Forestier de Hann
B.P. 1831
DAKAR
SENEGAL

Arid Zone Forestry Research
Forestry Research Institute
P O Box 658
KHARTOUM
SUDAN
[*Acacia, Prosopis*]

Forest Division
Silviculture Research Institute
P O Box 95
LUSHOTO
TANZANIA
[*Acacia, Cassia, Cupressus, Eucalyptus, Grevillea, Pinus, Terminalia*]

National Forest Research Institute
Route de la Souka
B.P. 2
ARIANA
TUNISIA
[*Acacia, Pinus, Populus*]

Forest Research Centre
P O Box HG 595
Highlands
HARARE
ZIMBABWE
[*Eucalyptus, Pinus*]

EUROPE

Danida Forest Seed Centre
Krogerupvej 3A
DK 3050 HUMLEBAEK
DENMARK
[Indian and S.E. Asian species, *Gmelina, Pinus, Tectona*, Central American conifers]

Centre Technique Forestier Tropical
45 bis Avenue de la Belle Gabrielle
F-94130
NOGENT-SUR-MARNE
FRANCE
[African and Australasian species]

The Seed Unit
FAO Plant Production and Protection Division
Via delle Terme di Caracalla
00100 ROME
ITALY
[*Prosopis tamarugo*]

Instituto Sperimentale par la Selvicultura
I-52100 AREZZO
ITALY
[Mediterranean conifers, *Abies, Pinus, Cupressus*]

Commonwealth Forestry Institute
South Parks Road
OXFORD OX1-3RB
UNITED KINGDOM
[Mainly Central American species, *Acacia, Albizia, Enterolobium, Gliricidia, Leucaena, Mimosa, Pithecellobium, Parkinsonia, Pinus, Prosopis*]

SOUTH AND CENTRAL AMERICA

Forest Seeds Centre
National Forestry Corporation
Constitucion 291, Casilla 5
CHILLÁN
CHILE
[*Acacia, Caesalpinia, Geoffroea, Prosopis*]

Banco Nacional de Semillas
Institute for the Development of Renewable Resources
Avenida Caracas Nr. 25A66
BOGOTA
COLOMBIA
[*Alnus*]

Centro Internacional de Agricultura Tropical
Apartado Aereo 6713
CALI
COLOMBIA
[*Leucaena*]

Latin American Forest Seed Bank
Centro Agronomica Tropical de Investigacion y Ensenanza (CATIE)
TURRIALBA
COSTA RICA
[*Alnus, Cassia, Eucalyptus, Gliricidia, Grevillea, Guazuma, Terminalia* and other central American native species]

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Banco de Semillas
Centro de Investigaciones Forestales
Calle 174 No. 1723/17B, 17C
Siboney, Marianao
HABANA
CUBA
[*Pinus*]

Banco de Semillas Forestales
Instituto Nacional Forestal
7a Avda. 7–00, Zona 13
GUATEMALA CITY
GUATEMALA

Banco de Semillas Forestales
Escuela Nacional de Ciencias Forestales
Aptdo. 2
SIGUATEPEQUE, Comayagua
HONDURAS

Centro de Germoplasma Forestal
Instituto de Investigaciones Forestal
Av. Progreso, 5
COYOACAN 21, D.F.
MEXICO
[*Alnus, Parkinsonia, Pinus, Prosopis*]

Instituto Nacional Recursos Bioticos
XALOPA, Vera Cruz
MEXICO
[*Acacia, Erythrina, Inga, Leucaena*]

Banco Nacional de Semillas Forestales
Servicio Forestal y de Caza
Natalio Sanchez 220-Jesus Maria
LIMA
PERU
[*Acacia, Caesalpinia, Jacaranda, Prosopis, Tipuana*]

Instituto Forestal Latino-Americano
Apartado 36
MERIDA
VENEZUELA
[*Alnus, Pithecellobium*]

NORTH AMERICA

U.S. Forest Tree Seed Center
P O Box 819
MACON, Georgia 31298
U.S.A.
[*Alnus, Fraxinus, Juglans, Paulownia, Pinus, Prunus, Robinia*]

Caesar Kelberg Wildlife Res. Institute (P. Felker)
Texas Agricultural and Industrial University
KINGSVILLE, Tx. 78363
U.S.A.
[*Leucaena, Prosopis*]

College of Forestry (J. Hanover)
Michigan State University
EAST LANSING, Mich. 48824
U.S.A.
[*Alnus, Gleditsia, Robinia*]

Southern Regional Plant Introduction Station
EXPERIMENT, Georgia 30212
U.S.A.
[*Leucaena*]

Hawaii Foundation Seed Facility
University of Hawaii
3190 Maile Way
HONOLULU, Hawaii 96822
U.S.A.
[*Leucaena*]

(b) Private suppliers

The majority of private suppliers carry a wide range of stocks and can supply catalogues on request.

Australian Tropical Plant Supplies
Pinnacle Road
JULATTEN, Qld 4880
AUSTRALIA

Western Wildlife Supply
P O Box 90
GILGANDRA, NSW 2827
AUSTRALIA

A.J. Frost
Skovfröhandel
7080 BÖRKOP
DENMARK

Etablissements Versepuy
F. 43 000 LE PUY, Haute Loire
FRANCE

M/S Balkishen and Co.
106 Rajinder Nagar
DEHRA DUN, U.P.
INDIA

Florsilva Ansaloni
Casella Postale 2100
40100 BOLOGNA
ITALY

Sabah Softwoods Sdh Bhd.
P O Box 137
TAWAU, Sabah
MALAYSIA

Setropa Ltd.
P O Box 203
BUSSUM
NETHERLANDS

Timmers and Leyer
P O Box 17
2100 AA HEEMSTEDE
NETHERLANDS

Herbst Brothers Seedsmen
1000 N Main Street
BREWSTER, N.Y. 10509
U.S.A.

Hurov Tropical Seeds
1470 Alencastre Street
HONOLULU, Hawaii 96816
U.S.A.

International Forest Seed Company
P O Box 76008
BIRMINGHAM, Ala. 35223
U.S.A.

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PLANT HEALTH LEGISLATION AND FOREST TREES

A Supporting Document Prepared for
A Workshop to Discuss International
Cooperation with Regard to Multipurpose
Tree Germplasm

By

M.N. Ivory

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INTRODUCTION

Sooner or later many plant pests, which are now geographically restricted, may be expected to spread to all parts of the world where their host plants are widely grown (Gregory, 1979). Natural agencies, such as wind and water, can readily disseminate some pests over long distances as in the case of wheat stem rust spores which are known to travel every year in high-altitude air currents from Spain to the United Kingdom, and from Mexico and southern U.S.A. to Canada. However, most pests are dispersed much less readily by natural means, especially across large geographic barriers. These latter pests are much more likely to be spread by man and his actions, especially those involved in the course of international trade in plants and plant products.

Although dispersal of pests may eventually take place, the longer the process can be delayed, the better. Consequently, all governments have enacted legislation to protect their own important crop-plant species against the early introduction of alien pests. The first measures were introduced about 100 years ago for a few crop species, such as the grapevine and the potato, but most of the acts and conventions embodying these measures have now been incorporated in, or superseded by, more general plant health legislation.

PLANT HEALTH MEASURES IN PRINCIPLE AND IN PRACTICE

Plant health legislation, whether on a local, national, or an international level, is drawn up to control the movement of plant materials, together with associated containers, packing and transportation equipment, and thus the pests contained within or attached to them (Kahn, 1977). The measures they embody can only be applied successfully to pests whose dispersal by natural means is slow or otherwise limited.

Forest trees are treated like agricultural or horticultural plants for plant health purposes. However, timber can present particular problems because of the large size of commercial consignments (Phillips, 1979).

Effective measures must take into account two main considerations as follows (Phillips, 1980):

(a) Scientific and Technical Considerations

These require assessments of the threat posed by each pest organism, assessments of the pattern of trade in terms of the quantities and the types of plant material transferred, and investigations of the various transfer procedures involved. These studies should indicate the presence of any weak link in the dispersal mechanism, or life cycle, of the pest which may enable effective controls to be implemented.

(b) Administrative and Organizational Consideration.

These require the determination of the degree of risk acceptable, and thus the stringency of the restrictions needed, and also the limitations imposed by the volume of trade needs (i.e. U.K. imports are 80-90% of its total requirements). These must then be balanced against the constraints imposed by the financial and manpower resources available to implement the legislation effectively.

Historically, national attitudes to plant quarantine and plant health legislation have ranged from a completely open-door policy to very restrictive policies, with most countries having some rigid legal restrictions which were established with little regard to their validity or effectiveness (Mathys, 1977b). In many cases these regulations also prevented international trade in non-target crop species for no good reason. Since 1940 it has been generally recognized that plant health legislation can only be effective if introduced in a uniform and cooperative manner within the various biogeographical regions of the world. At the same time it has been appreciated that such legislation should not be used as a covert tariff barrier to interfere unduly with international commerce and trade in plant materials. During this latter period various international and regional organizations have been established which have resulted in implementation of more logical legislation in many parts of the world. Regulations controlling the movement of forest tree materials between regions, or countries, usually contain a prohibition of plants with attached soil, and require all vegetative materials to be introduced through quarantine stations, or following inspection and treatment with pesticides (Ivory, 1980). Regulations for the latter materials may entail any of the following (Kahn, 1977):

(a) Specific prohibition;
(b) Specific prohibition with exceptions for scientific purposes;
(c) Quarantine procedures required;
(d) Treatment on arrival;
(e) Inspection on arrival;
(f) Permit required;
(g) Phytosanitary certificate and/or certificate of origin required;
(h) Various treatments and inspection before dispatch;
(i) Restrictions on the size and type of material involved.

Tree seed can usually be imported without difficulty following inspection and treatment with pesticides, although some countries impose more stringent restrictions against specified pests, or against imports from certain parts of the world.

Very few adequate quarantine stations exist for screening plant materials and, therefore, transfers are usually carried out between national plant quarantine services relying on inspection procedures and pesticide treatments. These measures, or their implementation, are often inadequate to detect many pests in vegetative or seed materials (Berg, 1977 b; Neergaard, 1977). In some cases, intermediate quarantine in a third country may be carried out when the risk is considered too great for the work to be done in the importing country, as in the case of rubber tree imports to Malaysia and the South American leaf-blight fungus Dothidella ulei.

All these measures are aimed primarily at commercial imports of relatively large quantities of plant materials. Small quantities for scientific purposes can usually be imported for most countries make exceptions in their legislation when adequate safeguards can be made (Kahn, 1977). Such transfers can, however, pose a very serious threat as they often occur between countries not normally involved in commercial transfer of similar plant species (Mathys, 1977b). These risks are often not

fully appreciated by the scientists involved, who not infrequently ignore or circumvent the regulations (Kahn, 1977). Each national plant health authority will assess the potential risks and benefits involved with each importation for scientific purposes and will then impose whatever conditions and restrictions that it sees fit on the materials involved (Kahn, 1977). Obviously small consignments of low-risk materials can be treated and inspected much more thoroughly than large consignments (Neergaard, 1977) and are thus more likely to be permitted.

Tissue cultures are very suitable in this regard because of their small size and in-built pest-detection systems (Kahn, 1979). However, all cultures are not pathogen-free (Kahn, 1979), so most countries still regulate such germ plasm imports (Kahn, 1977), and even, in a few cases, impose a total prohibition as with the coconut (Kahn, 1978). A major disadvantage of tissue culture is that the technique requires suitable sterile culture facilities at both ends of the transfer.

THE INTERNATIONAL PLANT PROTECTION CONVENTION (IPPC)

The IPPC was established in 1951 under Article 14 of the constitution of the Food and Agriculture Organization of the United Nations (FAO) and has now been ratified by about 80 countries. It aims to strengthen international efforts to combat important plant pests, and to limit their spread across international borders (Chock, 1979).

Each signatory to the Convention has the following obligations:

1. To set up an official plant protection organization which will (a) carry out inspections, and possible disinfection treatments, of plants and plant products for export and import; (b) issue phytosanitary certificates; (c) report pest outbreaks; (d) carry out research and advice on plant protection matters; and (e) publish and distribute plant health regulations. These national organizations presently vary in size from 1 to 1,500 people.

2. To cooperate in establishing regional organizations to promote and coordinate plant protection activities.

3. To formulate plant health legislation against pests which pose a likely threat to crop-plants judged on the basis of sound scientific evidence only, and not to impose restrictions which aim primarily to prevent or inhibit trade in particular commodities. Restrictions on the latter basis would also infringe other international agreements, such as the General Agreement on Tariffs and Trade (GATT).

Before the inception of the IPCC, phytosanitary certificates existed in a multitude of forms and had a multiplicity of requirements. These requirements were standardized in the Model Phytosanitary Certificate (MPC) drawn up by the IPPC in 1951. Essentially similar forms have been in use worldwide since that time, although several amendments to the MPC have been proposed since then to try to take into account the practical limitations imposed by trade and inspection procedures. Its value depends on the technical competence and integrity of the issuing authorities, and the effectiveness of the procedures in detecting and preventing the spread of any particular pest.

REGIONAL PLANT PROTECTION ORGANIZATIONS

Most countries of the world belong to one or more regional plant protection organizations, which operate mainly within the guidelines established by the IPPC. Eight such regional organizations now exist covering the areas shown in Figure 1 (Smith, 1979). Some are independent inter-governmental organizations, such as the European and Mediterranean Plant Protection Organization (EPPO), and some were set up by, and are now overseen by, FAO. Some overlapping of regions occurs because some countries, especially those with a wide range of climates, share trade and similar plant protection problems with countries from more than one region.

1. The European and Mediterranean Plant Protection Organization (EPPO)

EPPO is an independent inter-governmental organization which was established from the International Committee for the Control of Colorado Beetle and the European Working Party on Infestation Control about six months before the IPPC was convened. It is thus the oldest of the eight regional organizations. Since its inception it has expanded and now consists of 35 countries in Europe, North Africa, and West Asia.

Its principal functions, besides furthering the aims of the IPPC, are (a) to advise and assist member governments on the technical, administrative and legislative measures necessary to prevent the introduction and spread of pests of plants and plant products; (b) to disseminate information on important developments in the plant protection field; and (c) to study the possibility of simplification and unification of phytosanitary regulations and certificates (Smith, 1979).

EPPO has a small secretariat in Paris, but operates mainly through technical working parties of experienced specialists, or open conferences and colloquia on topics of current interest (Mathys, 1977). Conference recommendations may be passed to the Council for approval after evaluation by interested working parties, and possible consultation with member countries. The secretariat also acts as a centralized reporting service for incoming and outgoing information.

The Working Party on Phytosanitary Regulations is the oldest and most import, and is the one most concerned with the health of all crop plants. Phytosanitary regulations in forestry and special forestry problems are also considered by two smaller Working Parties. For 20 years the Working Party on Phytosanitary regulations concentrated its attention on rules relating to a few high-risk pests which were already established in part of the EPPO region. Since then, however, it has attempted to harmonize the regulations of the region by establishing its own lists of dangerous quarantine organisms. The general principles behind these lists are as follows:

(a) Regulations should relate as far as possible to specified pest organisms.

(b) Regulations should have a firm scientific basis.

(c) A common strategy should be applied within EPPO against external pests.

(d) Regulations should interfer as little as possible with trade in plant materials, and free movement of people.

(e) Explicit requirements for imports should be widely promulgated.

(f) Pests selected should be considered to be capable of surviving in the open under glass in the EPPO region, and be liable to cause major damage to an important crop species. They must also be likely to be spread by trade, and not likely to spread rapidly by natural means.

(g) The aim should be for zero tolerance for the most dangerous quarantine organisms on the 'A' list, with less stringent requirements for less dangerous organisms (category B). Specific quarantine requirements for organisms on these lists are presently being published by EPPO.

The A1 category contains many exotic forest pests, such as Ceratocystis fagacearum (Oak wilt fungus) and Hylurgopinus rufipes (N. American elm beetle), and larger groupings, such as the non-European Conifer rusts and weevils. The A2 category of pests already present in part of the EPPO region, contains fewer specified forest pests, such as the Dutch Elm disease fungus Ophiostoma ulmi. Member countries must impose stringent quarantine requirements against 'A' listed organisms unless the disease is already widespread in that country.

The B category organisms are considered to be less likely to pose a serious threat to crop yield either because (a) they affect crop quality only; or (b) they are already widespread; or (c) they are poorly adapted to local conditions; or (d) they are easy to control. The EPPO Working Party decided not to draw up a list of 'B' organisms, but left it to each member country, or group of countries, such as the Scandinavian block and the European Economic Community.

2. Other regional plant protection organizations

Three regional organizations were founded as statutory bodies of the FAO and are supported financially by the UNDP. These are the Plant Protection Committee for the South East Asia and Pacific Region (SEAPPC) (Reddy, 1977), the Near East Plant Protection Commission (NEPPC), and the Caribbean Plant Protection Commission (CPPC), (Berg, 1977). The 4 remaining regional organizations are independent intergovernmental bodies which cooperate closely with the FAO. These are The Organismo Internacional Regional de Sanidad Agropecuari (OIRSA) in Central America (Berg, 1977); The Interafrican Phytosanitary Council (IAPSC) for all member countries of the Organization of African Unity (Addoh, 1977); the Comite Interamericano de Proteccion Agricola (CIPA) for most of South America; and the North American Plant Protection Organization (NAPPO) for all of North America (Rohwer, 1979). Financial support for these organizations comes either from member countries or from international agencies (Berg, 1977).

All the above regional organizations have similar aims and objectives to EPPO; however, they function in different ways reflecting their different problems, circumstances and structures.

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NATIONAL PLANT PROTECTION AUTHORITIES

Most countries have established their own plant protection authority to implement and administer the plant health legislation enacted by their own government. The legislation usually embodies the minimum standards of regional measures recommended by the particular regional plant protection organization against pests which do not occur within the region, and national measures, as permitted by the Regional Organization, against pests which occur elsewhere in the region, but not in all, or part, of the country concerned. In addition, local measures may also be introduced to prevent the spread of a pest from one part of a country to another.

The situation can be further complicated in countries which are governed as federations, such as the United States of America and the Commonwealth of Australia, where legislation is enacted and implemented by both federal and state governments. For example the Federal Plant Quarantine Act in Australia (Morschel, 1979) covers all plant materials, and includes all recognized forest tree species, and related species, such as the following genera: Abies, Cupressus, Juniperus, Larix, Pinus and Populus. Vegetative materials are considered to pose the greatest risk and are therefore more severely restricted than seeds, for which inspection and treatment on arrival may be the only restrictions imposed. Tissue cultures are usually quarantined to detect viruses and other labile systemic pests.

Similarly the member countries of the European Community must incorporate the E.E.C. Plant Health Directive as the basis of their own legislation (Phillips, 1980). This covers all tree material in one way or another, irrespective of the intended purpose of each importation. Conifers and broadleaved trees are all restricted in general terms, but some specified genera including the following forest-tree genera are restricted in greater detail: Abies, Castanea, Larix, Picea, Pinus, Pseudotsuga, Quercus, Tsuga and Ulmus (Phillips, 1979).

Thus, although the legal requirements governing the international movement of plant materials are enacted and enforced at a national or state level, they show considerable uniformity now that most countries are signatories to the IUPPC and its constituent regional organizations, which set minimum standards and guidelines for the regulations.

Scientists, or commercial interests, involved in the international exchange of plant germplasm should be fully aware of the plant health regulations of the importing country which relate to the type and origin of the plant material involved. Except in the rare cases in which export restrictions apply, the above regulations are the only factors which determine the permissibility of any importation. Details of the regulations can be obtained from the quarantine service of the importing country, or from the quarantine service of the exporting country which will often be required to issue a phytosanitary certificate for each transfer.

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NGOS and AGROFORESTRY
TREE SEED SUPPLY IN KENYA
A CASE REVIEW

A Supporting Document Prepared for
A Workshop to Discuss International
Cooperation with Regard to Multipurpose Tree
Germplasm

By

Louise E. Buck

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Baobab Farms
NCWK
Maendeleo ya Wanawake
Digoi Women Group
Diocese of Maseno
East African Yearly Meeting of Friends
Action-Aid, Kenya
BAT, Ltd.,
ICRAF
Mennonite Central Committee
KENGO

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INTRODUCTION

During the past three years agroforestry has been elevated, in Kenya, from a relatively unknown concept shared by a handful of unconventional scientists to a popular idea which has caught the imagination of policy makers, development specialists and donor agencies who, together, represent a variety of pertinant interests and objectives. Several prominent developments have contributed to this transformation.

First, the Beijer Institute's national level study on Kenya's energy supply and demand balance, undertaken in association with the Ministry of Energy, concluded that agroforestry has a potentially significant role to play as a mitigation strategy for overcoming an identified shortfall in woodfuel supply (1,2). Second, a 10-day, national level seminar on agroforestry sponsored jointly by ICRAF and the University of Nairobi attracted over 60 papers pertinant to the subject which were compiled into a single volume and circulated to relevant government ministries, educational institutions and non-government organizations (3). Third, Nairobi's hosting of the U.N. Conference on New and Renewable Sources of Energy and the associated NGO Forum directed attention locally to agroforestry as a renewable energy strategy appropriate for Kenya and other developing countries (4).

In addition, three independent directives have been issued by Kenya's President Daniel arap Moi, all of which prescribe or allude to agroforestry as a promising method of executing his will. First, citizens were directed to eliminate soil erosion problems by practicing conservation measures; second, to make the country more productive in food by intensifying agriculture and better developing marginal lands; and third, to plant 2 Million tree seedlings per year to reduce the negative effects of deforestation.

Accompanying these and other national highlights has been a surge in the initiation of agroforestry project activity. At least four different ministries; Environment and Natural Resources (MENR) (5), Agriculture (MOA) (6), Energy (MOE) (7) and Livestock Development (MOLD) (8) are responsible for programs or projects which incorporate multi-purpose tree planting components. Although rationales for the various activities differ, orientation towards farmer involvement in the conscious raising of tree, a function traditionally reserved for foresters, is shared.

Of particular significance regarding the current intrigue with agroforestry is the generally positive view held towards it by Kenya's Forest Department itself. Gradually it is coming to recognize value in diversifying its approach in order to meet growing demand for non-timber tree products and services. Not incidentally, the Department is to take the lead in executing President Moi's directive to vastly escalate seedling production. To comply, it has contemplated all possible implementation channels and calculates that on-farm tree production is the most cost-effective means (9).

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At present the Department's "rural tree development" idea is new, and not yet adopted as official policy. Thus, the organization remains ill-equiped to play a strong role in guiding the concept into action. It does, however, "encourage" local initiatives in this regard, providing what limited technical and material assistance it can, and liases with other agroforestry implementing ministries as it make plans for stepping more firmly into a position of active leadership.

Non-government organizations have probably played the most significant role thus far in promoting tree-planting through actual on-the-ground activity. Responding usually to grass-roots pressure to engage in "relevant" development activity, NGOs are perhaps closer to the pulse of the movement, in many respects, than any government body. The positive will of the farmer is imperative to success of the movement and to date NGOs have made the most obvious advances in tapping it. Further, it is clear by examining agroforestry program plans of various government and government-assisting bodies that NGOs are valued as conduits for information and sentiment on behalf of the communities which the projects seek to serve, and also through which to implement project activities (10,11,12). It is within this context of rapidly and horizontally expanding interest in community level, or on-farm, multipurpose tree planting (i.e. agroforestry) that the issue of tree seed is explored, as it pertains to NGOs.

The element of Kenya's NGO community which concerns itself with issues of energy, environment and development is first briefly described and the types of organizations active in tree planting identified. Following this is a synopsis of relevant aspects of the national seed supply problem in Kenya, including some of the issues raised through debate on potential solutions. NGOs actively involved in seed procurement are then isolated and a brief review of the strategies employed is presented. From the foregoing some problems are highlighted and general conclusions drawn. These are followed by recommendations as to how the NGO community might proceed in addressing them.

NGOs IN AGROFORESTRY

How Many?

NGOs actively involved in tree planting in Kenya are numerous. A 1982 directory produced by the U.N. sponsored Environment Liaison Centre (ELC) lists 21 NGOs definately active, along with another 64 organizations most likely involved in tree planting and/or other aspects of renewable energy development (13). Of the 64, it has been confirmed that at least 25 of them do sponsor tree planting programs. Of the 46 confirmed tree-planting NGOs listed at least 20 are also engaged in raising seedlings in nurseries (14). It is these 20, then, and others like them, who constitute the principle subject of concern. Although the above figures attest to

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relatively significant level of activity, particularly in comparison with corresponding NGO performance in 38 other African countries listed in the directory, they do not reveal its real extent. NGOs do not themselves constitute an organized body amenable to ready monitoring.

As a disparate and basically uncoordinated group of organizations, who may share little except their non-government status, it is difficult, first, to obtain even a comprehensive listing, of who they are. Secondly, even upon identification by name, reliable information about their activities is often unavailable. In many cases regional or local level offices of a national organization, for example, are under no obligation to report to headquarters the specific nature of their activities. Or if reports are made, they are not compiled and distributed. Furthermore, there are a vast number of community-level groups in Kenya who are rightly classified as NGOs, but who are not formally affiliated with an umbrella organization.

For these reasons directory listings, or even a particularly well-tuned ear placed in Nairobi, do not provide realistic indications of on-going tree-planting activity in Kenya. This phenomena has been confirmed in many instances by researchers or program planners who have taken to "the field" in search of information or project target areas and found surprising levels of "unreported" interest and/or activity in tree planting in progress already.

Who Are They?

Churches, women's groups, schools and youth clubs are the organizations primarily responsible for non-government sponsored tree planting in Kenya. In addition, certain research organizations are involved, as well as a number of community service and commercial organizations.

Churches

Upon appearance, church groups are responsible for the most ambitious community-level tree planting and related projects undertaken in Kenya to date. Geographically, the extent of their activities include each of Kenya's eight provinces.

The Catholic church sponsors a number of tree-planting projects, each under the auspices of one of the regional level dioceses located throughout the country. The coordinating body for the Dioceses, the Kenya Catholic Secretariat, operates the programme through which these projects are sponsored. However, it does not actively coordinate the flow of information or inputs among them. Rather, each is essentially an autonomous unit.

Protestant churches, also, are widespread throughout the country and most of them are members of an umbrella organization, the National Christian Council of Kenya (NCCK). Although tree-planting projects are known to be sponsored through a number of individual churches, the NCCK itself, through its Nairobi headquarters, has taken a prominent role in coordinating these activities, particularly regarding the provision of certain fundamental inputs. The focus of NCCK's tree-planting activities has been in Kenya's northern dry areas, populated by pastoralists.

Other churches or church-sponsored organizations which feature on the rosters of tree-planters in Kenya include Salvation Army, Church Army in Eastern Africa, E.A. Yearly Meeting of Friends, Kenya YWCA and YMCA, Partnership for Productivity, World Muslim Congress, Institute for Cultural Affairs, Kenya Baha'i Community, African Inland Church, Mennonite Central Committee, World Neighbours and World Vision International. There may well be others. Together these represent substantial variation with regard to geographic scope, intensity of input and duration of project activity to date. Many are committed to an integrated approach to development which may feature tree-planting as part of a larger objective. Accordingly, churches are likely to posess the type of long term committment to a community which benefits successful tree establishment.

Women's Groups

Women's groups are viewed by many agroforestry development enthusiasts as the cauldron of vast untapped potential for implementing community level projects and for promoting adoption of agroforestry techniques at the household level. To date, however, the hypotheses that women will rally to the cause to supply labour on the scale projected remains unproven.

There are examples of women's groups who have undertaken promising tree planting projects. The most notorius of these is the so-called "greenbelt movement" instituted under the auspices of a national coordinating organization known as the National Council of Women of Kenya (NCWK).

NCWK's member groups have participated since 1977 in the greenbelt programme and, more recently, in its nursery development component. It has been with the expectation, though, of personal financial compensation. Thus, this program does not provide a good indicator of local women's groups' committment to raise trees for their own intrinsic value.

Within the past year Kenya's other national coordinating body for women's groups, Maendeleo ya Wanawake, initiated a different type of program to assist local groups with tree planting. Its emphasis is on material and technical inputs for nursery development and there is no provision for buying back the seedlings, once produced. They return instead to the women directly involved in production. Any financial assistance provided must be invested by the group directly into the nursery. It remains to be seen what the participants' response to this program shall be.

It is uncommon to find a rural women's group involved in raising trees who is not affiliated with either a church or one of the two umbrella organizations identified above, responsible for sponsoring the project. In the case of church - affiliated women's groups the fruit of the women's labour is generally owed to the church. Thus, in considering the role of its women in tree planting it is not very useful to think in terms of dealing with such groups directly, but rather with the church itself. The underlying question to be answered in consideration of any women groups' interest is whether or not the opportunity cost of the labour input is worth the return vis-a-vis its competing demands.

Schools

Schools appear to hold much greater potential as caretakers of trees than do womens' groups, at least for the time being. Already there are numerous examples of schools across the country who are in the process of transforming their compounds into "forests". To date a school's involvement in raising trees has been largely dependent upon initiative taken by the headmaster himself. There has been no national mandate that schools must raise trees, although the idea is under consideration. At the very least it can be expected that schools will be "encouraged" increasingly, not only to plant seedlings provided by the Forest Department but, where water is available, to raise seedlings as well.

Youth Clubs

Youth clubs are normally affiliated with either a church or with schools. Those involved in tree planting include Boys Brigade, Boy Scouts, Girl Guides, [illegible], Young Farmers and Wildlife Clubs of Kenya (WCK). Each of these clubs is headquartered in Nairobi from where general program direction is provided and the channeling of resources to the various member clubs facilitated.

Until now tree projects undertaken by the clubs under the supervision of a local teacher/sponsor have consisted primarily of planting and caring for trees provided by the Forest Department. Interest in establishing nurseries of their own is beginning to develop, however, and there are several in operation already. As with direct school-hosted initiatives, interest and committment is mainly dependent upon the sponsor/leader of each individual club. Thus, although potentially a very promising resource, actual performance remains to be assessed.

Other NGOs

Research organizations known to be involved in tree planting include University and College departments, as well as several independent institutions (15). The programs of such organizations are highly specific. Commercial interests involved in multipurpose tree planting include BAT, Ltd., and Baobab Farms Ltd. These, too, have relatively specific purposes, subject to discussion in the following section.

Additional Kenya-based NGOs likely to become involved in sponsoring or hosting tree planting programs include agricultural product cooperative societies and farmers' unions. Community service groups are also active. The Jaycee's and Men of Trees are two who have already undertaken substantial projects. Relief and community assistance organizations such as Action Aid-Kenya, Oxfam, and CARE-Kenya are involved as well, normally as sponsors of NGOs operating locally.

In summary, it is a potentially vast and obviously expanding community of non-government organizations who are interested and well suited to respond to the call to raise trees, whether they hear it from President Moi himself or from another, more private, messenger. Although many projects are in their infancy, interest is high among a number of national level organizations in expanding their programs geographically

to involve many times the present number of local groups in tree raising.

How Are They Heard?

NGOs relate to government at their respective levels of operation. Groups working at the community level, for example, are in contact with local chiefs. Regional branches relate to District officials about their program activities through District Development Committees (DDC) or a Ministry with whom the NGO may be affiliated. NGOs are registered at the National level, some being associated with a particular ministry while others are not. Churches, for example, operate independently. Women's groups and youth clubs are registered with the Ministry of Culture and Social Services. Additional ministries with whom tree-planting NGOs are associated include both Basic and Higher Education, Foreign Affairs, Commerce, and Tourism, and Wildlife. The NGO resource is thus widely distributed throughout the system, but only loosely controlled by governmental institutions. There is no official mechanism for coordination among those with similar programme orientations.

In anticipation of the Nairobi-held U.N. Conference on New and Renewable Sources of Energy and the associated NGO Forum in 1981, about 30 Kenyan NGOs organized as a coalition in order to speak as a unified voice and to promote renewable energy ideas and projects. Now one and half years old, KENGO publishes a periodic newsletter and employs two full time staff members to work on behalf of its constituent organizations. In general its purpose now is to act as an information exchange and to develop and promote renewable energy development or conservation project ideas for funding.

Among the specific activity areas upon which KENGO is currently focussing is the provision of tree seed and seedlings to NGOs, sponsorship of training workshops on tree planting and agroforestry, and publication of educational material on tree planting (16). An approach to these has been to pair government and NGO resources with the objective of mutual reinforcement of their various respective goals and activities. Thus, KENGO plays a valuable role in attempting to Create new cross-cutting linkages among ministerial bodies and NGOs who until now have had little connection.

THE SEED PROBLEM

Any of the NGOs identified above who have or intend to engage in nursery establishment require tree seed. Most who have considered raising seedlings have come to recognise that seed of environmentally suitable species which promise to meet the use specifications of project participants/beneficiaries is an essential input, but not easy to obtain.

The multipurpose tree seed shortage in Kenya is a well-cited problem (17,18). The essence of it is that the agroforestry or tree planting "movement" has outpaced the country's established tree seed handling institutions in their capacity to respond. Even seed of the Forest Department's plantation species is not plentiful enough to meet demand from the Department itself for its Rural Afforestation Extension Scheme (RAES) program. Distribution priority remains with the Department's traditional timber-oriented plantation program.

More specifically, neither the Forestry Division of the Kenya Agricultural Research Institute (KARI) in charge of seed procurement and processing, nor the Forest Department who assists KARI with collection and distribution, is sufficiently staffed or otherwise equipped to meet the surge in seed demand (19,20). For these institutions the situation is made more difficult by the sudden demand for species with which they had little, if any, experience. Particularly troublesome is the mushrooming interest in useful species adaptable in marginal and dryland areas. With these, Kenyan foresters have only recently begun to develop familiarity. Disappointment with species choice available through the Forest Department is commonly expressed among multipurpose tree planting enthusiasts.

Seed importation by these institutions is not a viable option either. Severe limitations on foreign exchange combined with lengthy lead times in placing an order through the necessary bureaucratic channels limit the attraction. In addition to the expense of imported seed, KARI also finds it to be of unreliable and often marginal quality, particularly with respect to viability (21).

During the past year a German Agency for Technical Cooperation (GTZ) mission visited Kenya to assess the need for donor assistance with its tree seed problem. External focus on the topic helped to illuminate the nature of the problem and raised some controversy about the best strategies for addressing it.

At the heart of the seed supply issue lies the question, where should institutional responsibility rest and how should ancillary organizations relate to the key agency? Related to this is the fundamental issue of seed quality control. The concern is that efforts by the institution concerned with and assigned to safeguard certain standards regarding collection, treatment, storage, distribution and propagation of seed may be negated by the unsupervised activities of another, or by individuals. It is already a fact that a number of government, as well as non-government organizations, who until recently have had nothing to do with seed have become directly involved in using and supplying it.

The search for answers to these questions in turn raises other issues. For example, should an expanded seed processing and holding facility be developed centrally, or on a decentralized basis to take advantage of agro-climatic variation in an expedient manner? What level of technological input is appropriate? How seriously should prospects for expansion into commercialization for seed exportation be considered given the level of technical and managerial input required to ensure sustained quality control? (22).

As answers to such questions are debated and plans drafted which, when implemented, would lead to an eventual easing of the shortfall, the local tree-planting movement rages. What then, is being done at present to facilitate the supply of the desired seed?

NGO SEED SUPPLY STRATEGIES

NGOs are presented with basically five choices for obtaining seed for their tree-raising projects. First, they may use official Forest Department channels. This involves ordering seed through Department Headquarters who either supplies it directly or forwards the request to KARI. KARI then supplies the seed if available, or places the order on a list of requests for collection.

As a second option NGOs may approach the Forest Department at District level through the District Forest Officers (DFOs). Depending upon the disposition of the particular officer and whether or not he has personnel and transportation resources available he may engage his staff to collect the desired seed. It is possible, also, that the seed required is already in stock, in which case it might be sold or traded directly with the requesting organization.

A third possibility is to seek seed from on-going projects, government and non-government, who may be willing to sell, trade or give it away, usually in minor quantities. Fourthly, an NGO might import seed from foreign sources provided it has a source of foreign exchange. And as a final option it may organize to collect its own.

Each of these methods is presently in operation. Different NGOs place varying emphasis upon the respective approaches depending upon the nature of their working relationship with the Forest Department as well as the technical and financial resources they have available. Following is a description of the strategies known to be employed by some of the key NGOs presently involved in nursery establishment and seed procurement. The discussion is not inclusive of organizations involved in nursery development, but does present essentially the range of strategies used by NGOs to obtain seed.

NCCK, Nairobi

NCCK as an umbrella organization for protestant churches operating in Kenya, began promoting tree establishment in the country's northern dry areas about 10 years ago. In 1977 it initiated a seed distribution program through which it obtained and redistributed seed on behalf of about 30 tree-planting organizations (23). These were not limited to Protestant churches, but included other churches, Forest Department and Ministry of Agriculture recipients as well.

The majority of the approximately 30 species obtained by NCCK in its peak year of operation, 1979-1980, came from three relatively large and well-established non-government organization programs. Some was obtained also through KARI and through smaller scale church-sponsored projects. The latter of these in turn obtained its seed by church-sponsored collections from locally growing trees.

NCCK's program has fallen into a state of relative inactivity since its originator/coordinator, a Canadian forester, left Kenya in 1981. However, NCCK continues to facilitate some seed trading among its own members.

While fully operational NCCK did not charge for the seed it distributed. Individual organizations who participated in the program may or may not have compensated their own members for collected seed, depending upon the particular relationships involved. NCCK provided the distribution function as a free service to encourage tree planting, particularly among its own member organizations. Normally, information provided on seed origin included only the general location of the project group responsible for collecting it.

Kositei Catholic Mission's - East Pokot Agricultural Project - Nginyang

(Mr. Edmund Barrow) via Nakuru

Among NGOs involved in tree-planting the Kositei Mission at East Pokot (Baringo) has established probably the most notoriously creative and successful project of its kind. For the past seven years Mr. Barrow has engaged in grass-roots level range rehabilitation efforts in a manner which has convinced local residents and, subsequently, project planners of similar inclination throughout the country.

Seedlings and subsequent planting trials have been established for over 30 different tree and shrub species potentially suitable for marginal to dry areas, without irrigation. Mr. Barrow's tree seed sources have included NCCK, through its distribution program described above; KARI; Baobab Farms Ltd., (described below); an F.A.O. forage project in Kitale associated with Ministry of Livestock Development; an F.A.O. dryland research project in Machakos associated with the Ministry of Agriculture; and the Ben Gurion University of the Negev in Israel. The latter source has provided seed of several exotic dry area species which have reached seed bearing stage at Kositei. This seed in turn has been made available to numerous other organizations through NCCK's distribution program (24).

Mr. Barrow now harvests seed from stands established under his supervision, and also sponsors seed collection of certain local species. In cases where substantial amounts of labour are required collectors are paid and the seed is sold. In many cases though, Mr. Barrow makes small quantities of seed available to other projects on an informal basis free of charge, or preferably, for trade. Mr. Barrow himself is familiar with the origin of seed collected under his supervision and is able to so inform any requesting party. However, no documentation is provided with the seed itself.

Baobab Farms Ltd., - Mombasa (Rene de Haller)

Baobab Farms, located at Bamburi Cement Factory on the Kenya Coast, produces seed on a commercial basis of eight species well-suited for agroforestry (25). Stands of each species, including both exotic and indigenous varieties, have been established at Bamburi as part of an ambitious and successful land rehabilitation program initiated nine years ago by Mr. de Haller. It is unknown by the writer from where the original seed of the exotic and non-coastal species was obtained. However, for indigenous coastal species seed was collected locally under the supervision of Mr. de Haller.

For his small-scale commercial seed operation Mr. de Haller uses Baobab Farms' hired labour for collection, cleaning and packaging. For species which loose viability quickly only quantities saleble that season are harvested. Because of the continuity in project management so far, it can be presumed that seed origins can be traced from Mr. de Haller. However, provenance information is not routinely provided with the purchased seed.

NCWK (National Council of Women of Kenya), Nairobi

The NCWK has to date sponsored approximately 50 tree nurseries through assistance to local women's groups. Seed for these is provided almost entirely through the Kenya Forest Department. Through a working agreement between the two organizations, NCWK purchases the seed either from Headquarters in Nairobi or directly from District Forest Officers(DFO). As some DFOs have agreed to provide technical assistance to the NCWK program as well, seed is commonly obtained directly through this channel (26).

The vast majority of NCWK nurseries are located in Kenya's medium to high potential areas. Thus, the species available from the Forest Department are generally appropriate for these sites with regard to environmental suitability. Most, however, are not considered to be particularly useful multipurpose species for integration into agroforestry systems.

Maendeleo Ya Wanawake, Nairobi

This organization's tree nursery program is very new and thus its record on seed procurement is short. Its basic strategy is to have seed collected locally by the women's groups whom Maendeleo assists in nursery development, under the supervision of District Foresters. It is intended that each group shall collect only the amount it needs, with any surplus either going to the Department or to another member group. Although no individual is compensated directly, Maendeleo will probably purchase collected seed from the various groups for distribution among its members with the stipulation that proceeds be "invested" in the tree projects. It is too early to tell whether provenance documentation by the groups will feature as part of this program, or how distribution will be organized (27).

Digoi Women Group, Maragoli

This local women's group has demonstrated over several seasons a committment to raise tree seedlings through provision of its own uncompensated labour, except for entitlment to the trees. Leucaena is the tree of major interest, for which seed is procured by the women from a near-by two year old seed stand. It is unknown by the writer who is responsible for the original stand, but it is presently claimed by the women's group (28).

Diocese of Maseno South, Kisumu

This Diocese provides a good example of an NGO working closely with the District Forest Department in its area with respect to both technical advice and seed acquisition. During the past year Department officers have assisted volunteer members of the Diocese to select and collect seed of various locally-growing species. However, there are approximately 180 groups within the Diocese who have been directed to plant trees and collect seed, and so direct supervision is not possible. Seed is shared among groups, but as far as is known is not accompanied by documentation (29).

East Africa Yearly Meeting of Friends, Tiriki

This group is another example of an NGO who has undertaken nursery activities within the past year through the provision of its own uncompensated labour. The group collects its own seed from locally growing species, apparently unassisted by the Forest Department (30).

BAT Ltd., Nairobi

BAT, (British-American Tobacco), has operated tree nurseries for the past 3-4 years which produce seedlings for the company's tobacco - growing farmers. Within the past two years the company has sought to diversify to include species other than Eucalyptus. It has since then purchased seed from foreign suppliers and has engaged in local seed collection under the supervision of its own hired foresters. It is also interested in trading seed with other multipurpose tree nursery projects. Seed exchange by such informal means are not accompanied by any documentation on provenence and do not appear to be recorded by BAT nursery supervisors (31).

ICRAF, Nairobi

ICRAF is an international organization with headquarters in Nairobi, so is not therefore a legitimate Kenya NGO. However, through its one-year Kenya Seed Project, completed in December 1982, it coordinated the efforts of several Kenyan NGOs to examine aspects of seed availability in Kenya (32). It also assisted in procuring seed for Mazingira Institute, a research NGO for whom ICRAF is also providing technical assistance in community level agroforestry demonstration plot design (33).

Seed procurement strategies used by ICRAF, through is NGO secondees to the project, included importation from foreign commercial suppliers; purchase or trade with ongoing agroforestry projects, both government and non-government; and community seed collections supervised by ICRAF's Kenyan forestry field technician.

Attempts were made through the project to document tree seed provenance information as fully as possible. It was often difficult, however. Foreign commercial suppliers normally provided information on the country of origin only. Information from other projects in Kenya required tracing, as seed was virtually never accompanied by provenance information. It was found that local seed collection efforts sponsored through certain government programs required and provided no documentation on seed provenance. ICRAF's project-supervised local collections were documented as thoroughly as feasible given the limitations of local circumstances and level of understanding. (34).

Mennonite Central Committee (MCC), Nairobi

MCC was one of three NGOs who participated in ICRAF's Tree Seed project (see above). Through it MCC developed interest in taking an active role to facilitate access of multipurpose tree seed to other NGOs. Accordingly, the organization has initiated a "seed bank" program, modeled in part after NCCK's once active seed

distribution program. In addition to providing a seed exchange service, MCC intends also to provide with each fulfilled request a sheet of information on certain pertinent aspects of the respective species.

Twenty-five "species sheets" were produced during the course of ICRAF's Seed project. They include information on environmental requirements; seed storage, treatment and propogation techniques; potential uses and any cultural anecdotes which may be known about species propogated through the project. Provenance information is not however, featured on the sheets, nor is it otherwise provided with distributed seed. The names of individuals and/or organizations from whom seed is obtained are kept by MCC in files. Theoretically them, as long as it remains possible to contact these, the origin of the seed may be tracable.

The "seed bank", scheduled to begin formal operation in mid-1983, is intended to operate primarily with seed collected locally by church-sponsored projects. To date seed has originated from various locations throughout Kenya as well as sites in Tanzania, Sudan, Somalia and Uganda. Generally, collections are undertaken without the benefit of technical supervision. A list of organization's so far involved in MCC's seed program is presented in ICRAF's Tree Seed Project report (35).

KENGO, Nairobi

This NGO coordinating body has recently cited tree seed procurement assistance as an area of priority attention on behalf of its member organizations. Through a survey KENGO has conducted of known NGOs, and also through two regional level agroforestry training workshops it has hosted during the past year, the organization has concluded that seed supply is the major bottleneck inhibiting nursery project development by NGOs (36).

CONCLUSIONS

From the foregoing discussion two related observations are noteworthy with regard to the national seed supply outlook. First, NGOs, many of whom operate without the benefit of technically qualified personnel, are rapidly assuming a significant role in an area which until very recently was almost entirely the purview of specific government institutions. Secondly, formally instituted channels for obtaining, processing and distributing tree seed are routinely circumvented, not only by NGOs, but by government ministries as well.

KARI and the Forest Department, as the key institutions responsible for handling tree seed and for safeguarding its quality, appear to be in a double bind over the developing situation. The Forest Department, in particular, would like to applaude NGOs for assuming part of the load in meeting its mandate to oversee production of 200 million seedlings per year. KARI, too, recognizes its program limitations in the face of the new national objective and therefore appreciates the inclinations of NGOs to operate relatively independently with regard to providing seed for projects outside the purview of the country's traditional forestry program.

On the other hand, these institutions do not formally recognize the nature of the evolving seed procurement situation. Officially, they appear to take little notice that large and growing quantities of tree seed are subject to collection and distribution locally and never pass through the requisit control facilities embodied principally in KARI. And no action is taken to control it.

The fact is that many groups involved in nursery establishment and seed procurement are simply unaware of the need for precautions in selecting and distributing seed. Operating without the benefit of advice from well-trained foresters, seed procurement to many begins and ends with identification of a popular tree and waiting for the seed to ripen. There is little conscious thought about selection and none about the need for documentation.

Perhaps none is needed, provided the collected seed and resulting seedlings are for use entirely within the community of origin. In Kenya, however, locally collected seed is not locally confined. Rather, it is passed indiscriminately among different project groups and among various subgroups within an organization, regardless of location. The tremendous agro-climatic variation within the country and East Africa results in substantial scope for geographic misallocation of tree seed in this way. Further, the absence of seed provenance data makes it difficult to monitor and evaluate species performance, and therefore to make meaningful comparisons among the vast number of trial establishment efforts. It appears unappreciated that in the long run progress in local tree establishment may be undermined without the benefit of such information.

NGOs find that raising seedlings is relatively easy work and with moderate levels of input, substantial tangible and intangible returns can be realized. For the time being, producing trees for farmers or local public places is a popular activity in Kenya and therefore project initiation and expansion is rampant. But the apparent ease with which results can be obtained undoubtedly contributes to the relative lack of concern for attention to technical "details". Particularly as appropriate technical advisory resources are so thinly stretched already, motivated NGOs are not inclined to delay project development in pursuit of such assistance.

Furthermore, in the absence of publicized guidelines for instituting caution with respect to seed procurement and distribution, there can be no realistic expectation of NGOs to do so. This, then, is the essence of the seed control issue as it pertains to NGOs in Kenya. Effectively, there is none.

Control is the responsibility of government. Presently, government is acting slowly in responding to a movement for which it is largely responsible through its own national directive on tree planting. Although attempts have been made by concerned individuals to institute an official governmental coordinating body to monitor and help control the activities of disparate groups involved in tree planting and seed handling, such a forum has yet to be instituted (37). When this eventually happens, NGOs have a rightful and valuable role to play in charting its course of action. In the meantime there are

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other measures which, in the interest of their own efforts, NGOs should consider adopting.

RECOMMENDATIONS

KENGO, as a coordinating body for NGOs involved in tree planting projects, should take the lead in bringing to the attention of its members the value in proper documentation of tree seed at the respective stages of handling.

In concert with awareness promotion, KENGO should set the standard for proper documentation and encourage its members to follow specified step by step procedures for recording pertinant provenance information and distribution data.

In order to inform itself adequately on proper documentation procedures, KENGO should first survey the opinions of knowledgeable informants and attempt to obtain a concensus of opinion as to what is considered fundamental information to include. Organizations for initial contact in this regard include the University of Nairobi Forestry Department (Chairman), KARI's Forestry Division (Head), and ICRAF (Senior Forester).

Recommended methods obtained from these organizations should then be "field tested" for feasibility of adoption by local groups involved in seed handling. Organizations posessing relevant practical experience who can assist KENGO in making this assessment include NCCK, Kositei Catholic Mission, Mennonite Central Committee and Mazingira Institute.

KENGO should use its newsletter to promote general awareness about the need for seed quality control precautions. It should use its NGO training workshop forum for conveying actual documentation methods to NGO representatives who must be encouraged, in turn, to enforce adoption by local groups with whom they operate. A special circular may be appropriate, also, as a means of conveying specific information on seed handling.

As government eventually becomes organized to recognize and effect control over seed handling by non-foresters, KENGO should stay abreast of developments and actively collaborate with government in bringing about appropriate measures. KENGO, in recognition of government's legitimate interest in control, should appear as a cooperative partner to avoid the possible creation of rules which may unnecessarily restrict the valuable role of NGOs in tree planting and seed handling.

In order to legitimize itself in the area of seed handling, and also to provide more useful advisory services to its member organizations, KENGO should consider campaigning for funds to hire an appropriately qualified forester.

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APPENDIX

NGOs INVOLVED IN TREE PLANTING IN KENYA*

1. Action Aid - Kenya*
2. Agricultural Society of Kenya
3. African Committee for the Rehabilitation of Southern Africa/ACROSS
4. African Inland Church
5. Boys Brigade Kenya
6. CARE-Kenya
7. Church Army in Eastern Africa
8. Council for Human Ecology - Kenya
9. Diocese of Garissa*
10. Diocese of Kisii*
11. Diocese of Kisumu*
12. Diocese of Maseno South Rural Development Service*
13. Diocese of Meru*
14. Digoi Women Group*
15. East Africa Women's League
16. East-Africa Yearly Meeting of Friends
17. East Pokot Agricultural Project*
18. Egerton Agricultural College*
19. Friends World Committee for Consultation
20. ICRAF*
21. Kenya Baha'i Community
22. Kenya Catholic Secretariat
23. Kenya Freedom from Hunger Council
24. Kenya Girl Guides Association
25. Kenya Jaycees*
26. Kenya Scouts Association
27. Kenya YMCA
28. Kenya YWCA
29. Limuru Boys Centre
30. Maendeleo ya Wanawake*
31. Mazingira Institute*
32. Mennonite Central Committee (MCC)*
33. Namundoli Union Group
34. National Christian Council of Kenya (NCCK)*

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*indicates the NGO is known to be involved in raising tree seedlings.

35. National Council of Women of Kenya (NCWK)[1]
36 Partnership for Productivity
37. Rajayoga Centre
38. Samia Cultural Community
39. Simon Community in Africa
40. Social Services Joot
41. The Salvation Army*
42. Thihamwa (Men of Trees)
43. Wildlife Clubs of Kenya*
44. World Muslim Congress
45. World Neighbours
46. World Vision International, Kenya

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*indicates the NGO is known to be involved in raising tree seedlings.